

ISSN 2091-042X  
ONLINE ISSN 2091-0428

# NEPALESE JOURNAL OF AGRICULTURAL SCIENCES

2022, volume 22



Himalayan College of Agricultural Sciences and Technology  
(HICAST)  
Purbanchal University affiliate  
Kalanki, Kirtipur 1, Kathmandu, Nepal

*Nepalese Journal of Agricultural Sciences, 2022, volume 22*  
*ISSN 2091-042X; eISSN 2091-0428*

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**ONLINE ISSN 2091-0428**

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**Published on:** 25 January 2022

<b>Price</b>	Nepal	NRs 500.00
(Including postage charge)	SAARC countries	US \$ 15.00
	Other countries	US \$ 25.00

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### **Publisher**

Himalayan College of Agricultural Sciences & Technology (HICAST)  
Post Box 25535, Kathmandu, Nepal  
Email: binayakprajbhandari@gmail.com  
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## **RESEARCH ARTICLES**

# **Boosting Youth Participation in Farming Activities to Enhance Food Self-Sufficiency: A Case Study from Nigeria**

**\*Omowumi A. Olowa and Olatomide W. Olowa**

Department of Agricultural Education, Federal College of Education (Technical), Akoka,  
Lagos State, Nigeria

**\*Corresponding Author:** olowaoa@gmail.com

### ***ABSTRACT***

*The food system in Nigeria is characterized by a demand-supply gap or a distorted balance between the market and the society, thus culminating in high food prices and endangering the much touted food self-sufficiency. While various investigations to unravel the possible causes have focused on other factors, assessment of this problem through the lens of youth involvement in farming production has been given little attention. This study focuses on factors that determined youth decision to participate in farming in Nigeria using Ogun State as a case study. Purposive and random sampling techniques were employed to obtain data from 300 youths spread across the four agricultural zones of the State. Collated data were analysed using descriptive, Logit and Poisson regression. The Logit model estimates revealed that years of youth in social organization, access to Information and Communications Technologies (ICTs), nature of land ownership, and youth access to State-owned agricultural programmes positively determine youth decision to participate in farming activities in the study area. On the contrary, male youth, years of formal education, and marital status of youth were negative determinants. The Poisson estimates showed that youth age, number of extension visits, and years in social organization as well as purpose of farming were positive determinants of the total hours spent by youths on farming activities per day in the study area. On the other hand, years of formal education, farm income of previous farming seasons, land ownership, and access to credit affect youth participation negatively. To increase youth participation in farming activities in the study area, it is recommended among others that the government should ease the access of youths to soft loans, tractor hiring services, land acquisition as a motivation to intensify their participation in farming activities.*

**Keywords:** Youth participation, farming, food self-sufficiency, agricultural zones

## **INTRODUCTION**

Food self-sufficiency is generally taken to mean the extent to which a country can produce the quantity of food (calories) that equals or exceeds its food

consumption (Gunnar, 2018). This most basic definition can apply at the level of individuals, countries, or regions. Food self-sufficiency is under increasing stress in many countries. A convergence of issues – such as climate change, resource depletion, dysfunctional farm policies, loss of biodiversity, and aging of farmers – is now threatening the availability of healthy food for an ever-increasing population.

Nigeria is a very large economy with a population of about 200 million according to World Bank (2019). The country represents about 20% of the total population of sub-Saharan Africa and about 76% of this population lives in the rural areas and about 90% of the rural dwellers are engaged in agricultural production (World Bank, 2016). Naturally, high rural population translates to increased farm and non-farm activities in labour-intensive agriculture. Unexpectedly, the goal of food self-sufficiency in Nigeria remains an elusive target in spite of its population advantage. One of the problems behind the non-achievement of this goal is the condition of Nigerian farmers whose current average age is around 55 years and it is expected to rise to around 75 years by 2030 (Akpan, 2010; Akpabio, 2012). The age and low level of education of average Nigerian farmers correlate with their aversion of risks associated with the adoption of new innovations; hence the very low productive capacity. In the opinion of many, getting youths to engage in farming seems a possible solution to the problem (Sarah, 2014).

The term ‘youth’ is sometimes considered by some schools of thought as a period of transition from the dependency of childhood to adulthood’s independence. This period is often characterized by sexual maturity, peak of strength and emotion as well as growing social and economic independency from parents and guidance. In developing societies, the period is often prolonged due, among others, to various types of social, economic, and political uncertainties (Akpabio, 2012). Generally, ‘youth’ as a social group is more often defined in terms of age. For this reason, the spectrum of youth has been variously defined as ranging from the ages of 10 or 11 year (as in some traditional societies in Africa) to as high as 35 years in some countries like South Africa and Tanzania. In an attempt to ‘standardize’ the concept of youth, international organizations such as the United Nations and the Commonwealth of Nations defined youth as encompassing those between the 15 to 24 age group (UNGA, 2008). The African Youth Charter, with final ratification in 2019 by the African Union, considers that youth are people in the age range of 15 to 35 years of age (AU, 2019). In a similar vein, Nigeria’s National Youth Development Policy encapsulates the youth as comprising all young persons of

age 18 to 35 years. However, the tendency to extend the category of youth to 35 years and beyond in Nigeria seems to be a reflection of the emerging phenomenon of the prolonged period of youth dependency on the host. The foregoing as noted by Alhaji and Rusmawati (2019) is a metaphor for Africa's poverty. This phenomenon is an indication of the inability of many young people in the country to be economically self-sustained, which is the result of the volatile economic situation in the country. Hence, for analytical purposes, and in corroboration with the definition of youth by the Nigeria's National Youth Development Policy, this study uses the age category 18 to 35 years as an acceptable definition of 'youth' in Nigeria.

The need to increase participation of youth population in farming activities is justified by many facts. *Firstly*, the current level of youth unemployment in Nigeria is alarming. According to the Nigerian Bureau of Statistics, the national unemployment rate is 23.9 % with the youth accounting for more than 70 %. Increased involvement of youth in farming activities will help reduce the problems of the ageing farm population and increasing youth unemployment. Youth unemployment incurred costs to the economy, society, and their families (Ajaegbu, 2012; CBN, 2014). *Secondly*, from researches, the current average age of a Nigerian farmer is around 55 years and it is expected to rise to around 75 years by 2030 (Akpan 2010; Akpabio 2012). The situation is worsened by the fact that by 2030, an estimated 50% more people will migrate to urban areas (Sarah, 2014). It is doubtful if the present farming practiced by ageing farmers can produce enough food to feed the anticipating population of 230 million people in 2030. The ageing of farmers in Nigeria and globally has been identified as one of the major structural and policy challenges facing the future of food self-sufficiency (Sarah, 2014). As the older generation retires, are the youth willing and ready to take over the food self-sufficiency challenges?

Within this perspective, this chapter attempts to empirically determine the expanded factors (pull, push, and economic-based factors) that model youth decision and actual participation in farming activities in Nigeria. More specifically, the chapter aims at: investigating the rate of youths' participation in farming activities; identifying the farming activities that youth participate in; estimating the factors that determine youths' decision to participate in farming activities; and isolating the factors that determine hours spent by youths in farming activities.

## METHODOLOGY

### The study area

The study was conducted in Ogun State in south-western Nigeria. The State has a total population of 7.1 million according to Ogun State website (ogunstate.gov, 2016) and is located in the rainforest vegetation belt of Nigeria within longitude 2° 45' and 3° 55' E and latitudes 7° 01' N and 7° 8' N in the tropics. It is bounded in the west by Benin Republic, in the south by Lagos State and Atlantic Ocean, in the east by Ondo State, and in the north by Oyo State. It covers a land area of 16,432 km sq., less than 2% of the country's landmass (ogunstate.gov, 2016). The rainy season starts around the middle of March and continues until late October whereas the dry season starts in November and lasts until February in most locations in the State. Rainfall ranges between 1600 and 900 mm annually. The State is warm throughout the year with a temperature between 28°C and 35°C. Humidity is between 85% and 95%. The main occupations of the people in the State are: agriculture, fishing, clothing, textiles, and civil service. The State was divided into four agricultural extension zones namely: Abeokuta, Ilaro, Ijebu-Ode, and Ikenne (OGADEP, 2005) (Figure 1). The four agricultural zones are well known for different kinds of farming activities.

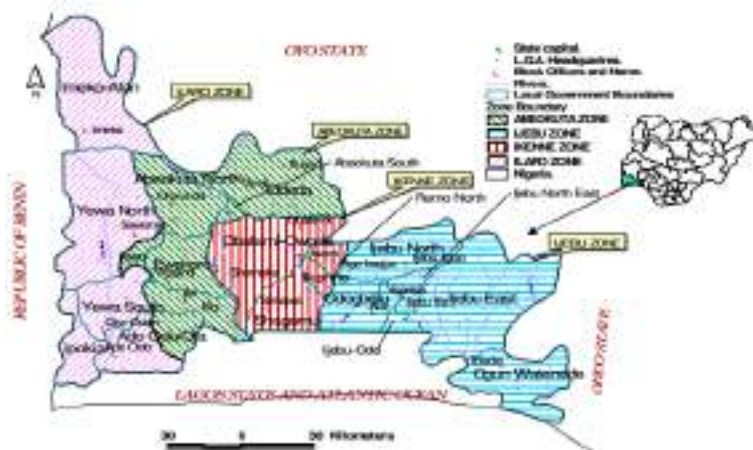


Figure 1. Map of Ogun State ADP zones and blocks showing study locations

### Data source and sampling procedures

Primary data were used and respondents were youths. Combinations of sampling methods were used to select respondents. First, the four agricultural zones – namely Abeokuta, Ilaro, Ijebu-Ode, and Ikenne – were purposively selected. In the second stage, three villages were purposively selected from each agricultural zone based on their popularity for farming activities, adding up to 12 villages in all. In the third stage, a total of 25 youths were randomly sampled in each of the

12 sampled villages. Hence, a total of 300 youths were randomly sampled and used for data collection.

## **Data analysis**

### ***Logit model***

A Logit model following Thakur and Jasral (2018) and modified was used to identify significant factors that influence youth decision to participate in farming activities in the rural areas of the State. Implicitly, the specified model is shown in equation 1. The Logit Model which captures youth decision to participate in farming activities is given below:

$$Dec = Ln \left( \frac{P_1}{1 - P_1} \right) = Z_j = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \beta_5 x_5 + \beta_6 x_6 + \beta_7 x_7 + \beta_8 x_8 + \beta_9 x_9 + \beta_{10} x_{10} + \mu \dots \dots \dots (1)$$

The marginal effect of the Logit model measures instantaneous effect that a change in a particular explanatory variable has on the predicted probability (i.e., the likelihood that a youth in the study area will choose to involve in farming activities or not); when the other covariates are kept fixed. They are obtained by computing the derivative of the conditional mean function with respect to explanatory variables.

$$\frac{\partial P_1}{\partial X_i} = \frac{E \{Y / X\}}{\partial X_i} = f(Z_1) \beta_1 = f(X \beta_1) \beta_1 \dots \dots \dots (2)$$

Variables used in equation (1) are defined as follows:

- Dec = Youth decision to participate in farming (dummy; 1 for yes and 0 for no).
- X<sub>1</sub> = Age of youth farmer (years)
- X<sub>2</sub> = Gender of the farmer (1=Male, 0 otherwise)
- X<sub>3</sub> = Formal educational (years)
- X<sub>4</sub> = Marital status of a youth farmer (1 for married and 0 otherwise)
- X<sub>5</sub> = Membership of social group (number of years)
- X<sub>6</sub> = Access to ICT (Number of times youth farmer browse in a week)
- X<sub>7</sub> = Nature of land ownership (dummy; 1 for owned land and 0 otherwise)
- X<sub>8</sub> = Number of non-farm occupations
- X<sub>9</sub> = Perceived price of fertilizer (dummy; 1 for high and 0 for normal)

$X_{10}$  = Youth access to State-owned agricultural programme(s) (Number of programmes accessed)

U = stochastic error term

Pi = Probability to participate in agricultural activity

Ln = Natural logarithm function

***Poisson model***

To estimate the determinants of number of hours spent by youth in farming activities, Poisson model, following Santos Silva and Tenreyro (2006), was adopted. The number of hour(s) spent by any youth was discrete and takes only non-negative integer values; therefore, the count-data model was specified. The model is explicitly expressed as:

$$\mu_i = E\{Y/X\} = \beta_0 + \beta X_1 + \dots + \beta_n X_n \dots \dots \dots (3)$$

In Poisson model, the estimated coefficients correspond to semi-elasticity. Thus, coefficient estimates can be directly converted into marginal effects. For a continuous regressor  $X_i$ , the marginal effect is:

$$\frac{\partial \mu_i}{\partial X_i} = \frac{E\{Y/X\}}{\mu_i} = \exp(X\beta)\beta = \beta_1 \mu_i = \beta_1 e^{\beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_n x_n} \dots \dots \dots (4)$$

Implicitly, the Poisson regression model is shown below:

$$\begin{aligned} Hrs = & \alpha_0 + \alpha_1 x_1 + \alpha_2 x_2 + \alpha_3 x_3 + \alpha_4 x_4 + \alpha_5 x_5 + \alpha_6 x_6 + \alpha_7 x_7 \\ & + \alpha_8 x_8 + \alpha_9 x_9 + \alpha_{10} x_{10} + \mu_i \dots \dots \dots (5) \end{aligned}$$

where:

- Hrs = Average number of hours spent in the farm in a day (discrete number)
- $X_1$  = Age of a youth farmer (years)
- $X_2$  = Farmer’s years of formal education
- $X_3$  = Last season farm income (N)
- $X_4$  = Number of times in contact with an extension agent in the last farming season
- $X_5$  = Membership of social group (number of years)
- $X_6$  = Purpose of farming (1 for commercial and 0 for family used)
- $X_7$  = Nature of Land ownership (dummy; 1 for owned land and 0 otherwise)
- $X_8$  = Access to credit facilities (dummy 1 for access and 0 otherwise)
- $X_9$  = Marital status of farmer (1 for married and 0 otherwise)
- $X_{10}$  = Average wage rate per day of hired labour (N)

## RESULTS AND DISCUSSION

### Descriptive analysis

#### *Socio-economic characteristics of youth in the study area*

The descriptive statistics of respondents is shown in Table 1. The result shows that the average age of youths in the study area was about 32 years. This means that most youths are in their active age. An average period of formal education stood at 10.4 years.

Table 1 Descriptive Statistics and socio-economic characteristics of youth in the Study area

Variables	Min	Max	Mean	Std. Var.
Age	18	35.0	32.02	5.321
Gender	0	1.00	0.64	0.492
Formal education	0	16.000	10.39	0.224
Marital status	0.000	1.000	0.721	0.401
No. of non-farm occupations	0	2.000	0.484	0.621
Membership of Social Group	0	14.000	3.093	0.884
ICT	0.000	1.000	0.086	0.361
Land ownership	0.000	1.000	0.204	0.456
Access to Agric. Prog.	0	5.000	0.658	1.162
Perceived Price of fert.	0	1.000	0.634	0.429
Hours	0.000	12.000	3.067	0.429
Purpose of farming	0	1.000	0.843	0.452
Access to Credit	0	1.000	0.105	0.326
Avg. wage rate per day	0	6.000	1230.5	894.630
Last season income	0	0.002	14400.0	0.006
No of Extension visit	0	45.000	4.8560	8.274

Source: Computed by Authors (2016)

This indicates that most youths in the area are educated, and there is high possibility of adopting agricultural innovations. About 64.20% of the respondents were male youths. The result also showed that 72.10% of youths interviewed were married. Social capital formation among youths was low in the study area, as shown by an average of three years in social organizations. Only 8.60% of the youths sampled had accessed to ICT facilities. The results also showed that about 20.40% of youths owned farm land. The rest acquired farm

lands probably through lease and borrowed arrangements among others. About 63.40% of youths in the sampled area perceived that fertilizer price was high. An average of five hours was spent daily in the farm by youths in the area. In addition, about 84.30% of youths engaged in farming activities for commercial purposes. Credit accessibility was very poor among youths in the area. The result further revealed that only 10.50% of the youths had access to credit facilities. An average cost of hired labour stood at N1230.5. Previous farming season income averaged N14400, while extension agent visits 4 times per season on average.

### ***Rate of youth participation in farming activities***

Following Nkonya et al. (1997) and Nnadi and Akwiwu (2008), the rate of youths' participation in farming activities was measured by calculating the percentage of those that participate and those that did not participate.

Table 2. Youth distribution according to rate of participation in farming activities

Participation	Frequency	Percentage
Yes	252	84
No	48	16

Source: Field survey (2016)

As shown in Table 2, the results reveal that 84% of the youths participated in farming activities, while 16% did not. The high involvement of youth in farming activities could be attributed to the availability of land in the area and the dependence on land for existence in the study area. The results are in agreement with the findings of Nnadi and Akwiwu (2008) that most youths in the rural area of Imo State, Nigeria are much involved in farming activities.

### ***3.1.3 Farming Activities in Which Youths Participated***

Table 3 showed that youth were highly involved in various farming activities with highest participation in planting (76.00%), fertilizer application (65.67%), and weeding (52.33%). Youths were moderately engaged in harvesting (44.00%) and land clearing (42.33%); lowly engaged in transportation (36.67%), processing (32.67%), marketing (29.67%), staking (28.67%), clearing of pens (19.67%), feeding of birds (14.67%), collecting of fodder (14.00%), and very lowly involved in compounding of poultry feeds (11.00%).

The findings implied that youths participate more in crop production and farm labour supply than livestock production. Such findings are in line with the work of Akpan et al. (2015) and Nnadi and Akwiwu (2008) who reported in their studies that youths were interested in crop production more than livestock, probably due to the short gestation period of the crop varieties produced, which ensures quick turnover. Moreover, livestock production could be more capital-intensive than crop production, hence the preference for crop production by most youths.

**Table 3. Farming activities in which youths participated**

Activities	Frequency	Percentages
Planting	228	76.00
Fertilizer Application	197	65.67
Weeding	157	52.33
Harvesting	132	44.00
Land clearing	127	42.33
Transportation	110	36.67
Processing	98	32.67
Marketing	89	29.67
Staking	86	28.67
Clearing of Pens	59	19.67
Feeding of Birds	44	14.67
Collecting of Fodder	42	14.00
Compounding of poultry Feed	33	11.00

Source: Field Survey (2016)

### **Estimates of regression models**

#### ***Estimates of logit regression on factors determining the youth's decision to participate in farming activities***

Empirical results revealed that the log odd coefficients of years of youths in social organization, access to ICT, nature of land ownership, and youth access to State-owned agricultural programmes are positive and statistically significant with respect to the decision or probability of youths' participation in farming activities in the study area. The odd interpretation implies that for every unit increase in years of youth in social organization, the log odd in favour of youths' decision to participate in farming activities increases by 1.204 or about 12.40% compared to youths who are not in a social organization. Similarly, increase in youth access to ICT facilities will result in about 1.760 or about 17.60% increase in the log odd in favour of youths' decision to participate in farming activities

compared to rural youths who do not have access to these facilities. Also, increase in youths' access to State-owned agricultural programmes will lead to about 1.277 or 12.77% increase in the log odd in favour of youths' decision to participate in farming activities compared to those who do not have access to such programmes.

Table 4. Estimates of Logit Regression on factors determining the youth's decision to participate in farming activities

Variable	Coefficient	log odd coefficient	Marginal Effect	Z-test
Constant	-1.284	-	-	-1.342
Age	0.025	1.034	0.0064	1.301
Gender	0.723	0.296	-0.2062	-3.426***
Education (Years)	0.064	0.820	-0.0123	-2.170**
Marital status	-0.823	0.321	-0.1718	-2.323**
Yrs of Youth in social org	0.167	1.204	-0.0534	3.642***
Access to ICT	1.760	2.507	0.2014	2.040**
Nature of land ownership	0.521	1.641	0.1223	1.863*
Number of non-farm occupations	0.143	1.139	0.043	0.535
Perceived price of fertilizer		-0.034 0.983	-0.0088	-0.143
Access to state owned agric. Prog	0.235	1.277	0.0563	1.792*
Log likelihood		-164.256	Log ratio test (10)	65.162***
McFadden R <sup>2</sup>		0.1352	correction prediction	79.80%
Akaike Criterion		372.862	Schwarz Criterion	425.304

*Source: Computed by authors, data from field survey 2016.*

*\*, \*\* and \*\*\* significant levels at 10%, 5% and 1% respectively.*

In a similar manner, about 1.641% or 16.41% increase in the log odd in favour of youth decision to participate in farming activities will occur for a unit increase in farm land owned by rural youth compared to those who do not own farm lands. The results imply that increase in years of rural youth in a social organization, access to ICT, nature of land ownership, and access to State-owned agricultural programmes will increase their chances to make a positive decision to participate in farming activities. Using marginal effect results, a unit increase in years of rural youth in a social organization, access to ICT facilities, nature of land ownership, and access to State-owned agricultural programmes among youths in the study area will increase the chance or probability of youths' decision to participate in farming activities by 0.0534, 0.2014, 0.1223, and 0.0568, respectively.

The positive determinants of probability of youths' participation in farming activities satisfied a priori expectations. For instance, the increase in years of

membership of a social organization promotes the social capital formation or networking among youths. Knowledge, ideas, and experiences are often shared among members of a social group. The social interaction among members helped sustain their belief and confidence in their occupations. Groups that shared the same occupation will easily encourage one another to stay put in their occupation. Also, increase in the use of ICTs promotes social interactions among peers and between youths and experienced aged farmers as well as scientists. These results suggest that the increase use of ICTs among youths will likely bring about resource-use efficiency. This can be achieved through exchange of information and exposure of the youths to the latest technology in their areas of activity. In addition, the increase of farm land ownership increased the probability of youths' participation in farming activities in the study area. An area with a high population density will likely have farmland encroachment and resulting in a pressure on agricultural land. This result perhaps suggests that rural youths' decision might be conditioned on the fact that the increase in land ownership among rural youths will likely reduce the cost of production and probably expand the level of farm's profit. Similarly, the increase in youths' participation in the State-owned agricultural programmes increases their probabilities of engagement in farming activities. This could likely be linked to available or anticipated incentives in such programmes. The results on membership of social organization and land ownership corroborate with the research report of Chikezie et al. (2012) and Onemolease and Alakpa (2009).

On the contrary, the marginal effect and the log odd coefficient of youth decision to participate in farming activities with respect to gender, education level, and marital status were negatively signed and statistically significant at 1%, 5% and 10% respectively. This means that as the number of male youths, years of formal education, and marital status increase, the probability of youths engaging in farming activities reduces. With respect to log odd coefficients, the results imply that a unit increase in the number of male youths reduces the odd of increase involvement of male youths in farming activities by 0.296 times compared to a unit increase in number of female youths. Using the marginal effect with respect to gender, the result implies that a unit increase in number of male youths will result in 0.2062 reductions in the probability of male youths' participation in farming activities. This result implies that male youths are more vulnerable to rural-urban migration compared to the female counterpart. This finding could be as the result of economic, social, and environmental factors as asserted by Akpan (2010). Similarly, a unit increase in the formal education of youths reduces the odd of increase involvement of rural youths in farming activities by 0.820 times compared to a reduction in years of formal education.

The results suggest that as youth acquired more years of formal education, they move out from rural areas in search of 'white collar' jobs in urban areas. The finding indicates that the absent of educational facilities in rural areas, where farming activities are mostly practiced, is a serious factor that prevent youths' involvement in farming activities. As pointed out by Akpan (2010), wage differential between rural and urban areas is one of the motivating factors for youth abandoning farming activities in rural areas. This result is also in agreement with the research findings of Nnadi and Akwiwu (2008) and Chizekie et al. (2012). In a similar manner, the relationship between marital statuses of youths and the decision or probability to participate in farming activity is inversely related. That is, a number increase in married youth reduces the log odd of youth decision to involve in farming activities in the study area by 0.321 times compared to celibacy. The likely reason for this result could be the difficulty to sustain a family in the area. This could be also linked to low income from farming, lack of health institutions and infrastructures/amenities necessary for family wellbeing. Similar findings had been reported by Chizekie et al. (2012).

### **Estimates of Poisson Model on Factors Determining the Number(s) of Hours Spent by Rural Youth Farmers in Agricultural Activities**

The diagnostic statistics of Poisson regression equation as presented in Table 5 show that the McFadden  $R^2$  is about 0.0742, which implies that all the explanatory variables included in the model were able to explain about 7.00% variability in the number(s) of hours spent by young farmers in the study area. The value of the normality test attested to the normal distribution of the error term generated in the Poisson regression.

The Chi square test (16.432\*\*\*) is statistically significant at 1% probability level, implying that the estimated Poisson regression has a goodness of fit. Empirical results showed that the age of youths in the study area has a positive relationship with the number of hours spent per day in agricultural activities. The results imply that a unit increase in the youth age will lead to about 3.35% increase in the hours spent per day in farming activities. This means that the number of hours spent by youth per day in farm activities in the study area increases with the increase in age of the youths.

Similarly, the number of hours a young farmer has contact with extension agent(s) positively influences hours spent per day in agricultural activities. For instance, a unit increase in extension agent visit will result in 6.05% increase in

hours spent in farming activities. This result suggests that a strong extension system can encourage youth to spend more hours in farming activities in the study area. In the same manner, membership in a social organization positively affects hours spent by youths in farming activities. Result revealed that a one-year increase in membership of a social group by youths in will result in 8.36% increase in the number of hours spent per day by them in farming activities. This result showed the importance of social capital formation among youth in the study areas.

Table 5. Poisson estimates on determinants of hours spent by youth in farming activities

Variable	Coefficient	Standard Error	Marginal Effect	Z-test
Constant	-1.2570	0.1522	-	6.110***
Age	0.0223	0.0031	0.0335	2.429**
Education (Years)	-0.0124	0.0048	0.0435	-2.342**
Last season farm income	-2.8700	1.2400	-0.0340	-2.321**
No. of times in contact with				
an ext. agent	-0.0319	0.0039	0.0605	7.234***
Membership of social group	0.0254	0.0061	0.0836	1.763*
Purpose of farming	0.2116	0.0623	0.6132	3.439***
Nature of Land ownership	-0.0739	0.0534	-0.2430	-1.710*
Access to credit facilities	-0.1740	0.0639	-0.0400	-2.521**
Marital status	-0.0390	0.0652	0.2311	-0.431
Avg. wage rate/day	-2.8392	2.7420	-1.1042	-1.0364
Log likelihood	-721.083		Normality test	12.314***
McFadden R <sup>2</sup>	0.0742		<u>Schwarz Criterion</u>	1534.603
Akaike Criterion	1316.83		Chi Square	16.432***

*Source: Computed by authors, data from field survey 2016.*

*\*, \*\* and \*\*\* significant levels at 10%, 5% and 1% respectively.*

The purpose of youth engagement in farming activities also has a strong positive correlation with the number of hours spent by them in farming activities. That is, for every commercial-oriented purpose of youth engagement in farming activities, there is 61.32% increase in the number of hours spent per day in farming activities. The result satisfies the a priori expectation, as a commercial-oriented farmer is expected to spend more hours in farming activities.

On the other hand, the coefficient of youth education, farm income of the previous farming season, land ownership, and access to credit have significant

inverse relationship with the number of hours spent per day by youth in farming activities. The result for education suggests that increase in years of formal education will lead to about 4.35% reduction in the average hours spent per day by youths in farming activities. This means that an increase in years of formal education of youth will expose them to better opportunities and high-wage rate jobs in urban areas, and this will motivate them to abandon farming activities. This result is in line with the findings of Chikezie et al. (2012) and Akpan (2010).

Similarly, a unit increase in the previous season farm income of youths reduces the number of hours spent by rural youths in farming activities at 3.40% per day. This means that as the previous farm income of youth increases, current hours spent per day reduces. Onemolease and Alakpa (2009) have reported similar results. The results also revealed that access to credit facilities has a negative association with our spent per day by rural youths in farming activities. This connotes that a unit increase in access to credit facilities by youth reduces the number of hours spent per day in farming activities by 40.50%. This means that there is an increase tendency of agricultural diversification when access to credit increases among youths. The results suggest that most youths perceived agricultural production as not profitable enough or yield low returns as compared to non-agro-based businesses. Another possible reason for the results could be the conditions attached to such credit facilities; this might motivate youths to diversify investment in order to avoid agricultural activities related risks.

## **CONCLUSION**

Youth participation in farming activities must be seen as a reliable way of managing food self-sufficiency and poverty as revealed by the results of this study indicating that the rate of youth participation stood at 84% in the study area. The implication of this for Nigeria is that, if the Government continues with feeble efforts and policy summersault on youths' unemployment and involvement in farming, the nation is likely to pay for it with wide food demand-supply gaps that may turn the nation to net food importer in the nearest future, thus resulting in increased food insecurity. The various farming activities in which youths are involved included land clearing, planting, fertilizer application, weeding, collection of fodder, cleaning of pens, etc.

In summary, the study has revealed that year(s) in social organization(s), access to ICTs, nature of land ownership, and access to State-owned agricultural

programmes are positive and significant drivers of youths' decision or probability to participate in farming activities in rural areas. On the other hand, rural youths' decision to participate in farming activities was negatively affected by gender composition of rural youths, years of formal education, and marital status. In addition, the number of hours spent by rural youths in farming activities was mostly influenced by age, the number of extension visits per farming season, purpose of youths' involvement in farming activities, and the magnitude of social capital formation among them. The antagonistic factors to number of hours spent by youths in agricultural activities included: i) increase in acquisition of formal education; ii) increase of access to agricultural credit; iii) increase in the previous farm's income; and iv) increase in self-owned farm land.

## **RECOMMENDATIONS**

Based on the above findings, it is recommended that:

- Youths should be given the right incentives by government to intensify their participation in farming activities. Such incentives include among others provision of soft loans and tractor hiring services, and facilitating land acquisition.
- There should be more extension agent visits. This will help increase the rate at which youths adopt new innovations and participate in farming activities.
- Youths should form more cooperative groups since membership of social groups will increase participation and hours spent in farming activities.
- Also, government and extension agents should intensify the provision of amenities in rural areas to make life more comfortable for the youths. These will not only encourage them to stay back, but also stimulate greater participation in full-time farming; hence help fostering the transition toward food self-sufficiency.
- There should be communal support through land donation to young farmers.

## **REFERENCES**

- Ajaegbu, O. O., (2012). Rising Youth Unemployment and Violent Crime in Nigeria, *American Journal of Social Issues & Humanities*; Vol.2 (5) pp.315 -321. ISSN: 2276 6928. <http://www.ajsih.org>.
- Akpabio, I. A. (2012). Youth employment and agricultural Development: The inextricable Siamese twins. *34th Inaugural lecture Series* of the University of Uyo, Nigeria.
- Akpan, S. B., (2010). Encouraging Youth Involvement in Agricultural Production and Processing in Nigeria. *Policy Note No. 29*: International Food Policy Research Institute, Washington, D.C.
- Akpan, S. B., Patrick, I. V., James, S. U. and Agom, D. I. (2015). Determinants of Decision and Participation of Rural Youth in Agricultural Production: A Case Study of Youth in Southern Region of Nigeria. *RJOAS*, Vol.7 (43), pp 35-48
- African Union (2019) African Youth charter. Addis Ababa. <https://au.int/en/treaties>

- Alhaji, B.M and Rusmawati, B.S (2019) Non-Income Poverty and Socio-Economics Characteristics: Evidence from Rural Nigeria. In *Urban and Rural Poverty*; Dima Oortwijn (Ed) Nova Science Publishers, New York
- Central Bank of Nigeria (CBN) Website (2014) Retrieved on the 5<sup>th</sup> of July, 2015, <http://www.cenbank.org/>.
- Chikezie N. P., Omokore D. F., Akpoko J. G. and Chikaire, J. (2012) Factors Influencing Rural Youth Adoption of Cassava Recommended Production Practices in Onu-Imo Local Government Area of Imo State, Nigeria.
- Economic Watch (2013) 'Nigeria Economic Statistics and Indicators,' Retrieved on October 29, 2013 from <http://www.economywatch.com/economicStatistics/country/Nigeria/>
- Gunnar, R (2018) Food Self-Sufficiency- Does it make sense? *Garden Earth*. <https://www.Resilience.org>
- Jibowo, A. A. and Sotomi, A. O. (1996) The Youth in Sustainable Rural Development. A Study of Youth Programme in Odeda Local Government Area of Ogun state, Nigeria. In Adedoyin, S.F. and Ilonsu, J.O.Y. (eds). *Sustainable Development in Rural Nigeria, Proceedings of the 8th Annual Conference of Nigeria Rural Sociological Association*.
- Nnadi, F. and Akwiwu C. (2008) Determinants of youths' participation in Rural Agriculture in Imo State, Nigeria. *Journal of Applied Sciences*; Vol. 8 (2), pp328 – 333.
- Nkonya, E., Schroeder T. and Norman D. (1997) Factors affecting adoption of improved seed and fertilizer in Northern Tanzania. *J. agric. Econ*. Vol.18: pp. 1-12
- Ogun state Government (2016) Ogun State Population. [Ogunstate.gov.ng/og](http://Ogunstate.gov.ng/og)
- Okafor, E. E., (2011) Youth Unemployment and Implications for Stability of Democracy in Nigeria. *Journal of Sustainable Development in Africa* Vol.13 (1), 2011, pp358-373.
- Olaoye O.J., Adekoya B.B., Ezeri G.N.O., Omoyinmi G.A.K, Ayansanwo T.O. (2007). Fish Hatchery Production Trends in Ogun State: 2001-2006. *J. Field Aquat. Stud. Aquafield*, 3: 29-40.
- Oloruntoba A, Adegbite DA (2006). Improving Agricultural Extension Services through University Outreach Initiatives: A Case of Farmers in Model Villages in Ogun State, Nigeria. *J. Agric. Educ. Ext.*, 12
- OGADEP (2005) Annual in-House Review Fisheries Report. Ogun State Agricultural Development Programme (OGADEP) Fisheries Unit, Vol. 10. (4), pp 273-283.
- Onemolease, E. and Alakpa, S. (2009) Determinants of Adoption Decisions of Rural Youths in the Niger Delta Region of Nigeria. *J. Soc. Sci*, Vol.20 (1), pp 61-66.
- Sarah, S (2014) Encouraging Youth Involvement in Agriculture and Agribusiness. Foodtank Newsletter, March, 2014. <https://foodtank.com>
- Thakur, A and Jasral, L (2018) A Logit Model to Predict Innovativeness among Mobile telecom Service Users. *Global Business Review*. <https://doi.org/10.1177/09721509177133>
- UN General Assembly Resolutions (2008) Definition of Youth. <http://www.un.org/documents/resga.htm>
- World Bank (2019) Population Data for Nigeria. <https://data.worldbank.org>.
- World Bank (2016) Poverty Reduction in Nigeria in the Last Decade; Country Report No- NGA World Bank, Washington, DC

# Cost-Benefit and Resource Use Efficiency of Oyster Mushroom Production: A Case of Freed *Kamaiya* in Kailali Nepal

**Jyoti Dhungana**

Agribusiness Expert, RJKIP

Corresponding Author: jyoti.hohen@gmail.com

## **ABSTRACT**

*Mushroom enterprises play a vital role to generate income for marginal farmers in Nepal. However, lack of adequate knowledge on the economics of production hinders the level of production. Thus, the present study aimed to examine the cost-benefit, resource use efficiency (RUE), and constraints faced by oyster mushroom grower farmers in Kailali, Nepal. In total 82 households was selected using a simple random sampling technique and the primary data on its production were collected from September to October 2021. Benefit-Cost (B:C) ratio, Cobb-Douglas production function, and scaling techniques were applied for data analysis using SPSS. The results revealed that the average cost for growing oyster mushroom was NRs. 59,839/shed and the gross revenue was NRs. 161,299/shed. The B: C ratio was found 2.71. The share of the cost to labor was found 32%; and for spawn it was 29%. The estimation of RUE showed that farmers were not efficient in utilizing the inputs in mushroom production. The result revealed that the inputs such as straw and materials were overused; and need to be decreased in terms of cost by 182% and 193%, respectively for the optimum allocation of resources. Similarly, the investment in labor, spawn and miscellaneous should be increased by 60%, 62% and 55%, respectively. The scaling technique further resulted that insufficient equipment, extreme weather, and lack of post-harvest facilities were the major constraints in growing oyster mushrooms in Kailali. It is concluded that the technical training on farm profitability facilitating the expansion of enterprises through production inputs and post-harvest facilities could contribute to enhancing the production in the study area.*

**Keywords:** Cost, efficiency, farmer, landless, return

## **INTRODUCTION**

Mushroom production is one of the affordable enterprises for landless farmers in Nepal (Pokhrel, 2016; Samrath, Nag & Kerketta, 2020). It provides huge employment opportunities for rural youth in the developing world (Thakur,

2020). It offers nutrient supplements to family members (Rathore *et al.*, 2019; Shivute, 2020) and is regarded as a healthy food item due to its high protein content and medicinal benefits (Sharma, Kumar & Guleria, 2016). It has been mentioned that a low level of investment can give high profit in oyster mushroom (*Pleurotus ostreatus*) by converting waste matters into beneficial products (Chang & Wasser, 2017) and contributing to environmental protection. Moreover, the demand for mushroom in Nepal has significantly increased and that was met through imports. It has been reported that the total quantity and the value of import of mushroom products were 313 Mt. and \$396,912 respectively, while the quantity of export was only 14.3 Mt. and its value was \$73,821 (MoALD, 2021). This figure clearly indicates the trade deficit of mushroom production in Nepal. However, the lower production of 10,500 Mt. of fresh mushroom in Fiscal Year (FY) 2017/18 was increased to 11,255 Mt. in FY 2018/19 and 12,607 Mt. in FY 2019//20 (MoALD, 2021) showing the steady increase in production of mushroom in Nepal.

Besides, a significant number of landless farmers, especially freed-*Kamaiya*<sup>1</sup> of Kaili district are involved in mushroom production for their livelihoods. However, they have poor production management and little information on farm economics. In addition, lack of adoption of improved practices (Tinzaara *et al.*, 2018; Raut, 2019) and the limited research for the efficient use of scarce resources (Shrestha *et al.*, 2018; Ullah *et al.*, 2019) hinders the level of productivity. Similarly, partial knowledge on farm rationality (Kunwar & Maharjan, 2019), improper use of inputs (Khan & Ali, 2013), and lack of technical efficiency in production (Onuwa *et al.*, 2021) were the gaps identified in the mushroom sub-sector. Hence, knowledge in investment, return and production optimization is essential for farm sustainability (MRSMP, 2017).

So, the farm-level efficacy can be measured through the cost-benefit analysis (MoAD, 2016). It is widely used by policymakers, scholars, and farmers to take strategic decisions for crop choice (Keck & Hung, 2019; MoLMAC, 2019). This helps to quantify the total expenditure made in the production process and its profits in monetary value (Rathod & Gavali, 2021). Likewise, resource use efficiency is defined as the capacity to maximize the output in per-unit use of input. It denotes how the farmers use their inputs in a proficient manner. It supports the farmers to optimize the use of land, labor, and capital in a sustainable way (Yang *et al.*, 2021). Apart from this, the problem of food security overlooked in the developing world can be solved through the proper

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<sup>1</sup> Freed-*Kamaiya* is defined as the labor who are free from the forced or bounded labor

use of scarce resources (Ishtiaque, Shrestha & Chhetri, 2017). This analysis helps to understand the optimization to derive the maximum output (Beetz & Greer, 1999; Rawat, Negi & Singh, 2020). Now the necessity is felt to bridge the above gaps by calculating the benefit level and analyzing on farm efficiency. Hence, the purpose of this study was to assess the cost-benefit analysis, resource use efficiency, and the constraints faced by freed- *Kamaiya* mushroom grower farmers of Kailali Nepal.

### **Conceptual framework**

The theoretical concept of this research is based on the theory of shadow price. This gives an idea of the value of additional effort put into the production process and is used to estimate the cost-benefit (Smirnov & Wang, 2019). The shadow price measures the total impact of benefit from the public sector (Dreze & Stern, 1987). It also applies to the private sector (Mirrlees, 1972; Guesnerie, 1979). The cost-benefit analysis in the private sector looks into the variables such as input constraints, environmental prices, and taxes (Dreze & Stern, 1987). In this study, the cost-benefit ratio was used as a decision-making tool based on the value of profit at shadow price, where total cost was calculated by summing up the production of variables and fixed costs incurred in the production processes. The variable cost includes the cost of labor, spawn, straw, materials (rope, white plastic, and firewood), and the cost of miscellaneous items (formalin, lime, nutrients). The fixed cost was calculated for 3 months period (1 lot) per shed, which was taken from the fixed assets like shed and equipment.

The second theory used in this study was the production function, which shows the association of factors and output pertained in the production process. The factors of production include the specific type of services and goods used in the production technology (Shephard, 1970) and the elasticity of production  $\alpha$  and  $\beta$  exist in the production function (Sato, 1981). It assists to take the proper decision to derive the maximum output in per unit of resource use (Olukunle, 2017). Therefore, in order to better understand the level of efficiency in mushroom production, the Cobb Douglas production function (Cobb & Douglas, 1928) was applied in this study. It holds the relationship between the production output and the factors of production such as labor and capital. Hence, this study was taken the total return (output) as a dependent variable, and the cost of labor, spawn, straw, materials, and miscellaneous (factors) were used as explanatory variables.

## METHODOLOGY

### Selection of the study area and sample size

Out of 13 municipalities in the Kailali district, Tikapur municipality and Janaki rural municipality were chosen for the study. The concentration of freed bonded labor (*Kamaiya*) engaged in mushroom production lies in these areas. Besides this, landless farmers are benefiting from mushroom farming. Further, the project of national pride named Rani Jamara Kulariya Irrigation Project (RJKIP) has been supporting the production of mushroom through the grant scheme. Thus, the commercial practices in these municipalities appear to be more fruitful than other locations. In total of 102 commercial mushroom farmers (Freed-*Kamaiya*) were identified as sampling frames from two municipalities (Annual Report, 2020). 82 households were randomly chosen, of which 58 from Tikapur and 24 from Janaki were selected based on the proportional size. The simple random sampling method is appropriate to reduce the sampling biases (Baker *et al.*, 2013). Raosoft was used to calculate the sample size (Raosoft, 2021), which is widely used to calculate the sample size (Al-Balas *et al.*, 2020). Pre-test surveys were organized as suggested by Converse and Presser (1986). Then, some variables were adjusted to get the required information. The primary data were collected through a household survey from September to October 2021. Also, the quantitative research approach was used to know the farm level economics (Dulal & Kattel, 2020).

### Methods of data analysis

Data were analyzed through descriptive statistics, cost-benefit ratio, and Cobb-Douglas production function and scaling technique using the Statistical Packages of Social Sciences (SPSS) software.

### Benefit-Cost analysis

The Benefit-Cost (B: C) analysis evaluates the ratio of benefit per unit of investment (Hwang, 2016). B: C ratio is calculated by using the following formula:

$$\text{B:C ratio} = \frac{\text{Total Return (NRs)}}{\text{Total Cost (NRs) .....(1)}}$$

Where, the total return is the volume of production (Kg.)  $\times$  average farm gate price (NRs.). Total cost of production is the summation of cost incurred in the variable inputs such as cost of labor, spawn, straw materials, and miscellaneous and fixed cost (NRs.)

Decision rule:

- B: C ratio >1; profitable
- B: C ratio =1; indifferent
- B: C ratio <1; loss

**Econometric model**

According to Cobb-Douglas, the production function formula is:

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} X_4^{b_4} X_5^{b_5} e^u \dots\dots\dots(2)$$

Where, **Y** = Total return from mushroom production in Nepalese Rupees (NRs/shed)

X1= Total cost of labor used in mushroom production in NRs/shed

X2 = Total expenditure on spawn in NRs/shed

X3= Total cost of straw used in NRs/shed

X4= Total cost of materials in NRs/shed

X5= Total miscellaneous cost in NRs/shed.

a = Intercept, e<sup>u</sup> = Error term, b1, b2.....b5 are the regression coefficients to be estimated

**Resource use efficiency**

A linear regression analysis was performed using the Cobb-Douglas production function to estimate the resource use efficiency (Dhakal *et al.*, 2019). It was computed with this formula:

$$r = \frac{MVP}{MFC} \dots\dots\dots(3)$$

Where, r = efficiency ratio, MVP=Marginal Value Product is the value of an incremental unit of output obtained from the additional unit of input use. MFC=Marginal Factor Cost is defined as the increase in the cost of inputs due to the expense made for an additional unit of inputs. This is equal to 1. Since both dependent and explanatory variables are converted to monetary value. MVP is calculated in the given formula below:

$$MVP = \frac{b_i \cdot \bar{Y}_i}{\bar{x}_i} \dots\dots\dots(4)$$

b<sub>i</sub> = Estimated regression coefficient of input X<sub>i</sub>

$\bar{Y}_i$  = Geometric mean value of output Y<sub>i</sub>

$\bar{x}_i$  = Geometric mean value of i<sup>th</sup> resources used

Decision rule:

**r = 1**; Efficient use of resource

$r > 1$ ; Underuse of the resource

$r < 1$ ; Overuse of the resource

Finally, the relative percentage change in MVP was calculated using the following way:

$D = (1 - \text{MFC}/\text{MVP}) \times 100$ , or,  $D = (1 - 1/r) \times 100$ , Where D= absolute value, which is taken from the change in value in MVP for each use of the resource (Mijindadi, 1980). The detailed calculation of parameters is given in **Appendix-1**

### **Indexing**

Scaling techniques was used to get the index level (Cooke *et al.*, 1987). The scale value of 5,4,3,2 and 1 was used to indicate the most serious, serious, moderate, a little bit serious, and least serious problem respectively. The index value of importance was computed by following formula:

$$\text{Imp} = \frac{\sum (S_i F_i)}{N} \dots\dots\dots(5)$$

Where, Imp = Index of importance,  $\sum$  = Summation,  $S_i = i^{\text{th}}$  Scale value (1, 2, 3, 4 and 5)

$F_i$  = Frequency of  $i^{\text{th}}$  importance given by the respondents, N = Total number of respondents

## **RESULTS AND DISCUSSION**

### **Descriptive analysis**

The summarized results of the socio-economic characteristics of sampled households in the study site are presented in Table 1. It has resulted that 91.5% of respondents were from Janajati (*Tharu*) in which 65% were female and 59% of household heads were female. Gender distribution of respondents reveals the majority of females had involved in mushroom production than their male counterparts. The findings of the present study are similar to Malakar, Ipulet and Byandusa (2016), who stated that females constitute 70-80% agricultural labor force in the production of mushroom. Likewise, the mean size of land in the study area was 0.10 ha. The land is the basic requirement for agriculture production but the mushroom can be produced by small and landless farmers (Sonam, Shishir & Prabhakar, 2021). In addition, the mean age of respondents was 37, which means the economically active farmers were engaged in the production. Similar findings were obtained in Addis Ababa, where 95% of farmers were from the 25-44 years age group (Gebretsadkan, 2015) in contrast

to that of India (Sonam, Kala & Hans, 2020) wherein the respondents of all age groups were involved in mushroom production.

Further, the mean size of the family in the project site was 6, which is more than the national average of 4.88 (CBS, 2012). Moreover, the education level of the respondents showed that the majority of households (42%) had received the secondary level of education, while only 2% were illiterate. It means that 98% of farmers are able to read and write. This finding is consistent with Abah, Ochoche, and Stephen (2021), who reported that education has a significant effect on the level of agriculture productivity. So, literacy is important to create awareness and innovate their production (Rengganata & Kantun, 2020).

Table 1. Socio- economic characteristics of households

Variables	Mean	Variables	Frequency
Age	37±9.5	Gender of household head	
Family Size	6±2	Female	48 (59)
Land size in ha	0.10±0.07	Male	34(41)
Variables	Frequency	Membership	
Gender		Yes	32 (39)
Female	53 (65)	No	50 (61)
Male	29 (35)	Education level	
Caste		Illiterate	2(2)
Janajati	75 (91)	Literate	15(18)
Others	4 (5)	Primary education	17(21)
Dalit	3 (4)	Secondary education	34 (42)
		College degree	14 (17)

(Source: Field survey, 2021), Note: Value after “±” indicate standard deviation & figures in parentheses indicate percentage

### **Benefit-Cost analysis**

#### ***Cost-share***

The total cost comprising the variable and fixed cost per shed incurred in the production of mushroom is presented in Table 2. The total cost per shed was NRs. 59, 839. The variable cost occupies 92% of the total cost, where fixed cost was too low (8%). The reason for the low cost was due to the use of locally available materials for the construction of the shed. This is agreed by Jegadeesh *et al.* (2018). Nearly the same result was reported in the study in India, where 97% of the cost was covered by variable inputs (Rawat *et al.*, 2020).

Along with, the survey result revealed that the largest share of cost 32% used for labor, followed by spawn 29%, the materials and straw costs were 14% and 10% respectively, while other costs were negligible (Figure 1). A similar pattern of

labor cost occupied 20% and the rest 82% of the expenditure was used for capital inputs in Uttar Pradesh in India (Sachan & Kumar, 2020).

On the contrary, the labor cost 44.4% and seed cost was 45.9%, which is almost double (Gahatraj & Uprety, 2019), the share of the fixed cost 34%, which was nearly four times more, and the labor cost found too low (7%) in Uganda (Mayanja & Tipi, 2017) than this survey results. However, the cost of materials depends upon the context and region (Mutema *et al.*, 2018). The result of this survey concluded that mushroom production requires intensive labor and would be better for those who have a small space of land. This is in line with Sonam *et al.* (2021), who concluded that mushroom production is beneficial for generating income for landless farmers.

Table 2. Cost of different items of mushroom production per shed

Variable cost (NRs/shed)		Fixed assets' cost(NRs/shed)	
Particulars	Average cost	Particulars	Average cost
Labor	19401	Labor cost for shed	5000
Spawn	17431	Bamboo and black plastic	24250
Straw	5670	Sprayer tank, drum	16663
Materials	8561	Digital weighting machine	3000
Miscellaneous	3885	Total cost	48913
Total Variable Cost	54,948	Total fixed cost for 1 lot (10)	4891
Total cost(variable+fixed cost)	59, 839		
Productivity	3.2 Kg/ball		
B:C ratio	2.71		

(Source: Field survey 2021)

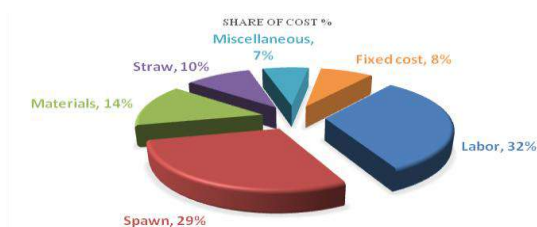


Figure 1. Share of cost % in different items

(Source: Field Survey 2021)

### **Net return and profit**

The gross return was found NRs. 161,299, which generates the net benefit of NRs. 101,460 per shed (Figure 2). Additionally, the B: C ratio was found 2.71 and the productivity was 3.2 kg/ball. This finding was similar to the study performed by MoLMAC (2019), wherein the B: C ratio was found 2.6 and the

productivity of 3.9 kg/ball of mushroom. However, the lower B: C ratio of 2.1 of mushroom with rice straw was observed in Darchula (Neupane *et al.*, 2018), and B: C ratio from 1.08 to 1.34 of oyster mushroom production were found in Indonesia (Rahmawati & Marbudi, 2021) and higher B: C ratio of 3.84 was cited by Mayanja and Tipi (2017) in Uganda than this survey result. Thus, it has been reported that the positive value of the B: C ratio is an indication of feasible business (Henke *et al.*, 2020). Hence, mushroom cultivation gives a good marginal rate of return in a short duration. It can be grown several times a year. It is also supported in a study in Zimbabwe by Mutema *et al.* (2018) and in Addis Ababa by Gebretsadkan (2015).

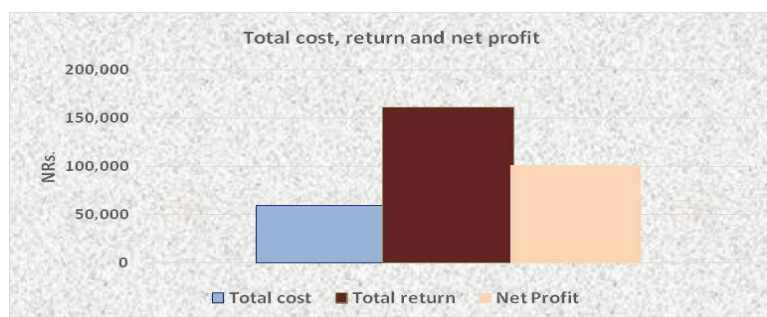


Figure 2. Bar diagram showing the total cost, return and net profit/shed (Source: Field survey, 2021),

### Estimation of resource use efficiency

The major inputs used in the mushroom production were namely labor, spawn, straw, materials and miscellaneous were considered (Table 3). The explanatory variables from the above equation (2) were transformed to linear log form to make it easier in computation. The result of the analysis of resource use efficiency indicated that labor, spawn and miscellaneous inputs in mushroom cultivation were under used, and thus, the investment in those inputs needs to be increased by 60%, 62% and 55%, respectively for its optimum allocation (Table 3). Again, the value of  $r$  was lesser than the unity for straw, and materials resources, which were over-used. The findings of this survey are consistent in the comparative study of the button and white mushroom in Kathmandu by Shrestha and Dhakal (2014) who explained the utilization of labor and materials were used inefficiently and underutilized. According to Sujan *et al.* (2017), in the research conducted in Munshiganj district of Bangladesh, where labor was underused.

Table 3. Estimation of resource use efficiency using Cobb-Douglas production function

Variables	Coefficient	MVP	MFC	r	D-value	Efficiency
Ln_Labor	0.288	2.478	1	2.478	60	Underused
Ln_Spawn	0.290	2.628	1	2.628	62	Underused
Ln_Straw	-0.043	-1.222	1	-1.222	182	Overused
Ln_Materials	-0.057	-1.071	1	-1.071	193	Overused
Ln_Miscellaneous	0.048	2.238	1	2.238	55	Underused

(Source: Field survey, 2021)

However, different results were observed of mushroom production in the Thane district in India by Wanole (2020), who stated that labor was over-utilized and spawn was underused. Hence, the reasons for the inefficient use of inputs were due to a lack of awareness on the utilization of the proper quantity of inputs like straw, spawn, nutrients, and use of labor. The same suggestion was provided by Khatun *et al.* (2019), who recommended the designing of capacity-building training for farmers for the best use of resources in a proficient manner. The result further indicated that the adjustment of production inputs is necessary by reducing the cost of inputs. Shrestha *et al.* (2016) agreed that the reduction of cost is possible with the efficient use of resources. Thusly, the recommended quantity of input is needed to gain the higher economic advantage of mushroom production. It was supported in a study in India by Deora *et al.* (2021), who concluded that the optimum use of spawn of mushroom contributed to the high return and cost reduction.

### **Constraints faced by mushroom farmers**

The data presented in Table 4 pointed out that the constraints faced by mushroom farmers at the production, technical, and marketing levels. Four major problems were specified in the questionnaire of each aspect. Respondents were asked to rank from 1 to 5 point likert scale based on the farmers' perception. The scaling technique showed the extreme weather ranked the most serious problem (0.72), followed by a shortage of quality spawn (0.63) in production. It was due to the fact that mushroom cannot be produced year-round in the hot summer season. As they do not have proper weather protective shed facility. The unavailability of quality spawn might be due to the lack of laboratory of spawn production in the nearby areas. These constraints were perceived in mushroom enterprise in west Bengal India by Roy *et al.* (2020).

Similarly, insufficient equipment ranked first (0.67) as a technical problem. This means the lack of required equipment for mushroom production namely straw cutter, sterile treatment materials, and machines. Farmers do work only

manually as they do not know about the technology for the use of the machines and are not practiced in the study sites. Also, the most serious problem of marketing is the lack of post-harvest management (0.66).

Table 4. Constraints faced by mushroom growers

Constraints	Index	Rank	Constraints	Index	Rank	Constraints	Index	Rank
Production			Technical			Marketing		
Extreme weather condition	0.72	I	Insufficient equipment	0.67	I	Lack of facilities of post-harvest	0.66	I
Shortage of quality spawn	0.63	II	Lack of skilled labor	0.63	II	Lack reasonable price	0.61	II
Lack of capital	0.60	III	Lack of sufficient training	0.59	III	Lack of good transportation	0.61	II
Lack of technical skills	0.59	IV	Irregular supply of electricity	0.50	IV	Lack of marketing facility	0.60	III

(Source: Field survey, 2021)

There were no such value addition activities done and the storage facilities are not available in the study sites. Along with, the high incidence of insect pests in production (Sharma *et al.*, 2016), lack of skills (Shirur *et al.*, 2016) significantly contribute to the low volume of mushroom production. Further, the mushroom sub-sector is handicapped by the unavailability of quality of spawns and lack of agro-processing unit (Sohi, Tanwar & Matharu, 2021), and the unorganized market in India (Radhakrishnan *et al.*, 2021).

### CONCLUSION

The estimation of resource use efficiency (RUE) showed that inputs were used uneconomically which is either overused or underused. The above findings of the cost-benefit analysis revealed that mushroom farmers received a good net profit. Furthermore, the extreme weather, insufficient equipment facilities, and lack of value addition activities were the major constraints of farmers. Thus, it would recommendable to enrich the farmers' technical skills on the economics of production and facilitate on the post-harvest management and weather protective shed. Support on these activities will certainly help to uplift the economic condition of freed-Kamaiya mushroom farmers in the study area.

### REFERENCES

- Abah, D., Ochoche, O. C. and Stephen, J.I. (2021) 'The effect of land conflict on rice production in Agatu local government area of Benue state', Nigeria. *International Journal of Agricultural Economics, Management and Development (IJAEMD)*
- Al-Balas, M., Al-Balas, H. I., Jaber, H. M., Obeidat, K., Al-Balas, H., Aborajoo, E. A., Al-Taher, R. & Al-Balas, B. (2020) 'Distance learning in clinical medical education amid COVID-

- 19 pandemic in Jordan: current situation, challenges, and perspectives', *BMC Medical Education*, 20(1). doi: <https://doi.org/10.1186/s12909-020-02257-4>
- Annual report (2020) 'Annual Progress Report. Agriculture Section', Tikapur Municipality, Kailai district Nepal
- Annual report (2020) 'Annual Progress Report. Agriculture Section', Janaki Rural Municipality, Kailai district Nepal
- Baker, R., Brick, J. M., Bates, N. A., Battaglia, M., Couper, M. P., Dever, J. A., Gile K.J., & Tourangeau, R. (2013) 'Summary report of the AAPOR Task force on non-probability sampling', *Journal of Survey Statistics and Methodology*, 1(2), pp. 90–143. doi: <https://doi.org/10.1093/jssam/smt008>
- Beetz, A. & Greer, L. (1999) 'Mushroom cultivation and marketing', Horticulture production guide. Appropriate technology transfer to the rural area, NCAT Agriculture Specialists
- CBS (2012) 'National population and housing census 2011 (national report)', Central Bureau of Statistics, Government of Nepal, National Planning Commission Secretariat, Kathmandu, Nepal
- Chang, S.T. & Wasser, S.P. (2017) 'The cultivation and environmental impact of mushrooms', Printed from the oxford Research Encyclopedia, Environmental Science (c) Oxford University Press, USA pp. 43
- Cobb, C. W. & Douglas, P. H. (1928), 'A theory of production', *American Econ. Rev.*, 8, 139–1965
- Converse, J.M. & Presser, S. (1986) 'Survey Questions: Handcrafting the standardized questionnaire', *Quantitative applications in the social sciences*, Sage Publications, Inc. Social surveys, Questionnaires
- Cooke, N. M. & McDonald, J. E. (1987) 'The application of psychological scaling techniques to knowledge elicitation for knowledge-based systems', *International Journal of Man-Machine Studies*, 26(4), pp. 533–550. doi: [https://doi.org/10.1016/s0020-7373\(87\)80086-x](https://doi.org/10.1016/s0020-7373(87)80086-x)
- Deora, A., Sharma, S. S., Kumari, P., Dahima, V., Kumar, S. and Rohith, M. (2021) 'Cultivation of Kabul Dhingri (*Pleurotus eryngii*) mushroom by standardizing protocols in subtropical zones of world', *Sci Rep*, 11, 14692. doi: <https://doi.org/10.1038/s41598-021-94038-2>
- Dhakal, R., Bhandari, S., Joshi, B., Aryal, A., Kattel, R.R. and Dhakal, S.C. (2019) 'Cost-benefit analysis and resource use efficiency of rice production system in different agriculture landscapes in Chitwan district Nepal', *Archives of Agriculture and Environmental Science*, 4(4), pp.442-448. doi: <https://dx.doi.org/10.26832/24566632.2019.0404011>
- Dreze, J. and Stern, N. (1987) 'The theory of cost-benefit analysis. Handbook of public economics', pp. 909-989. doi: [https://doi.org/10.1016/s1573-4420\(87\)80009-5](https://doi.org/10.1016/s1573-4420(87)80009-5)
- Dulal, S. and Kattel, R.R. (2020) 'Resource use efficiency of banana production and impact of insurance scheme adoption on banana farming in Chitwan, Nepal', *Int. J. Appl. Sci. Biotechnol*, 8(2), pp. 170-178. doi: <https://doi.org/10.3126/ijasbt.v8i2.29120>
- Gahatraj, S. and Uprety, R. (2019) 'Profitability and resource productivity analysis of garden pea (*pisum sativum*) production in Dhankuta, Nepal', *SAARC J. Agric.*, 17(2), pp. 165-172. doi: <https://doi.org/10.3329/sja.v17i2.45303>
- Gebretsadkan, G. (2015) 'Assessment of urban agriculture in Addis Ababa: The case of mushroom cultivation', MSc Thesis. Addis Ababa University, Ethiopia
- Guesnerie, R. (1979) 'General statements on second-best pareto optimality', *Journal of Mathematical Economics*, 6, pp.169-194. Retrieved from: <https://www.researchgate.net>
- Henke, I., Carteni, A., Moliterno, C. and Errico, A. (2020) 'Decision-making in the transport sector: A sustainable evaluation method for road infrastructure', *Sustainability*, 12(3), p.764. doi: <https://doi.org/10.3390/su12030764>
- Hwang, K. (2016). Cost benefit analysis: Its usage and critiques. *Journal of Public Affairs*. 16(1):75-80

- Ishtiaque, A., Shrestha, M. and Chhetri, N. (2017) 'Rapid urban growth in the Kathmandu valley, Nepal: Monitoring land use land cover dynamics of a Himalayan city with land sat imageries', *Environments*, 4(4), p. 72. doi: <https://doi.org/10.3390/environments4040072>
- Jegadeesh, R., Lakshmanan, H., yeul, J.K, Atnam, V.S. and Raaman, M. (2018) 'Cultivation of Pink oyster mushroom *Pleurotus djamor var. roseus* on various agro-residues by low cost technique', *J. Mycopathol Res*, 56(3), pp. 213-220
- Keck, M. and Hung, D.T. (2019) 'Burn or bury? A comparative cost-benefit analysis of crop residue management practices among smallholder rice farmers in northern Vietnam', *Sustain. Sci.*, 14, pp. 375-389. doi: <https://doi.org/10.1007/s11625-018-0592-z>
- Khan, H. & Ali, F. (2013) 'Measurement of productive efficiency of tomato growers in Peshawar, Pakistan', *Czech Agricultural Economics*, 59: 381-388
- Khatun, M., Rashid, M.A., Khandoker, S., Kundu, N.D. and Matin, M.A. (2019) 'Resource use efficiency analysis in strawberry production in selected areas of Bangladesh, SAARC', *Journal of Agriculture*, 17(1), pp. 189-200. doi: <https://doi.org/10.3329/sja.v17i1.42771>
- Kunwar, B. & Maharjan, B. (2019) 'Economic analysis of off-season tomato production under poly-house in Okhaldhunga, Nepal', *The Journal of Agriculture and Environment*, 20. Available at <https://www.nepjol.info/index.php/AEJ/article/view/25012/21042>, Accessed: 20 November, 2021
- Malakar, K., Ipulet, P. and Byandusa P. (2016) 'Role of women in mushroom growing in Uganda: The case of the mushroom training and resource center', South West Uganda. World Society for Mushroom Biology and Mushroom Products (WSMBMP), Bulletin, No: 14
- Mayanja, I. and Tipi, T. (2017). The economic empowerment of women in Uganda through mushroom production. *Turkish Journal of Agriculture - Food Science and Technology*, 5(11), pp. 1401-1406. doi: <https://doi.org/10.24925/turjaf.v5i11.1401-1406.1345>
- Mijindadi, N.B. (1980) 'Production efficiency on farms in Northern Nigeria', Doctoral dissertation submitted to Cornell University, USA
- Mirrlees, J.A. (1972) 'On producer taxation', *Review of Economic Studies*, 39, 105-111. 4
- MoAD (2016) 'Statistical information on Nepalese agriculture 2014/2015', Ministry of Agriculture Development, Singhadurbar, Kathmandu
- MoALD (2021) 'Statistical information on Nepalese agriculture 2018/2019', Ministry of Agriculture. Development, Singhadurbar, Kathmandu
- MoLMAC (2019) 'Production cost and profit margin of banana and mushroom 2076', Ministry of Land Management, Agriculture and Cooperatives Directorate of Agricultural Development, Provincial Government Province No. 5, Rupandehi, Nepal
- MRSMP (2017) 'Production cost & marketing of cereal, cash, vegetable & industrial crops in Nepal (2016/17)', Agribusiness Promotion and Market Development Directorate, Market Research and Statistics Management Program, Lalitpur
- Mutema, M., Basira, K., Savadye, D. and Parawira, W. (2018) 'Assessment of oyster mushroom production and profitability in Harare urban and periurban areas (RUWA), Zimbabwe', *Tanzania Journal of Science*, 45(1), pp. 114-130. Available at: <https://www.ajol.info/index.php/tjs/article/view/187088> (Accessed: 5 November, 2021)
- Neupane, S., Thakur, V., Bhatta, B., Pathak, P., Gautam, B.B. and Aryal, L. (2018) 'Performance of different substrates on the production of oyster mushroom (*pleurotus florida*) at Gokuleshwar, Darchula', *International Journal of Scientific and Research Publications*, 8(6), p.7832. doi: <https://doi.org/10.29322/IJSRP.8.6.2018>
- Olukunle, O.T. (2017) 'Profitability analysis of small scale fishery enterprise in Nigeria', *Journal of Agricultural Science*, 9(3). doi: <https://doi.org/10.5539/jas.v9n3p107>
- Onuwa, G.C., Emmanuel, B.A., Ubana Eshimutu, U., Victor Fatoke, V. & Birma, J. (2021). 'Cost-benefit analysis of cucumber production under irrigation management', *International Journal of Advanced*, 7(7). Available at: <https://www.ijaar.org/articles/v7n7/ste/ijaar-es-v7n7-Jul21-7735.pdf>

- Pokhrel, C.P. (2016) 'Cultivation of oyster mushroom: A sustainable approach of rural development in Nepal', *JIST*, 21(1), 56-60. Available at: <https://www.nepjol.info/index.php/JIST/article/view/16050> (Accessed: 1 November, 2021)
- Radhakrishnan, A., Balan, S., Indulekha, V.P., Simi, S. and Sruthi Krishnan (2021) 'Potential, economics and constraints of mushroom cultivation in Wayanad, Kerala', *J Krishi Vigyan*, 9(2), pp. 171-176. doi: <https://doi.org/10.5958/2349-4433.2021.00032.5>
- Rahmawati, N. and Marbud. S. (2021) 'Analysis of oyster mushroom farming in highlands (a case study in Sleman and Temanggung Indonesia)', *Web of Conferences*, 232, 01012. doi: <https://doi.org/10.1051/e3sconf/202123201012>
- Raosoft (2021). Sample size calculator. Available at: <http://www.raosoft.com/samplesize.html>(Accessed: 5 August 2021)
- Rathod, S.R. and Gavali, A.V. (2021) 'Economic analysis of banana production from Western Maharashtra', *The Pharma Innovation Journal*, 10(8), pp.379-384. Available at: <https://www.thepharmajournal.com/archives/2021/vol10issue8S/PartF/S-10-7-211-920.pdf> (Accessed: 29 October 2021)
- Rathore, H., Prasad, S., Kapri, M., Tiwari, A. and Sharma, S. (2019) 'Medicinal importance of mushroom mycelium: mechanisms and applications', *J. Funct. Foods* 56, pp.182–193. doi: <https://doi.org/10.1016/j.jff.2019.03.016>
- Raut, J.K. (2019), 'Current status, challenges and prospects of mushroom industry in Nepal', *International Journal of Agricultural Economics*, 4, pp. 154-160. doi: 10.11648/j.ijae.20190404.13
- Rawat, N., Negi, R.S. and Singh, S. (2020) 'Cost-benefit analysis of different mushroom production for diversification of income in Srinagar Garhwal valley, Uttarakhand', *Journal of science and technological researches*, 2(4). doi: <https://doi.org/10.51514/JSTR.2.4.2020.1-5>
- Rengganata, S. and Kantun, S. (2020) 'Benefits of literation information against improvement of mushroom agriculture in Rambipuji, Jember District', *IOP Conference Series: Earth and environmental science*, IOP publishing 485:012081. doi:<https://doi.org/10.1088/1755-1315/485/1/012081>
- Roy, R., Rudra, B.C., Majumder, D.J. and Mondal, A. (2020) 'Perceived constraints in mushroom production enterprise in West Bengal', *Int.J.Curr.Microbiol.App.Sci*, 9(4), pp. 1579-1583. doi: <https://doi.org/10.20546/ijemas.2020.904.185>
- Sachan, S. and Kumar, R. (2020) 'Cost benefit analysis and marketing of mushroom in Uttar Pradesh', *Plant Archives*, 20(2), pp. 2532-2536. Available at: [http://www.plantarchives.org/SPL%20ISSUE%2020-2/420\\_\\_2532-2536\\_.pdf](http://www.plantarchives.org/SPL%20ISSUE%2020-2/420__2532-2536_.pdf) (Accessed: 15 November 2021)
- Samrath, R., Nag, S. and Kerketta, D. (2020) 'Impact of oyster mushroom training programme on farm women of Bastar', *Journal of Pharmacognosy and Phytochemistry*, 9(3),1450-1452. Available at <https://www.phytojournal.com/archives/2020/vol9issue3/PartX/9-3-250-828.pdf>
- Sato, R. (1981). *Theory of Technical Change and Economic Invariance*. Academic Press, New York.
- Sharma, D., Kumar, A. and Guleria, J. S. (2016) 'Economic viability, technological gap and problems of mushroom cultivation in Mandi district of Himachal Pradesh', *Himachal J Agril Res*, 42(1), pp.47-54. Available at: <http://www.hjar.org/index.php/hjar/article/view/117259> (Accessed: 1 November 2021)
- Shephard, R.W. (1970) Edited By David Gale & Harold W. Kuhn, First Author, Ronald W. Shephard. 'Theory of cost and production functions', *Princeton studies in Mathematical Economics, Spectral analysis of economic time series*, By C. W. J. Granger and M. Hatanaka. Princeton University Press. Princeton: New Jersey

- Shirur, M., Shivalingegowda, N.S., Chandregowda, M.J. and Rana, R.K. (2016) 'Technological adoption and constraint analysis of mushroom entrepreneurship in Karnataka', *Economic Affairs*, 61(3): 427-436. doi: <http://dx.doi.org/10.5958/0976-4666.2016.00054.1>
- Shivute, F.N. (2020) 'Cultivation of edible mushrooms in Namibia: prospects and challenges of small scale farmers', *African Journal of Agricultural Research*, 16(11), pp.1582-1586. doi: <https://doi.org/10.5897/AJAR2020.15062>
- Shrestha, A., Sapkota, B., Regmi, R., & Dhungana, S. M. (2018) 'Economics of production and marketing of banana in Chitwan district, Nepal', *Azarian Journal of Agriculture*, 5(1), 12–19. Available at: <http://azarianjournals.ir/wp-content/uploads/aja17120101.pdf>. Accessed on: 5 November, 202
- Shrestha, L.K. and Dhakal, S.C. (2014) 'Comparative resource productivity of oyster (*pleurotus ostreatus* p.) and button mushrooms (*agaricus bisporus* j.) in Kathmandu, Nepal', *The Journal of Agriculture and Environment*, 15
- Shrestha, R.B., Huang, W.C., Gautam, S. and Johnson, T.G. (2016) 'Efficiency of small scale vegetable farms: policy implications for the rural poverty reduction in Nepal', *Agricultural Economics*, 62 (4), pp. 181-195
- Smirnov, R. G. and Wang, K. (2019) 'The Cobb-Douglas production function revisited', Department of Mathematics and Statistics Dalhousie University Halifax, Nova Scotia, Canada
- Sohi, H.S., Tanwar, P.S. and Matharu, K.S. (2021) 'Constraints perceived by rural youth in adoption of button mushroom cultivation and its success in district Barnala', *Journal of Community Mobilization and Sustainable Development*, 16(1), pp. 7-13
- Sonam, Kala, S. and Hans, H. (2020) 'Impact assessment on socio-economic profile of women mushroom growers in Samastipur district of Bihar', *Journal of pharmacognosy and phytochemistry*. 9(3): 1224-1227
- Sonam, Shishir, K. and Prabhakar P. (2021) 'Constraint analysis in mushroom cultivation among women mushroom cultivators in the state of Bihar, India', *Advances in Management; Indore*, 14 (2), 7-11
- Sujan, H.K., Islam, F., Kazal, M.H. and Mondal, R.K. (2017) 'Profitability and resource use efficiency of potato cultivation in Munshiganj district of Bangladesh, SAARC', *Journal of Agriculture*, 15(2), 193-206. doi: <http://dx.doi.org/10.3329/sja.v15i2.35151>
- Thakur, M.P. (2020) 'Advances in mushroom production: key to food, nutritional and employment security: A review', *Indian Phytopathology*, 73, 377–395. Available at: <https://link.springer.com/content/pdf/10.1007/s42360-020-00244-9.pdf> (Accessed: 12 November, 2021)
- Tinzaara, W., Stoian, D., Ocimati, W., Kikulwe, E. & Otieno, G. (2018) 'Challenges and opportunities for smallholders in banana value chains', *Achieving Sustainable Cultivation of Bananas*, 1, 65–90. doi: <https://doi.org/10.19103/as.2017.0020.10>
- Ullah, H., Santiago-Arenas, R., Ferdous, Z., Attia, A. and Datta, A. (2019) 'Improving water use efficiency, nitrogen use efficiency, and radiation use efficiency in field crops under drought stress: a review', *Advances in Agronomy*, 156, 109–157. doi: <http://dx.doi.org/10.1016/bs.agron.2019.02.002>
- Wanole, P.V. (2020) 'Economic analysis of mushroom production in Thane district (M.S.)', Department of Agriculture economics. Faculty of agriculture. Dr. Balasaheb Sawant Konkan Krishi Vidyepeeth. Agriculture University Maharashtra, India
- Yang, B., Wang, Z., Zou, L., Zou, L. and Zhang, H. (2021) 'Exploring the eco-efficiency of cultivated land utilization and its influencing factors in China's Yangtze River Economic Belt', *Journal of Environmental Management*, 294, 112939. doi: <https://doi.org/10.1016/j.jenvman.2021.112939>

## Profitability of Oyster Mushroom Spawn Production in Kathmandu Valley, Nepal

Sachita Bhandari<sup>1\*</sup>, Arun Gc<sup>2</sup>, Prabhat Pandit<sup>1</sup> and Kalpana Pande<sup>1</sup>

<sup>1</sup>Himalayan College of Agricultural science and Technology, Kathmandu

<sup>2</sup>Ministry of Agriculture and Livestock Development, Government of Nepal

\*Corresponding Author: sachibhandari2060@gmail.com

### ABSTRACT

*The study was carried out from December 2020 to March 2021 to analyze the profitability in oyster mushroom spawn production in the study areas. The main aims of the study are to evaluate the cost involved in oyster mushroom spawn production, to estimate profits, and to analyze the Benefit Cost Ratio (BCR) and Break Even Point (BEP). The Survey was conducted at the spawn production site scattered in Kathmandu valley to collect primary information using the pretested semi structured questionnaire. The selling price of oyster mushroom spawn was found NRs 30/200gm packet. The total cost of production was NRs 4217351.75 per/100,000kg/annum of which fixed cost and variable cost constitute 12% and 88%, respectively; and the Break even quantity was found 22,846 packets of 200 g. The study revealed that Gross and Net profit margin of oyster mushroom spawn production was 75.33% and 71.89%, respectively. The benefit cost ratio was 3.5 which indicated that the Oyster mushroom spawn production was a profitable enterprise.*

**Key words:** Benefit cost ratio, Break-even point, Oyster mushroom, Profitability

### INTRODUCTION

The primary goal of any business is to gain the profit and the measure of the profit is referred as profitability. Profitability may be defined as the ability of a given investment to earn a return from its use (Tulsian, 2014). The sustainability of any business depends on its profitability. Profitability analysis helps us to know how efficiently the business operation is running thus, it is important. Type of higher fungus “Mushroom” with a highly nutritious and medicinal values have a long association with humankind and provide profound economic and biological impact. Almost all over the world mushroom farming is done and in Nepal also it seems mushroom cultivation is one of the popular and successful commercial farming. However, for the successful mushroom cultivation quality of spawn is the must. Spawn is the planting material of mushroom like seed for

other crops. Failure and success of mushroom cultivation depends upon availability of pure culture spawn (Suman & Sharma, 2013) thus for successful mushroom industry its spawn production need to be successful.

Mushroom cultivation is growing agribusiness in rural, suburban and urban area now being profitable microenterprise. There are large number of species of edible mushroom among which commonly cultivable types of mushroom in Nepal are shitake, oyster, paddy straw, white button and Milky mushroom. Among these all popular Oyster Mushroom (*Pleurotus spp*) commonly referred as 'Kanye cheu' or 'Patye cheu' in Nepal is more popular and seems to be in high demand. Due to the ability to grow at a wide range of temperature and being a rich source of proteins, minerals and vitamins cultivation of oyster mushroom has increases tremendously throughout the world (Chitra et al., 2018).

In Nepal mushroom cultivation was introduced by Nepal Agriculture Research Council (NARC) in 1974 who initially introduce white button mushroom in 1977. After which the plant pathology division of NARC started distributing spawn and then Oyster mushroom in Nepal was introduced to farmers in 1984 which were farmed by only handful farmers in Kathmandu valley but now it's becoming popular among farmers all over the country. Currently NARC and other private farm provide spawn (Parajuli, 2014).

## **MATERIALS AND METHOD**

### **Selection of study area**

Based on the coverage of mushroom and mushroom seed production, Kathmandu valley was selected for the study. It is estimated to be about 9000 to 10000 mushroom farmers in Kathmandu valley alone. It was reported that 450,000 packets of spawn were sold and about 2000 metric tons of fresh mushroom produced in 2013 (Parajuli, 2014). Majority of the oyster mushroom spawn producers is located in Kathmandu valley. Kathamadu, Bhaktapur and Lalitpur were therefore selected as major locations for mushroom as well as spawn producers.

### **Sample size and sampling procedure**

Being very limited number of producers a census survey was performed. The number of respondents was 15 from three districts as shown below:

Table 1. Sample size distribution by districts

Districts	Sample size
Kathmandu	7
Bhaktapur	2
Lalitpur	6

### **Data collection and analysis**

Primary data were collected using pre tested semi structured questionnaire using face to face interview technique with mushroom spawn producers. The mushroom spawn production sites were personally observed as far as possible during the survey. In case of the respondents who are not available for the direct face to face interview telephone survey was also used for primary data collection. Secondary information was collected from websites of Ministry of Agriculture and Livestock Development (MoALD), Nepal Agriculture research Council (NARC), Central Bureau of Statistics (CBS), HICAST library and different websites of related field. The information from the survey was coded and data entry as well as data analysis was performed using MS Excel and SPSS.

### **Profitability Analysis**

Different financial ratios like Gross profit Margin, Net profit Margin was calculated for the economic evaluation.

Gross Profit= Gross revenue-cost of goods sold (Total variable cost)

Gross Profit Margin Ratio=Gross Profits/sales  $\times$ 100%

Net profit=Gross Revenue- Total cost

Net Profit Margin Ratio=Net profit $\div$ sales $\times$ 100%

### **Undiscounted Benefit cost ratio**

Economic evaluation was mainly done by calculating Benefit cost ratio. It is a profitability indicator used to analyze the cost benefit ratio.

Undiscounted Benefit cost ratio=Gross Revenue  $\div$ Total cost

### **Break Even point**

To determine the number of units need to be sold to cover cost the break-even point was calculated by using the formula:

Break Even point (units) =Fixed cost $\div$  (sales price per unit-Variable costs per unit)

## **RESULTS AND DISCUSSION**

### **Profitability Analysis**

Table 2 shows total cost of Oyster mushroom spawn production (100000kg/annum) was NRs 4217351.758 of which 88% was constitutes by variable cost i.e. NRs 3701097.918 and 12% by fixed cost i.e., NRs 516253.84 with Gross profit of NRs 11298902.08. And the net profit, which is total revenue less total cost of production was found to be 10782648.24 implying that oyster mushroom spawn production, is profitable in study area. The study further reveals that the cost for production per packet was NRs 8.43 in which variable cost is NRs7.40.

Table 2. Total cost of production

Profitability Analysis of Oyster Mushroom spawn production (per 100000kg per annum /500000 packets of 200 gm. per annum) at Kathmandu valley, Nepal 2021			
SN.	Particulars	Items	Cost(NRs)
		Depreciation on building	221119.03
1	Fixed cost	Depreciation on machinery	143090.25
		Interest on fixed assets	152044.56
2	Total Fixed cost		516253.84
3	Variable cost	Grain	2179708.9
		Calcium carbonate	32256.9709
		Calcium Sulphate	29018.889
		cotton	53564
		rubber band	110024.735
		Polypropylene packet	397149.4
		Readymade PDA or media	23063.3
		Energy consumption	93429.277
		Refilling of LPG	65096.058
		Miscellaneous	29809.267
		Wages	687977.121
4	Total Variable cost		3701097.918
5	Total cost(TVC+TFC)		4217351.758
6	Revenue		15000000
7	Gross profit		11298902.08
8	Net Profit		10782648.24
9	Financial Ratio		Percentage
	Gross profit Margin ratio		75.32601388
	Net profit Margin Ratio		71.88432161

Source: Field survey, 2021

The producers themselves fix the price of spawn packet as per market price. From the survey it was known that fix price by all producers was same that is: For 200gm packet = NRs 30 and for 400 g packet =NRs 60.

The gross profit margin ratio of oyster mushroom spawn production is 75.33%.It shows that direct costs of producing Oyster mushroom spawn that producer's sells consume 24.67% of its revenue. It has 75.33% of its revenue to cover indirect costs and create profit for the owners. The net profit margin ratio of oyster mushroom spawn production is 71.89%.It shows high net profit margin which indicates good cost control in spawn production business.

### **Benefit Cost Ratio**

Undiscounted Benefit cost ratio for Oyster mushroom spawn production was calculated by using Revenue and total cost for production of 500000 packets of 200 g spawn/year.

Table 3. Benefit cost ratio

Gross Revenue	Total cost	BCR
15000000	4217351.758	3.5

As per the general rule higher the BCR the greater the profit an investment is generated to expect. Thus calculated BCR from Oyster mushroom spawn production is greater than 1 indicates that it is profitable.

### **Break-even point**

Break-even point for the 500,000 packets of Oyster mushroom spawn production per year was calculated as shown in table 4. Selling 22846 packets reached the break-even point.

Table 4. Break-even point

Fixed cost	Sales price per unit	Variable cost per unit	Break Even point
516253.84	30	7.402195	22845.31

## **CONCLUSION**

This study showed that investment in mushroom spawn production has the potential to generate income for the interested producers. BCR of the business was greater than one indicating that Oyster mushroom spawn production was highly profitable business. Lack of technical support from mushroom experts was the major problem mushroom spawn producers were facing. And production of mushroom spawn depends upon the demand of mushroom cultivators so maintaining reliable good quality spawn is a challenge for

mushroom spawn producers for the profitable and sustainable mushroom spawn production business.

## **REFERENCES**

- Chitra, K. et al. (2018) Production and Economic Analysis of Oyster Mushroom (Pleurotus florida). *International Journal of Current Microbiology and Applied Sciences*, 7(9), 379-83.
- Joshi, G.R., (2020) Mushroom farming in Nepal. *Agricultural guide*, 12 november.
- Maharjan, S. (2017) *A Case Study of Mushroom Cultivation in Matatirtha VDC, Kathmandu*. Masters Thesis. Kathmandu: Tribhuvan University.
- Nayal, L., (2015) *Regression Analysis To Forecast the Demand of New Single Family Houses in USA*. Master Thesis. Minnesota: St. Cloud State University.
- Parajuli, G. P. (2014) Mushroom Research in Nepal: Current status and Prospect. In: *Proceeding of the seminar on Mushroom Consumption and Poisoning Risk*. Nepal Academy of Science and Technology, Khumaltar, Lalitpur: pp.19-22
- Raut, J.K., (2019) Current Status, Challenges and Prospects of Mushroom Industry in Nepal. *International Journal of Agricultural Economics*, 4(4), pp.154-60.
- Shimizu, A. (n.d.) *About:Oyster Mushroom Spawn*. [Online] Available at: HYPERLINK "<https://oystermushroomca.wordpress.com/about/>"  
<https://oystermushroomca.wordpress.com/about/> [Accessed 10 March 2021].
- Suman, B.C. & Sharma, V.P. (2013) *Mushroom cultivation and uses*. 2nd ed. Jodhpur: AGROBIOS.
- Tulsian, D.M. (2014) Profitability Analysis. *IOSR Journal of Economics and Finance (IOSR-JEF)*, 3Ver. I (Mar. - Apr. 2014), pp 19-22

# Economic Burden and Determinants of Cholera Outbreak among Farming Households in Kwara State, Nigeria

**\*Folasade O. Aminu and O. Odunlade**

Department of Agricultural Technology, School of Technology,  
Yaba College of Technology, Epe Campus, P. M. B. 2011, Yaba, Lagos State,  
Nigeria

**\*Corresponding Author:** folaafe02@gmail.com

## **ABSTRACT**

*Cholera is a global threat to public health, causing considerable morbidity and mortality worldwide. Cholera prevention is hinged on access to safe water, improved hygiene and sanitation practices. This study investigated the economic burden and determinants of cholera outbreak among farming households in Kwara State, Nigeria. Multistage sampling technique was used to select 120 farming households that had experienced cholera attack in the study area. Data were collected with the aid of pre-tested questionnaire and analysed using descriptive statistics, cost of illness approach and multiple regression analysis. Results from the pooled data revealed that majority (53.6%) of the respondents were male with a mean age of about 47 years. The major perceived causes of cholera outbreak in the study area were germs/infection, unsafe water, improper waste management and contaminated food while the major symptoms were: stooling, vomiting, stomach upset and dehydration. Results from the Cost of illness analysed showed that, the average COI incurred by the farming households as a result of cholera outbreak was ₦77,633.78. Results from the multiple regression analysis revealed that water treatment ( $p < 0.05$ ), drinking water source ( $p < 0.01$ ), water storage system ( $p < 0.01$ ), refuse disposal methods ( $p < 0.01$ ) and sewage disposal method ( $p < 0.01$ ) were the factors predisposing the farming households to cholera attack in the study area. Therefore, access to safe water, proper sanitation and appropriate waste management techniques should be provided by government and other relevant agencies for effective control of cholera outbreak in the study area.*

**Key words:** Cholera outbreak, economic burden, farming households, *Vibrio Cholerae*

## **INTRODUCTION**

Cholera is an acute diarrhoeal infection caused by ingestion of food or water contaminated with the bacterium *Vibrio Cholerae*. Cholera remains a global threat to public health and an indicator of inequality and lack of social development. Cholera transmission is closely linked to poor environmental

conditions. The absence or shortage of safe water and of poor sanitation, as well as poor waste management is the main causes of spread of the disease (WHO, 2015). Researches have estimated that every year, there are roughly 1.3 to 4 million cases, and 21,000 to 143,000 deaths worldwide due to cholera (Ali *et al.*, 2015). About two thirds of these cases are in developing countries, mostly in sub Saharan Africa. Several conditions on the continent make it fertile ground for the emergence and rapid spread of cholera. These include: inadequate access to clean water and sanitation facilities, especially in peri-urban slums, where basic infrastructures are inadequate, camps for internally displaced persons or refugees, where minimum requirements of clean water and sanitation have not been met. Crowded camps are fertile ground for cholera outbreak. Other humanitarian crises including flooding and earthquakes, civil unrest or war cause disruption of water and sanitation systems.

In Nigeria, the first Cholera outbreak was in 1970, the most severe outbreaks were reported in 1991, 1996, and 1999 and from 2009 to 2011 (Federal Ministry of Health, 2013). The outbreak affects the Northern states the most, with significant mortality of two thirds (66%) of the cases reported between 2004 and 2014. Faecal contamination of the environment is the root cause of an annual average of 5,400 cases of cholera affecting Nigeria. The cost of the necessary WASH response is estimated to be US\$3.5 million each year (WSP, 2012). In May 2017, suspected cholera cases were reported from five local government areas; Asa (18), Ilorin East (450), Ilorin south (215), Ilorin west (780) and Moro (50) in Kwara State (WHO, 2017). In addition to human suffering caused by cholera, cholera outbreak cause panic, disrupt the social and economic structure and can impede development in the affected communities. Unjustified panic-induced reactions by other countries include curtailing or restricting travel from countries where a cholera outbreak is occurring, or import restrictions on certain foods. For example, the cholera outbreak in Peru in 1991 cost the country US\$770 million due to food trade embargoes and adverse effects on tourism (WHO, 2015). However, the economic implications of cholera outbreak go beyond the immediate health system response, there are also costs related to productivity loss and premature death, diverting expenditures from other essential items and losses in trade and tourism revenue. Farmers' health has significant effects on agricultural productivity. Farmers are usually exposed to harsh weather, difficult working posture and lengthy hours of work due to the use of local farm tools since majority of them are small scale subsistence farmers, and this could lead to illness. A number of demographic and socioeconomic factors including age, gender, and nutritional status, social and economic status are also known to play crucial role in susceptibility to

cholera. Sanitation and nutrition are particularly important factors and it has become clear that good sanitation and hygienic practices largely prevent the disease (Adagbada *et al.*, 2012). From the foregoing, the study is aimed at examining the economic burden of cholera outbreak among farming household in Kwara State, North Central region of Nigeria. Specifically, the study describes the socio-economic characteristics of the respondents in the study area, highlights the perceived causes and symptoms of cholera, identifies the sources of treatment used as well as the cost incurred in treating cholera and determines the socio economic factors and other practices predisposing the farmers to cholera attack in the study area.

## **METHODOLOGY**

This study was conducted in Kwara State, North Central, Nigeria. The capital of the state is Ilorin. The state lies on Longitude 2 °45E and 6 °40N Latitude, and shares boundaries with Niger State in the North, Kogi State in the East, Oyo, Ekiti and Osun States in the South and an international boundary with the Republic of Benin in the West. The state has 16 Local Government Areas, naturally endowed with large expanse of land area of 36,825 km<sup>2</sup> and a total population of 3,192,893 (NBS. 2016). The main occupation of the people is farming. The main crops grown in the area include sorghum, melon, guinea corn, millet, vegetable, groundnuts. They also cultivate cash crops like cashew, sheanut, oil palm and poultry, cattle, sheep among others.

A multi-stage sampling technique was used in the selection of respondents for the study. The first stage involved the random selection of three Local Government Areas (LGAs) out of the five LGAs where cholera outbreak was pronounced in the state. According to WHO (2017), between 1<sup>st</sup> of May and 30<sup>th</sup> of June 2017, suspected cholera cases in Kwara State were reported from five LGAs; Asa (18), Ilorin east (450), Ilorin south (215), Ilorin west (780) and Moro (50). The randomly selected LGAs were Ilorin east, Ilorin south and Moro representing 60 of cholera endemic LGAs in the state. In the second stage, two communities were randomly selected from each LGA making a total of six (6) communities. The third stage involved the use of snowball sampling technique to select (20) twenty farming household that had experienced cholera disease from each selected community, making a total of 120 respondents, 40 from each LGA. However, 112 respondents (40 in Ilorin East, 39 in Ilorin South and 33 in Moro LGAs) were used for data analysis. Others were discarded due to incomplete information.

Primary data was obtained using a pre-tested questionnaire. Data were collected on the socio-economic characteristics of the farming household, the perceived causes and

symptoms of cholera, source of treatment and cost expended in treating cholera ailment in the study area.

The following analytical tools were employed in the study:

**Descriptive statistics:** Descriptive statistics such as means, frequencies, and percentages was used to describe the socio-economic characteristics of the respondents, perceived causes and symptoms of cholera as well as sources of treatment in the study area.

**Cost of illness:** The cost expended as a result of cholera incidence was analysed using the cost of illness procedure adopted by Sauerborn *et al.*, (1996); Aminu and Ayinde (2014) as follows:

1. Financial cost of illness

$$F = \sum_{i=0}^N (F_{dt} + F_{fi} + F_{tr} + F_{li}) \dots \dots \dots \dots \dots \dots \dots \dots \dots (1)$$

Where: F= total financial costs of health (₹),  $F_{dt}$  = financial cost of drugs and herbs (₹),  $F_{fi}$  = financial cost of medical consultancy (₹),  $F_{tr}$  = financial cost of travel (₹),  $F_{li}$  = financial cost of feeding (₹), N = number of illness episodes

2. Time cost of illness:

$$T = \sum [(T_{si} * awsi) + (T_{ci} * awci)] \dots \dots \dots \dots \dots \dots \dots \dots \dots (2)$$

Where: T= total time costs (days of forgone farming),  $T_{si}$  = time costs of the sick person (days of forgone farming),  $T_{ci}$  = time costs of the caretaker(s) (days of forgone farming),  $W_{si}$  = daily wage rate of the sick person (₹),  $W_{ci}$  = daily wage rate of the caretaker (₹)

To calculate the number of days of forgone farming it was assumed that average working condition prevail and adult male work for about 8 hours a day as used by Akinbode *et al.*, (2011). Thus, the actual total hours devoted to farm work were converted to male adult equivalent by multiplying those of male by 1, female by 0.75 and children by 0.5.

a = age coefficients (number). Following World Bank (1993) and Sauerborn *et al.*, (1996) the age coefficient “a” represents productivity coefficient and this takes on the following values: Age < 17years = 0.5, 18-40years=1, 41-55years=0.75, 56-65years = 0.67 and >65years = 0.5.

3. Economic cost of illness: Following Aminu and Ayinde (2014), a minor addition to this model is the inclusion of prevention cost (Pc) for the purpose of this study. Therefore, the economic cost of illness (COI) adopted for this study is:

$$E = \sum (Fi + Ti + Pc) \dots \dots \dots (3)$$

Where: E = Economic cost of illness, Fi = total financial cost of health (₦), Ti = Total time costs (days of forgone farming), Pc = Prevention cost

Multiple regression analysis: This was used to determine the socio economic factors and other practices predisposing the farming household to cholera attack in the study area. The model is explicitly expressed as:

$$Q = \beta_0 + \beta_1 P_1 + \beta_2 P_2 + \beta_3 P_3 + \beta_4 P_4 + \beta_5 P_5 + \beta_6 P_6 + \beta_7 P_7 + \beta_8 P_8 + \beta_9 P_9 + \mu \dots \dots \dots (4)$$

Where: Q = Cholera episodes (number); P<sub>1</sub> = Sex of farmer (1 if male, 0 otherwise), P<sub>2</sub> = Age of farmer (years), P<sub>3</sub> = Educational level (years), P<sub>4</sub> = Household size (No of people), P<sub>5</sub> = Water treatment (1 if treated, 0 otherwise), P<sub>6</sub> = Source of drinking water (1 if borehole, 0 otherwise), P<sub>7</sub> = Water storage system (1 if closed, 0 otherwise), P<sub>8</sub> = Refuse disposal method (1 if thrown in pit & burn, 0 otherwise), P<sub>9</sub> = Sewage disposal method (1 if pit latrine, 0 otherwise), μ = Error term.

The data obtained were fitted into three different functional forms namely, Cobb-Douglas, semi-log, and linear functions. The best of the 3 functional forms was selected based on: Economic criteria in terms of a-priori expectation of signs of coefficient; Statistical criterion in terms of values of coefficient of multiple determination (R<sup>2</sup>), and F-test statistics.

## **RESULTS AND DISCUSSION**

### **Distribution of respondents by selected socio-economic characteristics**

Table 1 presents the results of the selected socio-economic characteristics of the respondents in the study area. The result reveals that most (37.5%, 51.3% and 42.4%) of the respondents in Ilorin East, Ilorin South and Moro LGAs were within the age range of 41-50 years. The mean age of about 47 years for the pooled sampled indicates that the respondents were still young, economic active and should be able to practice good personal and food hygiene to guide against cholera outbreak in the study area. majority (53.6%) of the respondents were male. This implies that cholera disease was experienced by more male respondents than their female counterparts. This could be due to the facts that

male respondents were carefree about their personal hygiene and sanitation practices in the study area. However, female (76.9%) had higher percentage in Ilorin South LGA than male. Distribution by educational qualification reveals that, on the average, primary school (41.1%) was the highest educational attainment of the respondents' while 37.5% had no formal education. This could impede their level of adoption of agricultural innovation and improved hygiene and sanitation practices in the study area. Bompangue *et al.*, (2008) identified low educational status as one of the predictors of cholera in an endemic area of Bangladesh. About 90% of the respondents were married with a mean household size of 8 people. Large household size could be a risk factor to cholera outbreak especially when it is characterised by overcrowding and unsanitary living conditions.

Table 1. Socio-economic characteristics of respondents in the study area

Description	Ilorin East	Ilorin South	Moro	Pooled sample
<b>Age (years)</b>				
≤30	3(7.5%)	0(0%)	1(3.0%)	4(3.6%)
31-40	11(27.5%)	8(20.5%)	7(21.2)	27(24.1%)
41-50	15(37.5%)	20(51.3%)	14(42.4%)	47(42%)
≥50	11(27.5%)	11(28.2%)	11(33.3%)	35(31.3%)
<b>Mean (years)</b>	44.45±11.56	50.03±10.04	46.45±8.22	46.86±10.29
<b>Sex</b>				
Male	24 (60.0%)	19 (23.1%)	17 (51.5%)	60(53.6%)
Female	16 (40.0%)	20 (76.9%)	16 (48.5%)	52 (46.4%)
<b>Educational Status</b>				
No formal Education	9(22.5%)	21(53.8%)	12(36.4%)	42(37.5%)
Primary	18(45.0%)	10(25.6%)	18(54.5%)	46(41.1%)
Secondary	13(32.5%)	1(2.6%)	0(0%)	14(12.5%)
Adult/Vocational	0(0%)	3(7.7%)	2(6.1%)	5(4.5%)
Tertiary	0(0%)	4(10.3%)	1(3.0%)	5(4.5%)
<b>Marital Status</b>				
Single	1(2.5%)	0(0%)	0(97.0%)	1(0.9%)
Married	35(87.5%)	34(87.2%)	32(0%)	101(90.2%)
Divorced	1(2.5%)	0(0%)	0(3.0%)	1(0.9%)
Widowed	3(7.5%)	5(12.8%)	1(0%)	9(8.0%)
<b>Household Size (No)</b>				
≤5	11(27.5%)	8(20.5%)	12(36.4%)	31(27.7%)
6-10	25(62.5%)	20(51.3%)	14(42.4%)	59(52.7%)
>10	4(10.0%)	11(28.2%)	7(21.2%)	22(19.6%)
<b>Mean (people)</b>	<b>8</b>	<b>7</b>	<b>6</b>	<b>8</b>

Source: Field Survey Data, 2019

### **Distribution of respondents by water, sanitation & hygiene practices**

The results in Table 2 reveal that majority (50%) of the respondents in Ilorin East, 48.7% in Ilorin South and 45.5% in Moro LGAs sourced water from shallow well for their household use.

Table 2. Distribution of respondents by water, sanitation & hygiene (wash)

Description	Ilorin East	Ilorin South	Moro	Pooled sample
<b>Source of Water for Household Use</b>				
Well	20 (50.0%)	19 (48.7%)	15 (45.5%)	54 (48.2%)
Borehole	17 (42.5%)	11 (28.2%)	10 (30.3%)	38 (33.9%)
Tap Water	2 (5.0%)	6(15.4%)	2(6.1%)	10 (8.9%)
Stream	1 (2.5%)	3(7.7%)	6(18.2%)	10(8.9%)
<b>Drinking Water Source</b>				
Well	9 (22.5%)	2 (5.1%)	4(12.1%)	15 (13.4%)
Tap Water	13 (32.5%)	8 (20.5%)	11 (33.3%)	32 (28.6%)
Treated/packageged Water	2 (5.0%)	4 (10.3%)	6 (18.2%)	12 (10.7%)
Borehole	16 (40.0%)	25 (64.1%)	12 (36.4%)	53 (47.3%)
<b>Water Treatment</b>				
Treated water	18(45.0%)	12(30.8%)	9(27.3%)	39(38.4%)
Did not treat water	22(55.0%)	27(69.2%)	24(72.2%)	73(65.2%)
<b>Water Storage System</b>				
Closed storage	28 (70.0%)	26 (66.7%)	20 (60.6%)	74 (66.1%)
Opened Storage	12 (30.0%)	13 (33.3%)	13 (39.4%)	38 (33.9%)
<b>Sewage Disposal Methods</b>				
Shared flush toilet	16 (40.0%)	1 (2.6%)	5 (15.2%)	22 (19.6%)
Pit latrine	26 (65%)	20 (51.3%)	23 (69.7%)	69 (61.6%)
Bush	7 (17.5%)	1 (2.6%)	18 (54.5%)	26 (23.2%)
<b>Refuse Disposal Methods</b>				
Public dumpsite	5 (12.5%)	0 (0.0%)	0 (0.0%)	5 (4.5%)
State garbage truck	8(20.0%)	0 (0.0%)	0 (0.0%)	8 (7.1%)
Dug pit & burn	20 (50.0%)	29 (74.4%)	21 (63.6%)	70 (62.5%)
Thrown in bush	7 (17.5%)	10 (25.6%)	12 (36.4%)	29 (25.9%)

Source: Field Survey Data, 2019

Generally, 48.2% of the respondents sourced water from shallow well, 33.9% from borehole and 8.9% from tap water and stream respectively, for their household use in the study area. This implies that majority of the respondents' sourced water from unhealthy sources could make them to be more susceptible to cholera attack in the study area. Only 47.3% of the respondents sourced drinking water from borehole, others sourced drinking water from shallow well (13.4%), tap water (28.6%) and treated or packaged water (10.7%). This is also an indication that some of the respondents did not get their drinking water from safe sources. These results are in line with the findings of Nneka and Kabiru

(2017) who reported that majority of the respondents in urban slum in South-western Nigeria did not get their drinking water from safe sources. Emch *et al.*, (2008) also reported that people who use contaminated surface water for drinking, cooking, and bathing are more likely to contract cholera than those who do not.

In terms of water storage system, result from the pooled sample reveals that 66.1% of the sampled respondents used closed water storage system while 33.9% used opened water storage system. Opened storage system could harbour dirt and served as breeding sites for insects which could predispose the respondents to cholera attack in the study area. Distribution by sewage and waste disposal methods reveal that majority (61.6%) of the respondents used pit latrine. Chemicals and microbial contaminants in pit latrines can leach into groundwater sources such as borehole and well, thereby threatening human health (Graham and Polizzotto, 2013). Pit latrines have also been associated with increased well water turbidity. Also, 62.5% of the respondents poured their dirt in a pit and burn when it becomes full. This is an unhygienic practice that could increase the susceptibility of the respondents to cholera attack in the study area. These results agreed with the findings of Emch *et al.*, (2010) that cholera is more common in poorer households without safe water and proper sanitation system.

#### **Perceived causes of cholera outbreak in the study area**

Table 3 presents the results on the perceived causes and symptoms of cholera in the study area. The most perceived causes of cholera in Ilorin East LGA was germs/infections (55%). Improper waste disposal (69.2%), germs and infections (56.4%) were the most perceived cause of cholera in Ilorin South LGA. Respondents in Moro LGA identified germs/infections (57.1%) as the highest cause of cholera in the LGA. On the average, the perceived causes of cholera in the study area were germs and infections (57.1%), unsafe water (44.6%), improper waste disposal (41.1%), contaminated foods (35.7%), heat (12.5%) and contaminated fruits (11.6%). This result agrees with the report of Osei and Duker (2008) that unprotected water sources, and improper disposal of solid waste, liquid waste, and human faeces make the environment conducive for cholera transmission.

#### **Perceived symptoms of cholera in the study area**

Results in Table 3 reveals that stooling was recognized as the most noticeable symptom of cholera most of the respondents in Ilorin East, Ilorin South, and Moro LGA.

Generally, the perceived symptoms of cholera disease in the study area were stooling (87.5%), vomiting (33.0%), stomach upset (16.1%) and dehydration (11.6%). This result is in tandem with Jahan (2016) that clinical features of cholera include profuse watery diarrhoea, vomiting, increased heart rate, loss of skin elasticity, dry mucous membranes, low blood pressure, feeling of thirst, muscle cramps, metabolic acidosis, and restlessness or irritability.

**Table 3. Perceived causes and symptoms of cholera outbreak in the study area**

Perceived causes	Ilorin East	Ilorin South	Moro	Pooled sample
Contaminated fruits	6 (15.0%)	2 (5.1%)	5 (45.5%)	13 (11.6%)
Contaminated foods	13 (32.5%)	12 (30.8%)	15 (15.2%)	40 (35.7%)
Unsafe water	13 (32.5%)	15(38.5%)	22(66.7%)	50 (44.6%)
Germs/infections	22 (55.0%)	22 (56.4%)	20 (60.6%)	64 (57.1%)
Improper waste disposal	15 (37.5%)	27(69.2%)	4(12.1%)	46 (41.1%)
Heat	3 (7.5%)	5 (12.8%)	6 (18.2%)	14 (12.5%)
<b>Perceived Symptoms</b>				
Stooling	36 (90.0%)	32(82.1%)	30 (90.9%)	98 (87.5%)
Vomiting	16 (40.0%)	10 (25.6%)	11 (33.3%)	37 (33.0%)
Stomach upset	7 (17.5%)	6(15.4%)	5(15.2%)	18 (16.1%)
Dehydration	6 (15.0%)	4 (10.3%)	3 (9.1%)	13(11.6%)

Source: Field Survey Data, 2019

### **Type of treatment sought by respondents during cholera outbreak**

Result on type of treatment sought by the respondents during cholera outbreak in the study area is presented in Table 4. The result reveals that purchasing drugs from chemist without prescription by qualified medical practitioner was the prevalent type of treatment used in Ilorin East and Ilorin South LGAs. The respondents said they were already familiar with the symptoms and knew the right drugs to purchase. This is particularly dangerous as self-medication could further endanger the health of the respondents and increase the mortality rate from cholera outbreak. Visit clinic or hospital (33.3%) was the most used treatment type in Moro LGA. On the average, 33% of the respondents purchased drugs from chemist to treat cholera, 28.6% sought medical intervention in the clinic/hospitals, and 25.9% used home-made oral solution or local herbs while 12.5% patronised medicine vendors in the study area. This result is an indication that majority of the respondents did not utilize formal health care services where the right drugs can be prescribed and adequate care given during cholera episodes. This result corroborates the findings of Nneka and Kabiru, (2017), Oparinde *et al.*, (2018), Aboaba *et al.*, (2019), Aminu *et al.*, (2020).

### **Economic burden of cholera outbreak in the study area**

Results on the economic burden measured by the cost incurred in treating cholera episodes in the study area are summarized in Table 5. Results from the cost of illness showed that the average COI incurred by the farming households as a result of cholera outbreak in the study area was ₨77,633.78.

Table 4. Type of treatment sought by respondents during cholera outbreak

Type of Treatment	Ilorin East	Ilorin South	Moro	Pooled Sample
Use of ORS/Local Herbs	12 (30.0%)	10(25.6%)	7 (21.2%)	29 (25.9%)
Chemist	14 (35.0%)	18 (46.2%)	5(15.2%)	37 (33.0%)
Medicine Vendors	4 (10.0%)	0	10 (30.3%)	14 (12.5%)
Visit clinic/hospital	10 (25.0%)	11 (28.2%)	11(33.3%)	32 (28.6%)

Source: Field Survey Data, 2019

Out of this sum, ₨26,667.39 was spent in clinics/hospitals, ₨4,992.62 was spent on drugs and herbs while ₨670.59 was travel cost. The total indirect cost (i.e., the proportion of household's COI attributed to time cost of both the sick person and the caregiver per season) was ₨ 44,821.18.

Table 5. Summary of health cost associated with cholera outbreak

Cost Items	Cost of Treatment (₨)			
	Ilorin East	Ilorin South	Moro	Pooled
Amount spent in clinics/hospitals	15,687.50	9,076.92	1,902.97	26,667.39
Financial cost of drugs and herbs	2,887.97	1,169.23	935.42	4,992.62
Financial cost of travel	222.50	381.59	66.50	670.59
Total Direct Cost	18,797.97	10,627.74	2,904.89	32,330.6
Time cost of sick person	12,875.71	9,705.13	5,151.52	27,732.36
Time cost of caregiver	9,540.18	6,321.46	1,227.27	17,088.91
Total Indirect Cost	22,415.80	16,026.59	6,378.79	44,821.18
Prevention Cost	251.25	155.13	75.73	482.11
Total Cost of Illness (COI)	41,465.11	26,809.46	9,359.41	77,633.98

Source: Field Survey Data, 2019; Note: 1 US \$ = 415.29 ₨

These reflect the opportunity cost of time or labour earnings that were forgone as a result of cholera outbreak. As such, this reflects labour time that could have been spent on farming activities in the study area. This implies that cholera outbreak poses serious economic burden on the farming households which reduces the output, profit and hence productivity of the farmers in the study area.

### Determinants of cholera outbreak in the study area

Table 6 presents the results of the regression analysis showing the socio economic factors and other practices predisposing the farming households to cholera attack in the study area. The analysis was done for each LGA and at the aggregate level. Semi-log model was adopted to explain the factors determining cholera outbreak in Ilorin East and the pooled data while double-log model was adopted for Ilorin South and Moro LGAs. This was because the models had the highest values of coefficient of determination ( $R^2$ ), highest F value and highest number of significant variables conforming to the *a priori* expectations in the study area. The coefficient of determination values of 0.713, 0.744, 0.699 and 0.738 for Ilorin East, Ilorin South, Moro LGAs and the pooled data imply that about 71%, 74%, 70% and 74% of the variation in cholera episodes were jointly explained by the socio-economic variables and other practices included in the model. The F statistics values were significant at 1% level of probability, attesting to the good fit of the model. The result reveals that sex, education, water treatment, drinking water source, water storage system, refuse disposal methods and sewage disposal method were the significant variables predisposing the farming households to cholera attack in the study area.

Table 6. Determinants of cholera outbreak in the study area

Variable	Ilorin East	Ilorin South	Moro	Pooled
Constant	3.42***(6.34)	2.03***(3.61)	2.36***(2.58)	1.19**(2.15)
Sex	-1.08 (1.393)	0.05**(2.36)	-2.37(0.93)	-0.54(0.41)
Age	0.31(1.61)	-0.19(1.57)	-0.22(0.23)	-0.06(0.06)
Education	-0.04(0.03)	1.63(1.61)	0.670(1.497)	-0.08**(2.12)
Household size	-3.15(1.61)	1.25(0.69)	0.19(1.62)	0.17(0.56)
Water Treatment	0.43(1.45)	-0.28(0.27)	-0.18(0.12)	0.04*** (2.69)
Drinking water	-0.87***(2.45)	-1.13(1.64)	-1.19***(2.16)	-3.35*** (6.71)
Water storage	-0.37***(5.41)	-1.11*(1.74)	-3.38***(5.98)	-0.35***(2.09)
Refuse disposal	1.13*** (2.35)	1.35*** (4.23)	2.20*** (4.95)	2.23*** (5.19)
Type of toilet	0.24*** (3.18)	1.09** (2.27)	1.42*** (3.83)	2.23*** (5.82)
<b>R<sup>2</sup></b>	0.713	0.744	0.699	0.738
<b>Adjusted R<sup>2</sup></b>	0.622	0.711	0.665	0.699
<b>F-Value</b>	6.210***	3.377***	8.006***	11.205***
<b>Mean VIF</b>	1.405	1.231	1.536	1.264

Source: Field Survey, 2019 \*\*\* = significant at 1% ( $\alpha_{0.01}$ ) \*\* = significant at 5% ( $\alpha_{0.05}$ ); \* = significant at 10% ( $\alpha_{0.10}$ ) Figures in parenthesis are t-values

Sex of the respondents had negative significant relationship with cholera outbreak in Ilorin South LGA at 1% alpha level. This implies that female household members were more prone to experiencing cholera diseases more than their male counterpart in the LGA.

This could be because the females were complacent about good hygiene practices as they are more involved in household chores, cooking and other activities that could cause cholera than their male counterparts in the LGA. This result corroborates the findings of Nigeria Centre for Disease Control (NCDC, 2019) that among all suspected cases reported in 2019, 56.3% were female while 43.7% were male. Educational level ( $p < 0.05$ ) of the respondents were found to have a negative significant relationship with cholera outbreak in the study area. This indicates that farming households with little or no education experiences cholera attack more than the educated ones. This result is in consonance with the findings of Nneka and Kabiru (2017) that the more educated an individual is, the more he/she will be knowledgeable about diarrhoea and strive to prevent it. Water treatment ( $p < 0.01$ ) had a negative significant influence on cholera outbreak in the pooled data. This implies that farming households who treat their water before use were less susceptible to cholera outbreak in the study area. The coefficient of sourcing drinking water from borehole was negative and significant in Ilorin East LGA ( $p < 0.05$ ), Moro LGA ( $p < 0.05$ ) and pooled data ( $p < 0.01$ ). This implies that farming households who drank water from borehole in these areas were less prone to cholera attack indicating that borehole water was a safe source of water in the study area. In the same vein, water storing system was also negative and significant for all the locations. This implies that farming households who stored water in closed storage system were likely to have less cholera outbreak than that using open storage system in the study area.

Conversely, the coefficients of refuse and sewage disposal methods were positive and significant for all the LGAs and the pooled data. This implies that these variables increase the susceptibility of farming households to cholera outbreak in the study area. Emch *et al.*, (2010) submitted that, the secondary cases of cholera occur through faecal–oral transmission, and are related to poor waste management, poor hygiene, poor water and sanitation environment. According to CDC in Jahan (2016) five basic cholera prevention measures are drinking and using safe water; washing hands with soap and water; using latrines or proper sanitation methods; proper cooking of food, covering it, and eating it hot; proper cleaning up of places used for bathing and washing clothes.

## **CONCLUSION**

The study has established that cholera outbreak posed serious economic burden on the farming households in the study area. It also discovered that sex, education, water treatment, drinking water source, water storage system, refuse and sewage disposal methods were the significant factors predisposing the

farming households to cholera attack in the study area. Therefore, health education regarding personal and food hygiene practices should be provided to these communities. In addition, access to safe water, proper sanitation and appropriate waste management techniques should be provided by government and other relevant agencies for effective control of cholera outbreak in the study area.

## REFERENCES

- Aboaba K. O., Oyekale, T. O., Adewuyi, S. A. and Adigbo, S. O. (2019). Determinants of burden of disease among rice farming households in Ogun state, Nigeria. *Asian Journal of Agriculture and Rural Development*, 9(2): 264-273.
- Adagbada, A.O., Adesida, S.A., Nwaokorie, F.O., Niemogha, M. and Coker, A.O. (2012). Cholera Epidemiology in Nigeria: an overview. *Pan African Medical Journal*. 12:59
- Ali, M., Nelson, A.R., Lopez. A.L. and Sack, D. (2015). Updated global burden of cholera in endemic countries. *PLoS Negl Trop Dis*, 9(6)
- Akinbode, S. O., Dipeolu, A. O. and Ibrahim, D. A. (2011). Effects of disease burden on technical efficiency among lowland rice farming households in North Central Nigeria. *World Journal of Agricultural Sciences*, 7(3): 359-369.
- Aminu, F. O. and Ayinde, I. A. (2014). Effect of Disease Burden on Catch Efficiency among Small Scale Fisher Folks Households in Lagos State, Nigeria. *Tropical Agriculture Journal*, 91(1): 27-37.
- Aminu, F.O., Balogun, E.O.S. and Edun, T.A. (2020). Health Cost of Pesticide Use by Cocoa Farmers in Nigeria. *African Research Review*, 14(2): 222-233.
- Bompangue D, Giraudoux P, Handschumacher P, Piarroux M, Sudre B, Ekwanzala M, (2008) Lakes as source of cholera outbreaks, Democratic Republic of Congo. *Emerging Infect Dis.*, 14(5):798–800.
- Emch M, Feldacker C, Islam M.S. and Ali M. (2008). Seasonality of cholera from 1974 to 2005: A review of global patterns. 7:31-39.
- Emch M, Yunus M, Escamilla V, Feldacker C, Ali M. (2010). Local population and regional environmental drivers of cholera in Bangladesh. *Environ Health*. 9: 2.
- Graham, J.P. and Polizzotto, M.L. (2013). Pit latrines and their impacts on groundwater quality: a systematic review. *Environmental Health Perspective*, 121: 521-530
- Jasan, S. (2016). Cholera – Epidemiology, Prevention and Control. Intech Open, <http://dx.doi.org/10.5772/63358>
- Nigeria Centre for Disease Control (2018). Situation Report. *Cholera Outbreak in Nigeria*. 29 October 2018
- Nneka L. U. and Kabiru K. S. (2017). Household preventive practices and diarrhoea prevalence in urban slums, Southwestern Nigeria. *Ghana Social Science Journal*, 14(2): 98-120
- Osei, F. B. and Duker, A. A. (2008). Spatial and demographic patterns of cholera in Ashanti region - Ghana. *Int J Health Geogr.*, 7: 44.
- Oparinde, L.O., Ogunbusuyi O., Aturamu O. A., Oladipo C.O. (2018). Food crop farmers' health and poverty status nexus in Ondo state, Nigeria. *Journal of Poverty, Investment and Development*, 43, 47-5
- Sauerborn, R., Adams A. Hien M. (1996) Household strategies to cope with the economic costs of illness. *Social Science and Medicine* 43 (3): 291-301.
- WHO. (2015) Prevention and control of cholera outbreaks: WHO policy and recommendations [Internet]. WHO. Available from: <http://www.who.int/cholera/technical/prevention/control/en/index2.html> [Accessed: 2015-07-15]
- WHO. (2015). Cholera [Internet]. WHO. Available from: <http://www.who.int/csr/don/archive/disease/cholera/en/> [Accessed: 2015-07-15].
- WSP. (2012). Economic impacts of poor sanitation in Africa. Available online at [www.wsp.org](http://www.wsp.org)

## Adoption of New Improved Rice Varieties among Smallholder Farmers in Lamjung District, Nepal

**Sujan Dhakal and Binayak Prakash Mishra\***

Nepal Polytechnic Institute, Chitwan, Nepal

\*Corresponding author: binayakprakash.mishra@gmail.com

### **ABSTRACT**

*Adoption of new improved rice varieties can ensure long term food security by reducing the gap between potential yield and national average yield in the country. A research was carried out purposively in Rainas Municipality of Lamjung district during 2020/21 to identify the factors affecting adoption of new improved rice variety among smallholder farmers, analyze smallholder farmers preference for new improved rice attribute and identify the problems faced by smallholder farmers in rice farming. One hundred (100) smallholder farmers were selected randomly from the study area. Primary data was collected using pretested semi-structured interview schedule, FGD and KII. Descriptive statistics, probit model and index value was used to interpret the findings. Findings from the research revealed that 68% of the sample households adopted new improved rice varieties. Age, education and farm size was statistically significant in the adoption of new improved rice varieties. Potential yield followed by disease and pest resistance was the most preferred attributes for new improved rice varieties. Irregular rainfall followed by disease and pest incidence was major problem faced by smallholder rice farmers. Hence, it is recommended that high yielding and disease-pest resistant new improved rice varieties should be disseminated to young and educated smallholder farmers having small farm size for better adoption.*

**Keywords:** New improved rice varieties, adoption, yield attributes, problems, smallholder farmers

### **INTRODUCTION**

Rice is main staple crop in Nepal; it covers 46% of the cereal cultivated area and 55% of the production share (CBS, 2011). Sufficient production of rice is vital in achieving food security. However, Nepal is in the verge of becoming most food insecure country in the south Asia with lowest productivity in region where population growth rate surpasses the growth rate of cereals (Joshi, Conroy & Witcombe, 2012). There is more than 50% gap in the potential yield and actual yield in the country in terms of rice production (MoAC, 2010). One of the major reasons behind low productivity is low adoption of new high yielding rice

varieties among farming communities (Pandey et al., 2012). Though, policies and programs have been launched to improve the adoption of new improved rice varieties, still a fair portion of farming communities are still relying on old varieties. Hence, this study attempts to identify the factors affecting the adoption of new improved rice varieties. Further, understanding the farmers' preference for rice attributes and existing problems in farming is studied as it plays key factors in determining adoption and use intensity.

## **METHODOLOGY**

### **Study area**

The study was done during 2020/21 in Rainas municipality of Lamjung district, Nepal.

### **Sampling technique**

Rainas municipality was selected purposively because of two reasons: firstly, IRRI-STRASA project related to new improved rice varieties was implemented in this municipality in recent time and secondly, it is a major rice producing area of the country. Population for this study was farmers involved in small holding agricultural practices as the major occupation. Smallholders constitute more than half of Nepalese farmers and have farm size less than 0.5 ha per household (CBS, 2011). A total of 100 smallholder farmers were selected in the study area. The survey was carried out using a pretested semi-structured interview schedule with household head. One (1) Focus Group Discussion (FGD) and 1 Key Informant Interview (KII) was carried out to complement the information gathered through household survey.

### **Classification of new improved rice varieties**

Variety that was released in or before 1990 was considered old variety and variety released after 1990 was considered new improved variety for the study. Gauchan et al. (2012); Ghimire, Wen-chi & Shrestha (2015) also followed the same.

### **Empirical model**

Descriptive analysis and t-test was done using IBM SPSS Statistics 25. Preference for rice attributes and problems was analyzed using index value using following formula;

$$I_{imp} = \sum(S_i f_i) / N$$

$I_{imp}$  = Index of importance

$S_i$  = Scale value

$F_i$  = Frequency of importance given by the respondents

$N$  = Total number of respondent

Probit model was employed using Stata/SE 12.1 to determine the factors determining the adoption of new improved rice varieties. This model was used to identify the determinants (regressors) on the probability of adoption of new improved rice varieties (regressand). The likelihood of farmers adopting new improved rice varieties is a non-linear function of regressors. The probit model used is of the form  $\Pr(Y = 1) = (X_i)$  where  $\Pr(Y = 1)$  represents the probability of adopting new improved rice varieties with the change in  $X$  variable. A positive estimated coefficient implies an increase in likelihood of adoption of new improved rice varieties. Probit model establishes relation between probability values and explanatory variables and ensures the probability value between 0 and 1.

In probit model, let us suppose  $Y_i$  is the binary response of the farmers,  $Y_i = 1$ , if the farmer adopts new improved rice varieties, and  $Y_i = 0$  if the farmer does not adopts the new improved rice varieties.

If  $Y_i = 1$ ;  $\Pr(Y_i = 1) = P_i$

If  $Y_i = 0$ ;  $\Pr(Y_i = 0) = 1 - P_i$

Where  $P_i = E(Y = 1/X)$  represents the conditional mean of  $Y$  given certain values of  $X$ .

#### Model specification

$\Pr(Y = 1) = f(b_0 + b_1 X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + b_5 X_5 + b_6 X_6 + b_7 X_7 + b_8 X_8 + b_9 X_9 + b_{10} X_{10} + b_{11} X_{11} + b_{12} X_{12} + b_{13} X_{13} + b_{14} X_{14} + b_{15} X_{15} + b_{16} X_{16})$

Where,  $\Pr(Y = 1)$  = Probability of adopting new improved rice varieties

$X_1$  = Age of the respondent (years)

$X_2$  = Gender of the respondent (=1 if male, 0 female)

$X_3$  = Education of the respondent (years of schooling)

$X_4$  = Owned farm size (cultivated land area in ropani)

$X_5$  = Off farm work (=1 if respondent participate in off farm work, 0 otherwise)

$X_6$  = Yearly household income (NPR)

$X_7$  = Household net worth (NPR)

$X_8$  = Nature of production (= 1if commercial, 0 subsistence)

$X_9$  = Member in organization (= 1if respondent is member of agriculture related organizations, 0 otherwise)

$X_{10}$  = Contact with extension workers (=1 if respondent has regular contact with extension workers, 0 otherwise)

$X_{11}$  = Training (=1 if respondent had participated in improved rice seed related training, 0 otherwise)

$X_{12}$  = Access of seed (=1 if new improved seed is available at local store, 0 otherwise)

$X_{13}$  = Irrigation (= 1 if household has irrigation facility, 0 otherwise)

$X_{14}$  = High yield (=1 if the new improved rice varieties to yield more than the old one, 0 otherwise)

$X_{15}$  = Disease and pest resistance (=1 if the new improved rice varieties to be more resistant to field pests than the old one, 0 otherwise)

$X_{16}$  = Palatability (=1 if the new improved rice varieties perceived to be more palatable than the old one, 0 otherwise)

$b_0$  = Regression coefficient

$b_1, b_2 \dots \dots \dots b_{16}$  = Probit coefficient

## RESULTS AND DISCUSSION

### Descriptive statistics

The descriptive statistics of variables is presented in Table 1. As observed, 68% of the sample households adopted new improved rice varieties, and 13% of the households were headed by female. The average age of the household head was 45.61 years. Respondents, on average, had 9.29 years of formal schooling. The mean farm size is 6.94 ropani. Respondents on average had household income of NPR 337100 and net worth of NPR 7330000.

Table 1. Descriptive statistics of variables for adoption of new improved rice varieties

Variables	Type	Mean	SD
Dependent variable			
Adoption of new improved rice varieties		0.68	0.468
Independent variables			
Age	Continuous	45.61	10.19
Gender	Dummy	0.87	0.338
Education	Continuous	9.29	3.485
Owned farm size	Continuous	6.94	1.880
Off farm work	Dummy	0.57	0.497
Household income	Continuous	337100	253350.45
Household net worth	Continuous	7330000	7755812.42
Nature of production	Dummy	0.23	0.423
Member in organization	Dummy	0.98	0.1407
Contact with extension workers	Dummy	0.15	0.358
Training	Dummy	0.03	0.171
Access of seed	Dummy	0.80	0.402
Irrigation	Dummy	0.86	0.348
High yield	Dummy	0.87	0.338
Disease and pest resistance	Dummy	0.85	0.358
Palatability	Dummy	0.85	0.358

Source: Field survey, 2020/21

Note: 9.83 ropani = 0.5 ha; 1 USD = 116.49 NPR

On average, 57% of the respondents participated in off farm work, 23% of the respondents were engaged in commercial production, 98% of the respondents had participation in agriculture related organizations and 15% of the respondents had regular contact with extension workers. Similarly, 3% of the respondents had training related to seed, 80% of the respondents had access to seed and 86% of the respondents had irrigation facility.

### **Characteristics of adopters and non-adopters of new improved rice varieties**

Table 2 presents the results of differences between means of characteristics describing adopters and non-adopters of new improved rice varieties. There appeared to be a significant difference in education, farm size, contact with extension workers and technology specific variables between adopters and non-adopters. Education, contact with extension workers and technology specific variables was significantly higher for adopters compared with non-adopter counterparts. Farm size was significantly higher for non-adopters compared with adopter counterparts.

### **Factors affecting adoption of new improved rice varieties in the study area**

Factors affecting adoption of new improved rice varieties is presented in Table 3. Result showed that age, education and farm size was statistically significant in the adoption of new improved rice varieties.

Table 2. Characteristics of adopters and non-adopters of new improved rice varieties

Variables	Adopters	Non adopters	Mean difference	t-value
Age	44.52	47.94	3.42	1.58
Gender	0.87	0.88	0.01	0.10
Education	9.97	7.84	-2.13	-2.96***
Owned farm size	6.64	7.58	0.94	2.38**
Off farm work	0.53	0.66	0.13	1.19
Household income	350000	309687.50	-40312.50	-0.74
Household net worth	8029411.76	5843750.00	-2185661.76	-1.32
Nature of production	0.24	0.22	-0.02	-0.18
Member in organization	0.99	0.97	-0.02	-0.55
Contact with extension workers	0.19	0.06	-0.13	-1.69*
Training	0.02	0.06	0.05	1.31
Access of seed	0.84	0.72	-0.12	-1.39
Irrigation	0.90	0.78	-0.12	-1.56
High yield	0.94	0.72	-0.22	-3.21***
Disease and pest resistance	0.93	0.69	-0.24	-3.25***
Palatability	0.93	0.69	-0.24	-3.25***

*Source: Field survey, 2020/21*

*Note: \*, \*\*, \*\*\* indicate significant at 10%, 5%, 1% level of significance, respectively.*

Keeping the other variables constant, probability of adoption of new improved rice varieties decreased by 1 per cent with the increase in the age of respondents by one unit. This is possibly because old farmers feel easiness with the practices they followed from time back since their learning and information seeking behavior is low. Also they hesitate in new and risky options reducing adoption of new improved rice varieties.

Table 3. Probit regression analysis and marginal effect for factors affecting the adoption of new improved rice varieties

Variables	Coefficient	p-value	S. E.	dy/dx	S.E. (dy/dx)
Age	-0.032*	0.086	0.019	-0.010	0.005
Gender	-0.582	0.287	0.546	-0.148	0.114
Education	0.167***	0.006	0.060	0.051	0.018
Owned farm size	-0.449***	0.001	0.129	-0.137	0.038
Off farm work	0.285	0.496	0.418	0.088	0.67
Log(Household income)	-0.063	0.873	0.396	-0.019	0.121
Log (Household net worth)	0.736	0.103	0.451	0.225	0.132
Nature of production	0.270	0.581	0.489	0.078	0.133
Member in organization	1.605	0.153	1.123	0.577	0.314
Contact with extension workers	0.890	0.165	0.641	0.207	0.105
Training	-1.252	0.168	0.908	-0.464	0.319
Access of seed	-0.078	0.874	0.492	-0.023	0.145
Irrigation	0.028	0.960	0.576	0.008	0.178
High yield	0.938	0.652	2.078	0.337	0.792
Pest and disease resistance	0.521	0.754	1.664	0.177	0.615
Palatability	0.663	0.567	1.158	0.230	0.436
Constant	-10.068	0.104	6.190		
<b>Summary statistics</b>					
<b>Number of observation</b>	100				
<b>LR chi2(16)</b>	46.95				
<b>Prob&gt;Chi2</b>	0.0001				
<b>Pseudo R2</b>	0.3745				
<b>Log likelihood</b>	-39.210				

*Source: Field survey, 2020/21*

*Note: \*, \*\*\* indicate significant at 10%, 1% level of significance, respectively.*

These results are in line with Adeyemi et al. (2020). Probability of adoption of new improved rice varieties increases by 5.1 per cent with increase in education of the respondents by one unit. This is possibly because respondents can access more information on new improved rice varieties. This findings is in line with earlier literatures (Langyintuo & Mungoma, 2008; Kassie, Shferaw & Muricho, 2011; Asfaw et al., 2012; Ghimire, Wen-chi & Shrestha, 2015). Similarly, probability of adoption of new improved rice varieties decreases by

13.7 per cent with increase in farm size by one unit. This is possibly because respondents having small farm size have only option of adoption of new improved rice varieties to achieve sufficient production and food security. This result is in line with Bruce, Donkoh & Ayamga (2014).

**Smallholder farmers preferred attributes for new improved rice varieties in the study area**

Farmer’s preference for rice attributes is presented in Table 4. In brief, potential yield (0.98), disease and pest resistance (0.90), ecology adaptability (0.76) and palatability (0.63) were the top four preferred attributes for new improved rice varieties. Farm size is drastically decreasing and population is in increasing rate in the study area. The preference for potential yield is the reflection of this scenario.

Table 4. Smallholder farmers preferred attributes for new improved rice varieties in the study area

Attributes	Index value	Rank
Potential yield	0.98	I
Pest and disease resistance	0.90	II
Early maturity	0.48	VII
Ecology adaptability	0.76	III
Taste (palatability)	0.63	IV
Environment adaptability	0.61	V
Seed longevity	0.25	VIII
Shattering	0.24	IX
Seed rate	0.52	VI
Threshing	0.13	X

*Source: Field survey, 2020/21*

Farmers want to increase the productivity and hence want this attributes to be major characteristic of improved rice variety. Similarly, major loss is caused by abiotic and biotic stress in the study area, the preference for disease and pest resistance and ecology adaptability in improved varieties of rice is reflection of existing problem. These results are in line with Burman et al., 2018; Ghimire, Wen-chi & Shrestha, 2015; Laborte et al., 2015; Liang, Xu & Chen, 2017; Shaosheng et al., 2020. Least preferred attributes for new improved rice varieties was threshing (0.13).

**Problems faced by small holder farmers in rice farming the study area**

Major problems faced by rice farmers in the study area are presented in Table 5. In brief, irregular rainfall (0.96), disease and pest incidence (0.84), irregular availability of inputs (0.83) and lack of policy support (0.55) were the top four problems in the study area. Climate change is severe in many parts of the

country. Irregular rainfall, a most distinct effect of climate change is causing uncertainty in planting time in the study area. Similarly, pest and disease outbreak have caused significant grain loss and irregular availability of inputs due to small market have caused uncertainty among farmers in the study area. Rice farmers have experienced less policy support (on subsidy, insurance, agribusiness and credit) from government in the study area. Least problem was of irrigation facility (0.28). This is possibly because irrigation system (rainstar irrigation) is present in the study area. Result is in line with Bashyal et al. (2019) and Acharya et al. (2020).

Table 5. Problems faced by small holder farmers in rice farming the study area

Problems	Index value	Rank
Irregular availability of inputs	0.83	III
Disease and pest incidence	0.84	II
Land fragmentation	0.35	VIII
Lack of policy support	0.55	IV
Lack of postharvest technology	0.53	V
Lack of labor	0.53	V
Lack of credit	0.51	VII
Lack of irrigation	0.28	IX
Irregular rainfall	0.96	I

*Source: Field survey, 2020/21*

## CONCLUSION

Findings from the research revealed that 68% of the smallholder farmers adopted new improved rice varieties. This shows farmers are interested towards new improved rice varieties. Age of the smallholder farmers negatively affected the adoption of new improved rice varieties. This implies that the existing programs and policies related to new improved rice varieties should primarily focus on young farmers. Similarly, we found significantly positive influence of education on adoption of new improved rice varieties. This implies that the extension agencies of both government and NGOs should facilitate educated farmers more of the information related to new improved rice varieties. Moreover, this research showed that households having small farm size are more likely to adopt the new improved rice varieties. It means emphasis should be given to farmers cultivating rice in small farm area as they seem interested to achieve food security with use of high yielding new improved rice varieties. Potential yield and disease and pest resistance were the most preferred new improved rice attributes by smallholder farmers. This implies that the breeding program should focus on these attributes to gain maximum interest from smallholder farmers. Similarly, irregular rainfall and disease and pest incidence were the most severe problems in rice farming. Thus, government and privates

sector should come up with the solutions for these issues to achieve higher productivity.

## REFERENCES

- Acharya, S. R., Shrestha, A., Bhandari, S., Dahal, B. R. & Dutta, J. P. (2020) Analysis of factors and major problems of production of paddy farming in Sunsari district, Nepal. *Azarian Journal of Agriculture*. 7(5), 164-172.
- Adeyemi, A. A., Omotara O. A. , Adeyemo A. A. & Oludele A. S. (2020) Impact of improved rice varieties' adoption on sustainable rice productivity among farmers in Southwestern Nigeria. *International Journal of Advanced Research in Biological Sciences*. 7(4). DOI: 10.22192/ijarbs
- Asfaw, S., Shiferaw, B., Simtowe, F. & Lipper L. (2012) Impact of modern agricultural technologies on smallholder welfare: Evidence from Tanzania and Ethiopia. *Food Policy*. 37(3), 283–295.
- Basyal, C., Ghimire, S., Panthi, B. & Basyal, S. (2019) Constraints of paddy production in western terai of Nepal. *International journal of Environment, Agriculture and Biotechnology*. 4(5), 1584-1588.
- Bruce, A. K. K., Donkoh, S. A. & Ayamga, M. (2014) Improved rice variety adoption and its effects on farmers' output in Ghana. *Journal of Development and Agricultural Economics*. 6(6), 242-248. DOI: 10.5897/JDAE2013.0544
- Burman, D., Maji, B., Singh, S., Mandal, S., Sarangi, S. K., Bandyopadhyay, B. K., Bal, A. R., Sharma, D. K., Krishnamuthy, S.L. & Singh H. (2018) Participatory evaluation guides the development and selection of farmers' preferred rice varieties for salt-and flood-affected coastal deltas of south and South east Asia. *Field Crops Research*. 220, 67–77.
- Central Bureau of Statistics (CBS). (2011) Nepal Living Standard Survey 2010/11. Statistical Report, Volume II. Central Bureau of Statistics, National Planning Commission Secretariat. November, 2011. Government of Nepal. National Planning Commission Secretariat. November 2012.
- Gauchan, D., Panta, H. K., Gautam, S. & Nepali, M. B. (2012) Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed areas of Nepal. In: *Patterns of Adoption of Improved Rice Varieties and Farm-Level Impacts in Stress-Prone Rainfed Areas in South Asia*. Los Baños, Laguna, Philippines: International Rice Research Institute. 37–103.
- Ghimire, R., Wen-chi, H. & Shrestha, R. B. (2015) Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal. *Rice Science*. 22(1), 35–43.
- Joshi, K. D., Conroy, C. & Witcombe, J. R. (2012) Agriculture, seed, and innovation in Nepal: Industry and policy issues for the future. In: *International food Policy Research Institute Project Paper*: 60.
- Kassie, M., Shiferaw, B. & Muricho G. (2011) Agricultural technology, crop income, and poverty alleviation in Uganda. *World Dev*. 39(10), 1784–1795.
- Laborte, A. G., Paguirigan, N. C., Moya, P. F., Nelson, A., Sparks, A. H. & Gregorio G. B. (2015) Farmers' preference for rice traits: Insights from farm surveys in Central Luzon, Philippines, 1966-2012. *PLoS One*. 10(8), e0136562.
- Langyintuo A. S. & Mungoma C. (2008) The effect of household wealth on the adoption of improved maize varieties in Zambia. *Food Policy*. 33(6), 550–559.
- Liang, T., Xu, Z. J. & Chen, W. F. (2017) Advances and prospects of super rice breeding in China. *Journal of Integrative Agriculture*. 16(5), 984–991.
- Ministry of Agriculture and Cooperatives (MoAC). (2010) Statistical information of Nepalese agriculture. Agribusiness promotion and statistical division, Kathmandu, Nepal
- Pandey, S., Gauchan, D., Malabayabas, M., Bool-Emerick, M. & Hardy, B. (2012) Patterns of adoption of improved rice varieties and farm-level impacts in stress-prone rainfed

areas of Nepal. In: Patterns of Adoption of Improved Rice Varieties and Farm-Level Impacts in Stress-Prone Rainfed Areas in South Asia. Los Baños, Laguna, Philippines: International Rice Research Institute.

Shaosheng, J., Bashiru, M., Xin, J. & Haoyang, Li. (2020) Farmers' preferences for attributes of rice varieties in Sierra Leone. *Food security*.

## Cross Sectional Study of Diseases and Disorders in Sheep at Sheep and Goat Research Program, Guthichaur, Jumla, Nepal

Ramesh P. Sah<sup>1\*</sup>, M. P. Yadav<sup>1</sup>, S. P. Kanu<sup>2</sup>, Md S. N. Ali<sup>3</sup> and  
Md H. Talukder<sup>4</sup>

<sup>1</sup>Sheep and Goat Research Program, NARC, Guthichaur, Jumla, Nepal

<sup>2</sup>Institute of Agriculture and Animal Science, Tribhuvan University, Nepal

<sup>3</sup>National Buffalo Research Program, NARC, Tarahra, Sunsari, Nepal

<sup>4</sup>Department of Parasitology, Bangladesh Agricultural University, Mymensingh,  
Bangladesh

\*Corresponding Author: rpsnarc@gmail.com

### ABSTRACT

*A cross sectional study was carried out for six months from July to December, 2020 at Sheep and Goat Research Program (SGRP), Guthichaur, Jumla in order to know the prevalence or occurrence of diseases and disorders in sheep. Sheep of the farm were examined for occurrence of diseases, diagnosed based on clinical signs and treated accordingly. All the sheep of farm were vaccinated with FMD and PPR vaccine in April, 2020. Recording of data related to clinical cases were done regularly in record book. Information related to sheep diseases were obtained from that record book maintained at farm and obtained information were analyzed using Microsoft Excel. Altogether 98 cases of various diseases were found during study period. From this study, out of 27 types of identified diseases and disorders, major five diseases and disorders were nasal discharge (rhinitis), parasitic disease, debility, pneumonia and anestrus. Among parasitic diseases, 11 sheep were found positive for Fasciola species and four sheep were found positive for Moneizia species. According to system affected respiratory, digestive and reproductive diseases were found in 35, 22 and 13 cases respectively. Diseases related to urinary, cardiovascular and nervous system were not found in any cases during study period. It is found that majority of diseases were not so serious and they were cured by general treatment. It is concluded that prevalence of diseases can be minimized by using vaccination and deworming. From this study, it can be recommended that diseases in sheep occurring in surrounding villages can be minimized by general treatment.*

**Keywords:** Cross sectional study, Diseases, Sheep, SGRP, Jumla, Nepal

## **INTRODUCTION**

Small ruminants particularly sheep in Jumla are amongst the commonest farm animal species, which contribute to the livelihoods of smallholders and the rural poor including women headed household situations (Annual Report SGRP 2019). Sheep population is projected at 806,079 heads in Nepal (about 70,000 heads in Jumla), and meat (mutton) production is 2735 metric ton in 2019-20 (Agriculture Diary 2078). The herd is mainly composed of indigenous animals and small proportion of upgraded. Their small size, quick maturity, low capital asset per head and quick returns suit them to the needs of poor resource farmers. Sheep production provides animal protein (meat), immediate cash income, manure, raw materials (hides and skin), and capital investments and fulfills socio-economic and cultural obligations (Adane and Girma 2008, Dhaba *et al.*, 2012, Pandey and Gyawali 2012). Thus, sheep make a significant contribution to nutrition and food security especially to the poor in the rural areas (Gupta *et al.*, 2018).

### **General Information about SGRP**

As the commodity program SGRP has mandated for the whole country to conduct its program/ experiments/ activities related to sheep and goat. Basically, SGRP has launched its direct activities in Karnali province. Karnali Province has different 10 districts including Jumla and capital is Birendranagar, Surkhet (Figure 1).

### **Historical background**

The initiation of sheep development in western mountain region of Nepal was started in 1970 AD (2027 BS) by establishing Karnali Sheep Farm at Guthichaur Village Development Committee -6 in Jumla. Originally the farm was aimed to produce the crossbred sheep for distribution among the farmers to upgrade the local sheep flock and to study performance of the different sheep genotype. Sheep and Wool Development Project of the FAO/UNDP supported the farm, both financially and technically during 1973 to 1979. In 1989, the farm was renamed as National Sheep and Goat Research Program under the administration of Nepal Agricultural Research and Service Centre (NARSC). Later in 1992, the program was again renamed as “Sheep and Goat Research Program” within the autonomous body of Nepal Agricultural Research Council (NARC) established under the council act 1991 by H.M.G., Nepal. Goal of this research program is “Uplifting the farmer's livelihood by increasing the national production and productivity of the sheep and goat based farming system”. Meteorological information of SGRP is given in Table 1.

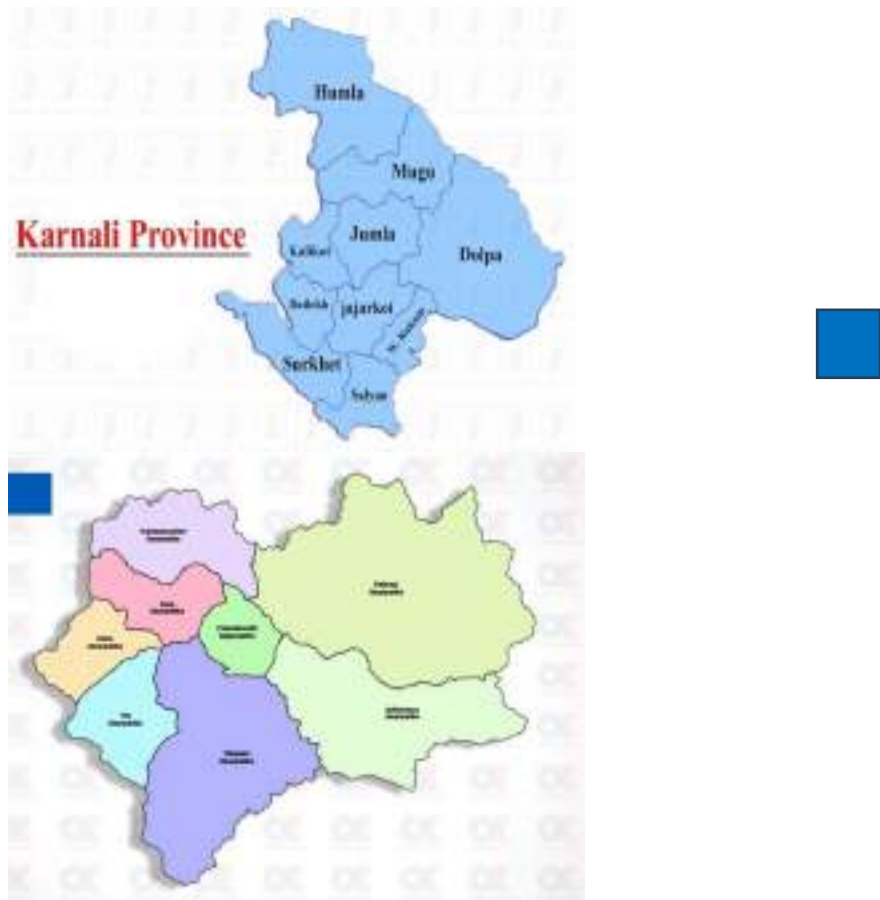


Figure 1. Left: Map of Karnali Province with 10 districts. Right: Map of Jumla having local government bodies (blue rectangular symbol indicates Guthichaur Rural Municipality)

Table 1. Meteorological information of SGRP

Particulars	Record
Rainfall	755 mm (June-Sep: 85%)
Temperature	Max.27.3°C to Min. -5.7°C
Snowfall	December to March
Relative humidity	60-84%
Sunshine hour	9.3 hrs in winter
Latitude	29°21'58.63" N
Longitude	82°30'99.41" E
Elevation	2700 masl

Currently, sheep production in Jumla is confronted with various challenges that greatly affect its economic returns. High incidence of diseases and parasites are considered as major restrictions causing direct losses, such as death and diminished production, and indirect losses, such as export limitations (Tiwari 2001, Pradere 2014, Torsson *et al.*, 2017, Sah *et al.*, 2020).

Poor management and husbandry practices and diseases of varied etiologies are among the leading bottlenecks of sheep and goat production (Molla 2016). Among the wide range of diseases that affect sheep and goats, respiratory diseases are most frequent as air and blood are their main routes of transmission (Tesfaye and Mekonnen 2016). Overcrowding coupled with the involuntary inhalation of air polluted with a variety of potentially injurious materials is the most important risk factor for transmission (Caswell and Williams 2007).

The etiology and incidence of respiratory diseases in sheep vary with the geographical location and management system. Many bacteria, viruses and helminthes parasites are known to cause respiratory diseases in sheep (Sah *et al.*, 2020, Mlimbe *et al.*, 2020). Pneumonia (43.7%), starvation (18.4%) and abscess (15.5%) were the topmost causes of mortality in Tanzania (Mlimbe *et al.*, 2020). However, to the authors' knowledge, very little work has been done to date on diseases and disorders in sheep. Thus, the present study was conducted with the objective to know the prevalence or occurrence of diseases and disorders in sheep.

## **MATERIALS AND METHODS**

Sheep and Goat Research Program is situated at Guthichaur Rural Municipality ward no 2, Jumla, Karnali Province, Nepal and is located at 19 Km far from District head quarter (Khalanga) Jumla (Figure1). Sheep maintained at farm is around 300 in number (Breeds: Baruwal, Bhyanglung, Romney marsh, Coopworth and their crosses).

A cross sectional study was carried out for six months from July to December, 2020 at Sheep and Goat Research Program (SGRP), Guthichaur, Jumla. Sheep of farm were examined for diseases and disorders, diagnosed based on clinical signs and treated accordingly. All the sheep of farm were vaccinated with FMD and PPR vaccine in April, 2020. Recording of data related to clinical cases were done regularly in record book. Information related to sheep diseases were obtained from that record book maintained at farm and obtained information was analyzed using Microsoft Excel. Data were interpreted to achieve objective.

## **RESULTS AND DISCUSSION**

Altogether 98 disease cases were encountered and were categorized and ranked upto seven (Table 2).

Table 2. Occurrence of different diseases of sheep during six months at SGRP farm

Name of Category (Total cases)	Case S.N.	Type of cases	No of cases	System wise rank	Case wise rank
Digestive system (22)	1	Diarrhoea	2	2	
	2	Anorexia	2		
	3	Tympany	1		
	4	Parasitic infestation- <i>Fasiola species</i>	11		2
	5	Parasitic infestation- <i>Moneizia species</i>	4		
	6	Parasitic infestation- nematode	1		
	7	Poisoning	1		
Respiratory system (35)	8	Pneumonia	6	1	4
	9	Rhinitis (nasal discharge)	25		1
	10	Cough	4		
Musculo-skeletal system (10)	11	Lameness	3	4	
	12	Simple fracture	1		
	13	Sprain	1		
	14	Horn fracture	2		
	15	Hoof overgrowth	3		
Reproductive system (13)	16	Dystocia	1	3	
	17	Prolapse of vagina	2		
	18	Anestrus	5		5
	19	Repeat breeding	1		
	20	Agalactia	3		
	21	Maternal death	1		
Skin disease (6)	22	Wound- Abscess	2	6	
	23	Wound- cyst	1		
	24	Wound- cut wound	3		
Endocrine system (2)	25	Impotence- lack of libido	2	7	
Miscellaneous (10)	26	Weakness- debility	7	5	3
	27	Corneal opacity	3		
		Total	98		

Altogether 98 cases of various diseases were found during study period. From this study, out of 27 types of diseases major five diseases were prevalent and these were nasal discharge (rhinitis), parasitic disease, debility, pneumonia and anestrus.

In case of parasitic disease, more sheep were positive for *Fasciola species* (11) followed by *Moneizia species* (4). Previous study by Sah *et al* (2020) investigated ovine fascioliosis, was recorded 34% in fecal test, 6.7% in slaughtered sheep and 23.5% in post mortem examinations. Mature flukes were present in liver and gall bladder of inspected sheep (Sah *et al.*, 2020). This prevalence found in the study area could be due to the marshy and water-logged swampy area which is suitable for the breeding of intermediate host (snail). Similarly pneumonia (43.7%), starvation (18.4%) and abscess (15.5%) were the topmost causes of mortality in Tanzania (Mlimbe *et al.*, 2020).

According to system affected respiratory, digestive and reproductive diseases were found in 35, 22 and 13 cases respectively. Diseases related to urinary, cardiovascular and nervous system was not found in any cases during study period. Respiratory diseases were common and are supported by Sah *et al* (2021). They reported 160 cases of pneumonia in sheep in surrounding areas of SGRP within a year. Poor ventilation, overcrowding, dirty or poorly ventilated barn, muddy floor, and high humidity may be the predisposing factors for occurrence of pneumonia (Sah *et al.*, 2021, Annual Report SGRP 2020). It was found that majority of diseases were not so serious; and they were cured by general treatment.

## CONCLUSION

It is concluded that diseases prevalence can be minimized by using vaccination and deworming. From this study it can be recommended that diseases in sheep occurring in surrounding villages can be minimized by general treatment.

This study indicated the occurrence of common disorders/diseases in sheep within six months study period and helps to control and prevent further such diseases on and around farm. It is concluded that diseases prevalence can be minimized by using vaccination and deworming.

## RECOMMENDATIONS

From this study it can be recommended that diseases in sheep occurring in surrounding villages can be minimized by general treatment.

Integrated approach, which is a combination of selective chemotherapy and selective vector control, should be considered more practically and economically feasible. Therefore, awareness to the farmers needs to be created so as to follow the good management practices for rearing sheep.

## REFERENCES

- Adane, Y., and Girma, A. (2008) Economic significance of sheep and goats, In: Alemu and Yami and R C Markel (Eds.). Sheep and Goat Production. *Handbook for Ethiopia. ESGPIP*

(*Ethiopia Sheep and Goats Productivity Improvement Program*). Addis Ababa, Ethiopia. pp 2-24.

- Agriculture Diary (2078) Ministry of Agriculture and Livestock.
- Annual Report, SGRP. (2019) Sheep and Goat Research Program.
- Caswell, J. L., and Williams, K. J. (2007) Respiratory system. In *Jubb, Kennedy and Palmer Pathology of Domestic Animals*, M. G. Maxie, Ed., vol. 5th. pp. 524–650, Elsevier, Edinburgh, Scotland.
- Dhaba, U., Belay, Solomon, D., and Taye, T. (2012) Sheep and goat production systems in Ilu Abba Bora zone of Oromia Regional State, Ethiopia: Feeding and management strategies. *Global Veterinaria*. 9(4): 421–429.
- Gupta, A., Chaudhary, M., Goyal, R. K., Yadav, V., Chandra, S., and Sinha, S. (2018) Recent advances in reproductive biotechnologies in small ruminants. *Journal of Entomology and Zoology Studies*. 6(3): 62-66.
- Mlimbe, M. E., Hyera, E., Ochanga, P. O., Nguluma, A. S., Marwa, L. J., Rugaimukamu, A. P., Godfrey, J. D., Ngabo, M. S., and Shirima, E. J. M. (2020) Study on the causes and pattern of sheep mortality under farm conditions in Northern Tanzania. *Livestock Research for Rural Development*. 32 (10): 1-8.
- Molla, B. (2016) Te health performance of imported Boer goat (*Capra hircus*) and their crosses with Woito-guji goat breeds in South Omo Zone, South-Western Ethiopia. *Tropical Animal Health and Production*. 48(4): 855–861.
- Pandey, L. N., and Gyawali, R. (2012) Constraints and potential of goat and sheep production under transhumance management system in the high mountainous regions of Nepal. *Conference paper: The Proceeding of the National workshop on Research and Development Strategies for Goat Enterprises in Nepal 27-28 September 2012 held in Kathmandu*. Pp.92-101.
- Pradere, J. P. (2014) Improving animal health and livestock productivity to reduce poverty. *Revue scientifique et technique*. 33: 723-744.
- Sah, R. P., Yadav, M. P., Kanu, S.P., and Rijal, T. R. (2020) Study on ovine fascioliasis: Case study, associated risk factors and economic significance at Sheep and Goat Research Program, Guthichaur, Jumla, Nepal. *International Journal of Veterinary Sciences and Animal Husbandry*. 5(4): 164-168.
- Sah, R. P., Yadav, M. P., and Kanu, S. P. (2021) Study on association of different animal and management factors on occurrence of Pneumonia in sheep in Jumla. *Nepalese Journal of Agricultural Sciences*. 21: 110-118.
- Tesfaye, S., and Mekonnen, N. (2016) A study on major causes of organs condemnation and their financial losses in cattle slaughtered at Gondar ELFORA abattoir, Northwestern, Ethiopia. *Global Veterinaria*. 17: 365–374.
- Tiwari, M. R. (2001) Exploration of constraints and opportunities of small ruminant production system in Karnali zone. *Final Technical Paper*. Sheep and Goat Reseach Programme (SGRP), Guthichaur, Jumla.
- Torsson, E., Berg, M., Misinzo, G., Herbe, I., Kgotlele, T., Paarni, M., Roos, N., Blomstrom, A. L., Stahl, K., and Wensman, J. J. (2017) Seroprevalence and risk factors for peste des petits ruminants and selected differential diagnosis in sheep and goats in Tanzania. *Infection Ecology and Epidemiology*. 7: 1-13.

## Comparative Efficiency of *Clarias gariepinus* Production under Alternative Protein Feeding Regimes in Selected Local Government Areas in Ogun State, Nigeria

<sup>1</sup>I.A. Ayinde, <sup>1</sup>O. Omoyinmi, <sup>2\*</sup>F. O. Aminu and <sup>1</sup>M. Suleman

<sup>1</sup>Department of Agricultural Economics and Farm Management, Federal University of  
Agriculture, Abeokuta, Nigeria

<sup>2</sup>Department of Agricultural Technology, School of Technology, Yaba College of  
Technology, Epe Campus, P. M. B. 2011, Yaba, Lagos State, Nigeria

\*Corresponding Author: folajy2003@gmail.com

### ABSTRACT

*The study applied stochastic metafrontier model to estimate technical efficiency (TE) and technology gap ratios (TGR) in Clarias gariepinus production under alternative protein feeding regimes in selected Local Government Areas in Ogun State, Nigeria. A multistage sampling technique was used to select 200 catfish farmers for the study. Separate stochastic frontier models were estimated for three feeding regimes, feed only, feed and maggot and feed and chicken offal, along with a metafrontier model to obtain alternative estimates for the technical efficiencies of farmers in the different feeding regimes. Results revealed that, majority (76.9%) of the catfish farmers were male with a mean age of 41 years, had tertiary education (89.5%) and used more of concrete ponds (32.2%). The average technical efficiency level was 0.840 for the pooled sample, 0.846, 0.867, and 0.829 for feed only, feed and maggot, and feed and chicken offal respectively, suggesting that there is substantial scope to improve catfish output in the study area. The mean technology gap ratio (TGR) value of 79.3% indicated that, on the average, the catfish farmers in the study area would have to close a gap of 21.7% in order for them to be technically efficient. The study recommended that catfish farmers using the feed only and feed and maggot systems could improve their technical efficiency through a better management using the available technologies and resources while intervention to raise technology that will help close the gap between the regional frontier curve and the global frontier curve should be adopted for feed and chicken offal regime*

**Key words:** Catfish farmers, comparative, technical efficiency, technology gap ratio,

## INTRODUCTION

Nigeria is a maritime country where fishing plays an important role in the national economy and the citizens' diet. It is generally accepted as protein source in diets of average Nigerians (Agbabiaka, 2010). Nigeria consumes over 1.5 million tons of fish annually (Makinde, 2015). Fish is supplied by a variety of sources including imports, domestic capture (i.e., fish caught from the various inland waters and coastal areas by artisanal fisher folks using boats and nets) and fish farming and Nigeria is a significant importer of frozen fish in Africa (Olaoye *et al.*, 2016). Small-scale fish-farming and artisanal fisheries make up about 80% of the fisheries sector, supplying roughly 82% of the country's domestic fish production. In the Nigeria, catfish is the predominant farmed fish in Nigeria and the fish-farming sector is increasingly important with large numbers of new entrants over the last decade, particularly small-scale fish farmers (Makinde, 2015). According to Food and Agriculture Organization (FAO, 2002), fisheries products represented a major source of export revenue for developing countries, amounting to over US \$ 20 billion per annum in late 1990s. This exceeded the values obtained from the exports of meat, dairy, cereals, vegetables, fruit, sugar, coffee, tobacco and oilseeds in 1997 from developing countries (International Trade Centre, 2002). Also in 2014, fisheries contributed 0.48% to the agriculture GDP. However, Nigeria imports about 560,000 tonnes of fish estimated at about \$ 400 million annually while annual domestic fish supply in Nigeria stands at about 400,000 tonnes. This makes Nigeria one of the largest importers of fish in the developing world (FAO, 2007). According to the fisheries data management unit (FDMU 2014), the total fish demand for Nigeria based on 2014 population estimate of 180million is 3.32m MT. the domestic fish production from Aquaculture, Artisanal and industrial fisheries for 2014 is 1.123m Mt.

The African catfish, *Clarias gariepinus*, is a major cultured fish in Nigeria because of its fast growth, good feed conversion, hardiness, and high market value and as such, its importance cannot be overemphasized. According to Anoop *et al.*, (2009), it provides food for the populace, it allows for improved protein nutrition because it has a high biological value in terms high protein retention in the body, higher protein assimilation as compared to other protein sources, low cholesterol content and one of the safest sources of animal protein. It serves as a source of income, reduces the rate of unemployment in the economy and increases the Gross Domestic Product (GDP). In most countries it fetches a higher price than tilapia as it can be sold live at the market as they have a market value two to three times than that of tilapia (Emokaro, 2010). It requires less space, time, money and has a higher feed conserving rate Olagunju,

*et al.*, (2007). However, catfish production is plagued with high cost of fish feed caused by the escalating cost of fishmeal, the main protein source in fish feeds (Adebayo and Daramola, 2013). The sustainability of the catfish culture industry, therefore, depends on reducing the fishmeal content of fish feeds by finding alternative protein sources of good nutritional quality that are readily available and more cost effective than fishmeal (Adewolu, 2011). In 2014, partnership Initiatives in the Niger Delta region of Nigeria (PIND) noticed that the preferred fish feed is the foreign floating variety. Foreign feeds have a higher proportion of protein than Nigerian produced feed, which gives better results in terms of table size fish at shorter time but the cost. imported fish meals which is the protein source is very high. In general, locally produced feeds are cheaper than imported products. However, imported feeds have better floatability characteristics and higher protein percentage. Nigeria imports feed from USA (Ziegler brand), China (Sharp brand), Brazil (Pira brand), Netherlands (Coppens), Multifeed (Israel).

In Nigeria, the raw material for fish feed formulation such as under-utilized “trash” fish, groundnut cake, palm kernel cake and soybeans are becoming increasingly expensive (Sogbesan, 2014). As a result of high cost of these materials emphasis is placed on the evaluation of the potential of some locally available but under-exploited and under-utilized materials such as tadpoles, toads, crabs, shrimps, maggot, earthworm etc. (Sogbesan, 2014). The cost of feeding fish is about 60% of the total recurrent cost of fish farming, hence a need for an alternative protein source at a cheaper rate to substitute the expensive feed meal. It is therefore imperative to compare the efficiency of *clarias gariepinus* production under alternative protein feeding regimes in some selected Local Governments in Ogun State, Nigeria.

## METHODOLOGY

### Study Area

The study was carried out in fish farming areas of Ogun State. The state is located in the rainforest vegetation belt of Nigeria within longitude 2° 45' and 3° 55' E and latitudes 7° 01' N and 7° 8' N in the tropics. It is bounded in the west by Benin Republic, in the south by Lagos state and Atlantic Ocean, in the east by Ondo State, and in the north by Oyo State. The state has a total population of 3,728,098 according to National Population Commission (N.P.C, 2006) and covers a land area of 16,409.28 km<sup>2</sup>. The rainy season starts around the middle of March and continues until late October. The dry season starts in November and lasts until February in most locations in the state. Rainfall ranges between 1600 and 900 mm annually. The state is warm throughout the year with a

temperature of between 28 and 35°C. Humidity is between 85 and 95%. The main occupation of the people in the state are: agriculture, fishing, clothing, textiles and civil service. The state was divided into four agricultural extension zones namely: Abeokuta, Ilaro, Ijebu-Ode and Ikenne (OGADEC, 2005). These four agricultural zones are well known as best ecological areas for fish production and hence the state is referred to as the basket of fish for the nation because of abundance of wetland with annual growth rate of 3% per annum. As at 2008, farmed fish produced by 6,664 productive fish farmers was found to be synchronous with the growth trend of aquaculture and the resources in Ogun state within the same period (OGADEC, 2009).

The sampling respondents for this study were catfish farmers in the study area. A multistage sampling technique was used in this study. In the first stage, purposive sampling technique was used to select two highest fish producing Local Government Areas in Ogun State, the second stage involved the random selection of 10 Villages each from the selected LGAs making a total of 20 villages. In the third stage, 10 fish farmers per village were randomly selected, making a total of 200 respondents for the study. However, 143 questionnaires representing 71.5% of the respondents were used for data analysis. Others were discarded due to incomplete and outrageous information.

Data were collected with the aid of structured questionnaire. The questionnaire has three different sections. The first section was designed to capture the socio economic characteristics of the fish farmers; the second was designed to get information germane for determination of farmer's production efficiency of the protein sources; while the third section of the administered questionnaire was used in collecting information on the farming activities. The data collected were analyzed using Descriptive Statistics, likelihood ratio test and stochastic-meta frontier production.

**Descriptive statistics:** Descriptive analysis such as frequency counts, percentages and mean were used to analyze data on the socio economic characteristics, dietary habits, and nutrient intake of the fish farmers in the study area. The data required were the gender, educational level, age, years of experience in fish farming, the farm size, labour size, membership of co-operative, extension worker visits etc.

**Likelihood ratio test:** A likelihood ratio (LR) test was conducted to show that there are technology differences across different ecologies. This was done to determine whether the meta-frontier is necessary for estimating the efficiency

levels of catfish farmers in Ogun State. If the three feeding regimes (feed only, feed with maggot and feed with chicken offal) share the same technology, the stochastic frontier production model is appropriate to estimate the efficiency of the fish farmers. A likelihood ratio (LR) test with the null hypothesis that the stochastic frontier model for the three feeding regime is the same was calculated. This was obtained after estimating the stochastic frontier by pooling the data from all three feeding regime. The likelihood ratio (LR) statistics is defined as:

$$\lambda = -2 \left\{ \ln \left[ \frac{l(H_0)}{l(H_1)} \right] \right\} = -2 \{ \ln[LH_0] - \ln[LH_1] \} \quad (1)$$

Where:

$\ln[L(H_0)]$  = represents the value of the log likelihood function of the stochastic frontier estimated by pooling the data for the feeding regimes

$\ln[L(H_1)]$  = represents the sum of the values of the log likelihood functions for the stochastic frontiers for each of the three feeding regime estimated separately.

The result of the test is verified using Chi square statistics. The degrees of freedom for the Chi square statistics are the differences between the numbers of parameters estimated under  $H_0$  and  $H_A$ . The decision rule for accepting or rejecting the hypothesis is that: if the  $\chi_{cal} < \chi_{tab}$  will fail to reject (accept) the null hypothesis. If the null hypothesis that the stochastic frontier for the pooled data is rejected, then the data cannot be pooled and in such case metafrontier framework is appropriate for estimating and comparing technical efficiencies across the group frontiers (Battese *et al.*, 2004).

### **Stochastic Meta-Frontier Analysis**

The estimation of a metafrontier is an approach proposed by Battese and Rao (2002), to adjust the TE scores from Stochastic Frontier Analysis (SFA) in order to account for differences in technology. Suppose that there are  $j$  production systems in the fish farm. The stochastic production frontier is specified as:

$$Q_i = f(X_i, \beta) \exp(v-u) \quad (2)$$

Where,  $Q_i$  is the output of the  $i$ th farm

$x_i$  is the vector of inputs used by the  $i$ th farm

$\beta$  is a vector of production input parameters to be estimated

$v$  is assumed to be independent and identically distributed random error, representing the effects of statistical noise, having a normal distribution with zero mean and variance given by  $\sigma^2$ , i.e.  $v \sim N(0, \sigma^2)$ .

$u$  represents the farm-specific technical inefficiency in production and is assumed to be independent of  $v$  and non-negative truncation of the half-normal distribution, i.e.  $u \sim [N(0, \sigma^2)]$ . (Aigner *et al.*, 1977): (Battese and Coelli, 1995) and it follows that (Aigner *et al.*, 1977):

$$\sigma^2 = \sigma_v^2 + \sigma_u^2 \tag{3}$$

When data are in logarithm terms,  $u$  is a measure of the percentage by which a particular observation or farm fails to achieve the frontier, ideal production rate (Greene, 2012).

Following Battese and Corra (1977), the departure of output from the frontier due to technical inefficiency is defined by a parameter ( $\gamma$ ) given by:

$$\gamma = \frac{\sigma_u^2}{\sigma^2}, \text{ such that } 0 < \gamma < 1 \tag{4}$$

$$Q_{ij} = f(X_{ij}, \beta_j) \exp(v_{ij} - Z_{ij}\delta) \tag{5}$$

Where  $Q_{ij}$  is the output for the  $i$ th farm in the  $j$ th production system of the fish farm

$f(\cdot)$  is the functional form used

$\beta_j$  is a vector of input parameters to be estimated for  $j^{\text{th}}$  production system

$Z$  is a matrix of factor that influence the technical inefficiency of farms

$\delta$  is a vector of inefficiency parameter to be estimated.

Assuming that any deviation is pure statistical noise ( $V$ ) (such as measurement errors and other unobserved factors or those outside a farmer's control e.g., animal disease outbreak and weather), the TE can be expressed as the ratio of actual output observed to the expected maximum level from the use of available inputs (Boshrabadi *et al.*, 2008):

$$TE_{ij} = \frac{f(X_{ij}, \beta_j) \exp(v_{ij} - Z_{ij}\delta)}{f(X_{ij}, \beta_j) \exp(v_{ij})} = - Z_{ij} \tag{6}$$

A frontier measures individual farmers' performance, relative to the dominant technology in a particular production system. As noted above, all farms do not necessarily operate using the same technology and assuming similar technology might result in measurement errors.

Therefore, the stochastic frontier model in (5), which only allows comparison of farms operating with similar technologies is inappropriate for comparing the

performance of farms across different groups of farms which are basically not identical in terms of technology access and usage (O'Donnell *et al.*, 2008). To accommodate such differences in technology, various alternatives have been proposed in the literature.

Following O'Donnell *et al.*, (2008), the stochastic meta-frontier equation can be expressed as:

$$Q^* = f(X_i, \beta^*) \quad i= 1,2,\dots,N \tag{7}$$

Where  $f(\cdot)$  is a specified functional form;

$Q^*$  is the meta-frontier output;

$\beta^*$  denotes the vector of meta-frontier parameters satisfying the following constraints:

$X$  vector of explanatory variables of farm used

$$f(X_i, \beta^*) > f(X_i, \beta_j) \text{ for all } j=1, 2,\dots,j \tag{8}$$

In order to satisfy the condition in (7), an optimization problem is solved where the sum of absolute deviations (or squared deviations) of the meta-frontier values from the values of the group frontiers are minimized as:

$$\text{Min} \sum_{i=1}^n |\ln f(X_i, \beta^*) - \ln f(X_i, \beta_j)| \tag{9}$$

S.T.

$$f(X_i, \beta^*) \geq \ln f(X_i, \beta_j)$$

The standard errors of the estimated meta-frontier parameters can be obtained through bootstrapping or simulation methods. In terms of the meta-frontier, the observed output for the  $i^{th}$  farm in the  $j^{th}$  production system (measured by the stochastic frontier in equation 5) can be expressed as:

$$Q_{ij}^* = \exp(-Z_{ij}\delta) \cdot \frac{f(X_i, \beta_j)}{f(X_i, \beta^*)} \cdot f(X_i, \beta^*) \exp(v_{ij}) \tag{10}$$

Where (recall from equation 5 that  $-Z\delta = TE$ ) the middle term represent technological gap ratio (TGR) that can be expressed as:

$$TGR = \frac{f(X_i, \beta_j)}{f(X_i, \beta^*)} \tag{11}$$

Given the observed inputs, according to Battese and Rao (2002), the TGR measures the ratio of the output for the frontier production function for the  $j^{th}$  group or production system relative to the potential output defined by the meta-frontier. TGR values a farm in a given production system producing nearer

to the maximum potential output given the technology available for the whole industry.

To account for the wider environment in which production takes place and other factors that might influence the potential productivity gains from a given technology, the TGR is, hereafter, referred to as meta-technology ratio (MTR).

The TE of the  $i^{\text{th}}$  farmer relative to the meta-frontier ( $TE_i^*$ ) is the ratio of the observed output for the  $i^{\text{th}}$  farm relative to the meta-frontier output, adjusted for the corresponding random error such that:

$$TE = \frac{Q_{ij}}{f(X_i, \beta^*) \exp(v_{ij})} \quad (12)$$

Following (6), (10), and (11)  $TE_i^*$  can be expressed as the product of the TE relative to the stochastic frontier of a given production system and the MTR:

$$TE_i^* = TE_{ij} \cdot MTR \text{ (TGR)}_i \quad (13)$$

The explicit form for efficiency model can be estimated as:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \varepsilon \quad (14)$$

Where:

$Y_i$  - Fish output in kg

$Y_{1a}$  - The quantity of fish feed (Coppen alone) in kg;  $Y_{1b}$  - The quantity of fish feed (Coppen and Maggot) in kg;  $Y_{1c}$  - The quantity of fish feed (Coppen and Chicken offal) in kg

The explanatory variables  $X_s$  are:  $X_1$  - Feed quantity (kg),  $X_2$  - Agrochemical (litres),  $X_3$  - Pond size ( $m^2$ ),  $X_4$  - Stock size (number),  $X_5$  - Labour in man day,  $X_6$  - Capital in Naira,  $\beta_0$  - Intercept,  $\beta_i$  - The coefficients to be estimated; they represent the elasticity when the production function is based on Cobb-Douglas's type  $i = 1, 2, 3, n$  Fish Farms;  $\varepsilon$  = stochastic frontier model error term and can be rewritten as;

$$\varepsilon = v - u \quad (15)$$

$V$  = a two-sided normally distributed random error that captures the stochastic effects outside the farmer's control (e.g., weather, natural disasters, economic adversity), measurement errors, and other statistical noise.

$U$  = is a one-sided efficiency component that captures the technical inefficiency of the farmer.

Thus, equation (6) becomes an explicit form of Inefficiency model can be estimated as:

$$U_1 = Z = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 \dots\dots\dots + \delta_n Z_n \quad (16)$$

Where;  $U_1 = Z$  = Technical inefficiency;  $Z_1$  = Educational level (Years of schooling);  $Z_2$  = Farming experience (Years);  $Z_3$  = Membership of cooperative society (dummy);  $Z_4$  = household size. (Number of persons);  $\delta_0$  and  $\delta_i$  = parameters to be estimated ( $i = 1, 2, \dots, n$ ).

## RESULTS AND DISCUSSION

### Socio-economic characteristics of the respondents

Table 1 presents the result on the socio-economic characteristics of the fish farmers in the study area. The result reveals that majority (76.9%) of the fish farmers were male while 23.1% were female. This is an indication that the production of fish is widely popular among the male in the study area while the women are likely to be more involved in fish marketing. This is in consonance with the findings of Oyinloye (2012); Olaoye *et al.*, (2013) in a similar study in Oyo State, Nigeria. A larger percentage (48.3%) of the fish farmers fell between 41 and 50 years of age. The mean age of 41 years implies that the fish farmers were still young and economically active and therefore, have the capacity for high productivity. Distribution by educational level reveals that all the sampled fish farmers were literate, while 10.5% of the respondents had secondary education, 89.5% had tertiary education. This result corroborates The submission of Olayiwola, (2013) that education has positive influence on the understanding and application of improved techniques and probably output level of the respondents. Majority (79%) of the respondents were married. This implies that the fish farmers were responsible. Amos (2006) submitted that married farmers are expected to strive to make rational production decisions that will enhance returns from the business since they may be relying on the produce from the farm to provide for their family members. Majority (65.1%) of the fish farmers had between 1 and 5 persons in their household. The mean household size of 5 persons implies that the fish farmers had small household size which could impact negatively on the availability of family labour in the study area. Distribution by fish farming experience reveals that majority (76.9%) of the fish farmers had fish farming experience of 10 years or less. The mean years of experience of about 8 years implies that had considerable years of experience in fish farming. Experienced fish farmers have good skill, better approaches and ability to forecast market situation in which they sell their products at higher prices. Furthermore, 58.7% of the fish farmers cultured their fish in earthen pond, 32.2% in concrete pond while 9% made use of plastic pond. This implies

that earthen pond was mostly used in the study area. This could be due to the fact that earthen ponds are easier to manage and production is usually faster because of the addition of natural food to supplement artificial feed being given to fish. This result agrees with the finding of Ele *et al.* (2013) that earthen pond was mostly preferred by fish farmers in Calabar. Also, juvenile stocked by 60.1% of the respondents was the most fish stock type in the study area. The reasons given for preferring juvenile to fingerlings were reduced mortality rate and shorter production cycle which gives rooms for more production seasons in a year. In addition, majority (80.4%) of the fish farmers sourced their fish seed (juvenile or fingerlings) from fish farms. This agrees with the work of Raufu *et al.* (2009) that majority of fish farmers in Alimosho Local Government Area of Lagos State obtained their fish seed from fish farms.

### **Production efficiency of different feeding regimes**

#### **The maximum likelihood estimates of the cobb-douglas production frontiers**

For the purposes of this study, fish farmers were grouped into three feed types: i. feed only, ii. feed+ maggot and iii. feed+ chicken offal. The results of the stochastic production frontier are presented in Table 2 which revealed that pond size ( $p < 0.01$ ), stock size ( $p < 0.01$ ) and labour ( $p < 0.01$ ) had positive influence on fish output for group of farmers that fed their fish with feeds only. This implies that an increase in the usage of these inputs will increase fish output for this group of farmers in the study area. This result agrees with the findings of Oyakhilomen *et al.*, (2016) that as labour and the quantity of feed consumed increase, catfish output increases. However, agrochemicals ( $p < 0.05$ ) and capital ( $p < 0.01$ ) had negative significant relationship with fish output for this category of the farmers. This implies that a percentage increase in the quantity of agrochemical used and cost of capital invested will reduce fish output by in fish output by 0.018kg and 0.015kg respectively. The result of the inefficiency model for this group of farmers reveals that educational level of the farmers, their years of experience and membership of cooperative association reduce technical inefficiency as their coefficients were negative and significant at 5% and 1%, respectively. This implies that educated fish farmers who are highly experienced members of cooperative association were technically more efficient and vice versa.

This result is in line with the report of Aminu *et al.*, (2014) that the more the years of experience had by the fisher folks, the more efficient they would be. Pond size ( $p < 0.01$ ), stock size ( $p < 0.01$ ), and capital ( $p < 0.05$ ) had positive

significant influence on fish output for group of the farmers that fed fish with both feed and maggots.

Table 1. Distribution of fish farmers by socio-economic characteristics  
 (N = 143)

Description	Frequency	Percentage
<b>Sex</b>		
Male	110	76.9
Female	33	23.1
<b>Age</b>		
Less or Equal to 30	23	16.0
31-40	42	29.4
41-50	69	48.3
51-60	9	6.3
Mean	41.0	8.3
<b>Educational Status</b>		
Secondary	15	10.5
Tertiary	128	89.5
<b>Marital Status</b>		
Single	23	16.1
Married	113	79.0
Widowed	4	2.8
Divorced	3	2.1
<b>Household Size</b>		
1-5	93	65.1
6-10	49	34.3
>10	1	0.7
Mean	5	
<b>Fish Farming Experience</b>		
≤10	110	76.9
11-20	33	23.1
Mean	7.7	
<b>Pond Type</b>		
Earthen Pond	84	58.7
Plastic Pond	13	9.1
Concrete Pond	46	32.2
<b>Stock Type</b>		
Fingerlings	57	39.9
Juvenile	86	60.1
<b>Fish Source</b>		
Purchased	115	80.4
Self – bred	28	19.6

Source: Field Survey Data, 2018

This implies that fish output under the feed and maggot type increases with increase in pond size, stock size and capital invested in the study area. A 1% increase in these inputs will increase the productivity of this group of farmers by 0.043kg, 1.060kg and 1.237kg respectively. The quantity of agrochemical used was however found to decrease fish output for this group of farmers as it was negative and significant at 5% alpha levels.

The result of the inefficiency model for farmers that fed their fish with both feed and maggots reveals that educational level of the farmers reduced inefficiency as it was negative and significant at 5% alpha levels. This implies that educated farmers were more technically efficient than their uneducated counterpart in this group of farmers.

Table 2. Maximum likelihood estimates of the stochastic production frontier

Variables	Feed only (N=36)		Feed and maggot (N=47)		Feed and chicken offal (N=60)	
	Coefficient	Z-value	Coefficient	Z-value	Coefficient	Z-value
<b>Constant</b>	0.216	2.290	-0.093	-0.573	0.147	1.270
Ln feed	-0.002	-0.466	-0.024	-1.510	0.030**	2.008
Ln agrochemical	-0.018**	-2.740	-0.047**	-2.074	0.038**	2.245
Ln pond size	0.033***	5.781	0.043***	2.720	0.037***	2.586
Ln stock size	1.010***	78.970	1.060***	39.855	1.109***	33.464
Ln labour	0.012***	4.389	-0.006	-0.589	0.012	0.256
Ln capital	-0.015***	-3.121	1.237**	2.033	-0.047***	-3.717
<b>Inefficiency Effects</b>						
Constant	0.298	3.628	0.628	1.233	0.159	0.201
Education	-0.015**	-2.045	-0.993**	-2.018	0.150***	2.564
Experience	-0.036***	-4.545	-0.026	-0.949	-0.107***	-2.764
Cooperative	-0.056**	-2.180	0.018	0.131	-0.401***	-7.289
Household size	-0.043	-0.637	0.039	0.723	-0.435***	-5.685
Sigma square	0.0039***	2.63	0.0037***	4.64	0.141***	7.392
Gamma	0.933	121.142	0.937	12.377	0.953	45.435
Log likelihood	86.366		74.835		48.979	

Source: Field survey, 2018

NOTE: \*\*\*, \*\* Statistical Significance levels at 1% and 5%

In the same vein, feed ( $p < 0.05$ ), agrochemical ( $p < 0.05$ ), pond size ( $p < 0.01$ ) and stock size ( $p < 0.01$ ) had positive influence on fish output for the group of farmers that fed their fish with feed and chicken offal. This implies that an increase in these inputs will increase fish output for this group of farmers. However, capital had negative significant relationship with fish output for this group of farmers at 1% alpha levels. This implies that a 1% increase in the cost of capital invested in feeding fish with feed and chicken offal will decrease fish output by 0.047kg in the study area. The result of the inefficiency model for this group of farmers

reveals that highly educated farmers that fed their fish with feed and chicken offal were less efficient than those with lower level of education as education ( $p < 0.01$ ) had a positive significant relationship with inefficiency for this group of farmers. This result is in conformity with Onumah *et al.*, (2013) that formal education may not necessarily improve one's technical efficiency but the level of one's knowledge and education pertaining to the practices of fish production matters. Inefficiency was however found to decrease with experience ( $p < 0.01$ ), cooperative membership ( $p < 0.01$ ) and household size ( $p < 0.01$ ) in the study area.

The estimated sigma squared is significantly different from zero at 1% for all the feeding regimes indicating a good fit and correct specification of distributional assumptions of the composite error. The estimated gamma parameters were 0.933, 0.937 and 0.953 for feed only, feed and maggots, feed and chicken offal respectively. This suggests that about 93.3%, 93.7%, and 95.3% of the variation in yield among fish farmers were due to the differences in technical efficiency, while 6.7%, 6.3% and 4.7% for feed only, feed and maggots, feed and chicken offal respectively, were due to random shocks outside farmers' control.

#### **Estimates of the stochastic metafrontier model and likelihood ratio (lr) test**

The parameters estimate of the pooled stochastic frontier model and the metafrontier model are presented in Table 3. It was observed from the result of the pooled data that feed ( $p < 0.05$ ) and the stock size ( $p < 0.01$ ) were positive and significantly affect catfish production. This implies that 1% increase in these inputs will increase the output of catfish by approximately 0.025kg and 1.034kg respectively. The result of the inefficiency model for the pooled data reveals that education ( $p < 0.01$ ), cooperative membership ( $p < 0.05$ ) and household size ( $p < 0.01$ ) had negative significant relationship with technical inefficiency in catfish production in the study area. This implies that inefficiency in catfish production decrease with increase in years of education, membership of cooperative society and household size in the study area.

The estimated sigma squared is significantly different from zero at 1% for the pooled sample, indicating a good fit and correct specification of distributional assumptions of the composite error. The estimated gamma parameter for the pooled sampled is 0.877, implying that 87.7% percent of the discrepancies between the observed value of fish output and the frontier output can be attributed to factors within the fish farmers' control.

### **Metafrontier Model**

The likelihood ratio (LR) statistics computed from equation 1 shows that  $\ln[L(H_0)] = 203.376$  and  $\ln[L(H_A)] = 210.18$  and that the generalized likelihood ratio test statistics for the null hypothesis is  $\lambda = 21.698$ . The null hypothesis (fish farmers feeding with the different feeding regimes share the same technology sets) was rejected with chi-square critical value of 13.27 at 1% significant level and 5 degrees of freedom. Thus the data for the three feeding regimes cannot be pooled to estimate the technical efficiency of the fish farmers. This suggests that the production practices and technology were different across the production system. Based on this, the parameters of meta-frontier were estimated by solving the linear programming problem specified in equation (7). This justifies the use of meta-frontier framework for technology differences for the three feeding regimes. Similar results were reported by Onumah *et al.*, (2013) and Aminu *et al.*, (2020).

Contrary to the results of the pooled data, the metafrontier result in Table 3 reveals that an increase in quantity of feeds fed to the fish ( $p < 0.01$ ), increase in pond size ( $p < 0.01$ ) and stock size ( $p < 0.01$ ) would lead to significant improvement in fish output while the use of labour ( $p < 0.05$ ) would reduce fish output by 0.223kg. This result further confirms the appropriateness of metafrontier framework for technology differences for the three feeding regimes.

### **Technical efficiency and technology gap ratio of different feeding regimes**

The results reported in Table 4 reveals that, the mean technical efficiencies from the stochastic frontier models were estimated to be 0.846, 0.867, and 0.829 for feed only, feed and maggot, and feed and chicken offal respectively. This implies that fish output in these feeding regimes were 15.4%, 13.3% and 17.1% below their group frontier. The mean technical efficiency scores for the pooled data was 0.840 indicating that catfish farmers produces 84 percent of the potential output given the technology available to them. Relative to the meta frontier, feed only have a mean TE of 0.797, feed and maggot a mean of 0.801 and feed and chicken offal a mean of 0.804.

This indicates that contrary to the results on technical efficiency relative to SFA, farmers who fed their fish with feed and chicken offal were more technically efficient than other feeding regimes. The average pooled sample TE with respect to the meta frontier was 0.801, implying that there is scope to improve catfish production in the study area by up to about 20% of the total potential (Table 4). It is important to note the difference between the average technical efficiency

scores from the SFA and the meta frontier models. For example, the average technical efficiency for feed and maggot relative to the meta technology is 80.1 percent, while its mean efficiency is quite large with respect to its own SFA, 86.7 percent. The differences between the two efficiency scores confirm the inappropriateness of the technical efficiencies obtained by using the SFA, relative to the technology available for the feeding regimes in the study area

**Table 3. Parameter estimates of the pooled frontier and metafrontier**

Variables	Pooled frontier		Metafrontier	
	Coefficient	z-value	Coefficient	z-value
Constant	0.152	1.395	37.337	14.762
Lnfeed	0.025**	2.006	0.676***	4.562
Lnagrochem	-0.002	-0.161	-0.094	-1.192
Inpondsize	0.013	1.267	1.099***	2.797
Instock	1.034***	5.680	20.237***	9.780
Ln labour	-0.003	-0.385	-0.223**	-2.189
Ln capital	-0.014	-1.679	-0.075	-1.28
<b>Inefficiency Effects</b>				
Constant	1.664	3.912		
Education	-0.132***	-3.188		
Experience	-0.026	-1.313		
Coop membership	-0.287**	-2.156		
Household size	-0.210***	-6.466		
Sigma square	0.102***	8.575		
Gamma	0.877***	9.119		
Log likelihood	133.294			

Source: Field survey, 2018; Note: \*\*\* Statistical significance level at 1%

Estimates of the technology gap ratios (TGR) reveal that the three feeding regimes have a mean potential ratio of 0.841, 0.844 and 0.824 for feed only, feed and maggot, and feed and chicken offal respectively. The values of the TGRs indicate that if catfish producers in the study area were technically efficient, they could have increased the output by closing a gap of 15.9%, 15.6% and 17.6% respectively. The mean technology gap ratio (TGR) in the pooled sample is 0.793, implying that, an average catfish farmer in the study area produces about 79% of the maximum potential output achievable from the available technology. This also indicates that, on the average, the catfish farmers will have to close a gap of about 20.7% in order for them to be technically efficient and that the available technologies are used sub-optimally. Perhaps this can be explained by the view of Diagne (2010) that low rates of adoption or poor use of agricultural technologies in sub-Saharan Africa is largely due to lack of awareness on the technologies and/or technical know-how. The average TGR is highest in feed and maggot (0.844) and lowest in the feed

and chicken offal system (0.824). This is consistent with the differences in relative levels of investments in the fish enterprise by catfish farmers in three production systems.

Further, that the TGR is higher for feed and maggot than for feed only or feed with chicken offal can perhaps be explained by the notion of ‘catching-up or convergence to best practice’ (Rao and Coelli, 1998). This stipulates that, an average fish farmer who conventionally operates below the technology frontier might be expected to adopt technologies at a relatively faster rate than those who produce near the frontier. The maximum estimated TGR is 1 in feed and maggot, feed and chicken offal production systems, which means that the group frontier is at tangent to the metafrontier (Battese *et al.*, 2004); it was found that 2% of farmers in the sample (at least one fish farm from each production system) produce on the metafrontier.

Table 4. Technical efficiency and technology gap ratio of different feeding regimes

Feeding Regimes		SFA-TE	MF-TE	TGR
Feed only	Mean	0.846	0.797	0.841
	Std. Deviation	0.031	0.012	0.101
	Minimum	0.826	0.468	0.508
	Maximum	0.979	0.992	0.999
Feed & Maggot	Mean	0.867	0.801	0.844
	Std. Deviation	0.037	0.091	0.078
	Minimum	0.817	0.556	0.714
	Maximum	0.985	0.983	1.000
Feed & Chicken offal	Mean	0.829	0.804	0.824
	Std. Deviation	0.123	0.096	0.086
	Minimum	0.037	0.514	0.556
	Maximum	0.977	1.000	1.000
Pooled	Mean	0.840	0.801	0.793
	Std. Deviation	0.082	0.101	0.087
	Minimum	0.037	0.468	0.508
	Maximum	0.985	1.000	1.000

Source: Field Survey, 2018

This suggests that in order to achieve further productivity gains (for the small proportion of technology-optimal farmers) it is important to provide a relatively better technology. When TGRs are higher than meta-technical efficiency scores, it implies that individuals are better at using available technologies, but their efficiency measures remain relatively low due to other non-technology factors.

## CONCLUSION

This study applied Meta frontier function technique to investigate technology gaps and technical efficiency in catfish production in the study area. The

outcome of the stochastic frontier analysis showed that feed, pond size, stock, agrochemical and labour significantly affect catfish production in the study area. It was also observed that the elasticity estimates for stock is highest across the three feeding regime with values of 1.010, 1.060, and 1.109 respectively for feed only, feed with maggot and feed with chicken offal. The findings from the stochastic metafrontier analysis showed that the average TGR is 0.841, 0.844 and 0.824 for feed only, feed with maggot and feed with chicken offal, also that the maximum TGR is 0.999 and 1.000 respectively for feed only, feed with maggot and feed with chicken offal, indicating that some fish farmers in the study area were operating close or on the metafrontier. The study concludes that, the catfish farmers exhibited above average efficiency in catfish production implying that farmers were knowledgeable about catfish production techniques. However, the technology gap ratio for feed and chicken offal (which is the lowest) confirms the need for the catfish farmers using the feeding system to step up technology drive for increased catfish technical efficiency.

## RECOMMENDATIONS

The study recommends that, for feed and chicken offal system, the intervention should be to raise technology (to close the gap between the regional frontier curve and the global frontier curve). Feed only and feed with maggot feeding systems could improve their performance through a better management using the available technologies and resources.

## REFERENCES

- Adebayo, O. O. and Daramola, O. A. (2013). Economic analysis of catfish (*Clarias gariepinus*) production in Ibadan metropolis. *Discourse Journal of Agriculture and Food Sciences*, 1(7):128-134
- Adewolu, M. A. and Adamson A.A. (2011) *Amaranthus spinosus* leaf meal as potential dietary protein source in the practical diets for *Clarias gariepinus* (Burchell, 1822) fingerlings. *International journal of zoological Research* 7(2): 128-137
- Agbabiaka, L. A., (2010). Evaluation of some under-utilized protein feedstuffs in diets of *C. gariepinus* fingerlings. *International Journal of Tropical Agriculture and Food systems*, 4(1): 10–12
- Aigner, D., Lovell, K. and Schmidt, P. (1977). Formulation and estimation of stochastic frontier production function models. *Journal of Econometrics*, 6(1):21-37.
- Aminu, F. O., Ayinde, I. A. and Afolami, C. A. (2014). Technical efficiency of artisanal fish production in lower ogun river basin areas of Lagos state, Nigeria. *Journal of Applied Agricultural Research*, 6 (2): 3-15.
- Aminu, F. O., Ayinde, I.A. and Sanusi, R.A. (2020). Technical efficiency and technological gaps in agricultural production in selected African countries: A Stochastic Metafrontier approach. *Middle East Journal of Agriculture Research*, 9(2): 282-293.
- Amos, T.T. (2006). Analysis of backyard poultry production in Ondo state Nigeria. *International Journal of Poultry Science* 5: 247-250.

- Anoop, K.R., Sundar, K.S.G., Khan, B.A., Lalm S., (2009). Common Moorhen *Gallinula chloropus* in the diet of the African catfish *Clarias gariepinus* in Keoladeo Ghana National Park, India. *Indian Birds* 5(2):22-23
- Battese, G.E., Rao, D.S.P. and O'Donnell, C. (2004). A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. *J. Prod. Anal.* 21(1):91-103.
- Battese, G.E. and Rao, D.S.P., (2002). Technology gap, efficiency, and a stochastic metafrontier function. *International Journal of Business and Economics*, 1(2):87-93.
- Battese, G.E., Corra, G.S., (1977). Estimation of a production function model with application to the pastoral zone of eastern Australia. *Australian Journal of Agricultural Economics*, 21:169-179.
- Battese, G.E., Coelli, T.J., (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics*, 20(2), 325-332.
- Boshrabadi, H., Villano, R. and Fleming, E., (2008). Technical efficiency and environmental technological gaps in wheat production in Kerman province of Iran. *Agricultural Economics*, 38(1):67-76.
- Diagne A (2010). Technological change in smallholder agriculture: Bridging the adoption gap by understanding its source. *Afr. J. Agric. Res. Econ*, 5(1):261-286.
- Ele, I.E., Ibok, O.W., Antia-Obong, E.A., Okon, I.E. and Udoh, E.S. (2013). Economic analysis of fish farming in Calabar, Cross River State, Nigeria. *Greener Journal of Agricultural Sciences*, 3(7): 542-549
- Emokaro, C.O and P.A Ekunwe, (2010). Profitability and viability of catfish farming in Kogi State, Nigeria. *Research Journal of Agricultural and Biological Sciences*, 6(3): 215-219.
- FAO, (2002). *Projected population and fish demand and supply in Nigeria*. Food and Agriculture Organization, Rome.
- FAO (2007): *State of world fisheries and aquaculture*. Food and Agriculture Organization, Rome.
- Greene, W. H. (2012). *Econometric Analysis* (Seventh ed.). Boston: Pearson Education. pp. 803–806. ISBN 978-0-273-75356-8.
- International Trade Centre (2002). ITC Databases: Aggregated Trade Centre. <http://www.thewaveonline.com/article/?id=13781> Accessed April 23, 2003.
- Makinde, O.O., Edun, O.M., Akinrotimi, O.A. (2015). Comparative assessment of physical and chemical characteristics of water in Ekerekana and Buguma creeks, Niger Delta Nigeria. *Journal of Environment Protection and Sustainable Development*, 1: 126-133.
- O'Donnell, C.J., Rao, D.S.P. and Battese, G.E. (2008). Metafrontier frameworks for the study of firm-level efficiencies and technology ratios. *Empirical Economics* 34(2): 231-255
- OGADEP (2009). Ogun State Agricultural Development Programme Fisheries Report, 12 p.
- Ogun State Agricultural Development Project (OGADEP) (2005). Statistics of fisheries production in Ogun state (Fisheries Unit). 21pp.
- Olagunju, F.I., Adesiyun, I.O., Ezekiel, A.A., (2007). Economic viability of catfish production in Oyo State, Nigeria. *Journal of Human Ecology*, 21(2): 121-124 (2007)
- Olaoye, O. J., Ashley-Dejo, S. S., Fakoya, E. O., Ikweinwe, N. B., Ashaolu, O. F. and Adelaja, O. A. (2013). Assessment of socio-economic analysis of fish farming in Oyo state, Nigeria. *Global Journal of Science Frontier Research Agriculture and Veterinary*, 13(9): 45 – 55.
- Olaoye, O.J., Ojebiyi, W.G., Opele, A.I., Baiyewu, A.K. (2016). Socioeconomic analysis of small scale fish farmers in Ilaro agricultural extension zone of Ogun State, Nigeria. *Journal of Agriculture, Forestry and Fisheries*, 15(2):64-74
- Olayiwola, O.O. (2013). Technical efficiency of fish production in Ijebu-ode Local Government area of Ogun State, Nigeria. *International Monthly Referred Journal of Research in Management and Technology* 2: 26-42

- Onumah, J.A., Onumah, E.E., Al-Hassan, R.M. and Brumme, B. (2013). Meta-frontier analysis of organic and conventional cocoa production in Ghana. *AGRIC. ECON. CZECH*, 59(6): 271–280.
- Oyakhilomen, O., Murtala, M.O., Abraham, F. and Kwagyang, S.M. (2016). Technical efficiency of catfish farming in Alimosho Local Government Area of Lagos State, Nigeria: A gender perspective. *AGRICULTURAL TROPICA ET SUBTROPICA*, 49(1-4): 45-49
- Oyinloye, Y. M. (2012). Economic analysis of fish farming system and its impact on net farm income in Badagry Local Government Area of Lagos State. An unpublished B.Tech. Project submitted to the Department of Agricultural Economics, Ladoko Akintola University of Technology, Ogbomosho.
- Rao, D.S.P., Coelli, T.J. (1998). Catch-up and convergence in global agricultural productivity 1980-1995. *CEPA Working Paper* No. 98, Centre for Efficiency and Productivity Analysis (CEPA), University of New England, Armidale.
- Raufu, M.O., Adepoju, A.A., Salau, A.S. and Adebisi, O.A. (2009). Determinants of yield performance in small scale fish farming in Alimosho local government area of Lagos State. *International Journal of Agricultural Economics and Rural Development*, 2(1): 9-14
- Sogbesan O. A (2014). Non-conventional animal protein feedstuffs for the culture of catfish. Ibadan University Press (Tetfund, Nigeria). 1-3.

## A Study on Coliform Contamination in Milk at Various Flow Levels and Seasonal Effect on Its Count

**Krishna P. Sharma**

Himalayan College of Agricultural Sciences and Technology, Kathmandu  
krishnabastola2@gmail.com

### **ABSTRACT**

*High microbial load associated with coliform bacteria in milk could lower their keeping quality and might be the sources of potential risk for milk epidemics. A prospective study has been carried out during the period July 2013 to January 2014 with the objective to understand the major steps involved in milk collection and processing and correlate it with the coliform load and milk hygiene in the milk chain system of a dairy plant (A) viz., farmer, collection centre, chilling centre, raw milk reception dock, and packaged milk of summer and winter season. The data were set in a complete randomized design statistical model having 10 treatments with 5 replications. The results showed that average coliform count of farmer, collection centre, chilling centre and reception at dairy of summer season were found to be 4.1820 log<sub>10</sub>, 5.074 log<sub>10</sub>, 5.44 log<sub>10</sub>, and 6.482 log<sub>10</sub> cfu/ml respectively and the average coliform count of farmer, collection centre, chilling centre and reception of winter season were found to be 1.96 log<sub>10</sub>, 3.908 log<sub>10</sub>, 4.232 log<sub>10</sub>, and 5.360 log<sub>10</sub> cfu/ml at dairy respectively. Results indicated that coliform load in milk is much higher than EU regulation (less than 2 log<sub>10</sub> cfu/ml or less than 100 cfu/ml). Coliform count increases rapidly from just after milking to reception at dairy and the coliform load reduces drastically in winter season due to temperature effect. The average coliform count of packaged milk was found to be 1.034 log<sub>10</sub> cfu/ml in summer and 0.7040 log<sub>10</sub> cfu/ml in winter, which crosses the permissible limit of zero per ml (Nepal Gazette, 2001). The high coliform count was due to lack of personal hygiene, chilling facilities, and cleanliness of cattle/shed and improper handling of milk as revealed by the socio-economic survey. Results concluded that coliform load in milk in different flow levels and season differ significantly ( $p < 0.05$ ). The study provides vital information for all the milk handlers to get rid of high coliform load in milk in the milk chain system from farmer to consumer.*

**Key words:** Coliform, VRBA, Milk Chain System, Seasonal effect

## **INTRODUCTION**

Milk is defined to be clean lacteal secretion, practically free from colostrums, obtained by the complete milking of one or more healthy cows, 5 days after and 15 days before parturition, and containing the minimum prescribed percentages of milk fat and milk-solids-not-fat (De, 2011). Milk constituents include water (87.20%), protein (3.50%), fat (3.70%), milk sugar or lactose (4.90%), ash (0.70%) and dry matter (12.80%) (De, 2011).

Milk and milk products consist of high moisture, nearly neutral in pH and are rich in vitamins. Hence, milk easily favors the growth and multiplication of many bacteria, even pasteurized or refrigerated. These bacteria may significantly influence the quality of the milk and milk products. Milk is synthesized in specialized cells of the mammary gland and is virtually sterile when secreted into the alveoli of the udder. Beyond this stage of milk production, microbial contamination can generally occur from three main sources i.e., within the udder, the exterior of the udder and the surface of the milk handling and storage equipment (Godefay and Molla, 2000). Bacterial contamination of raw milk can originate from different sources: air, milking equipment, feed, soil, feces and grass (Coorevits *et al.*, 2008). The number and types of micro-organisms in milk immediately after milking are affected by factors such as animal and equipment cleanliness, season, feed and animal health. It is hypothesized that differences in feeding and housing strategies of cows may influence the microbial quality of milk (Coorevits *et al.*, 2008). Rinsing water for milking machine and equipment washing may also be responsible for presence of high number microorganisms including pathogens in raw milk (Bramley *et al.*, 1990). Gram-negative bacteria usually account for more than 90% of the microbial population in cold raw milk that has been stored (Buchanan *et al.*, 1984). Although milk is known to possess several antimicrobial systems, bacterial numbers will double in less than 3 hours in unchilled milk. The rate of microbial growth will depend on initial numbers and the temperature at which milk is held after milking and thereafter (Kurwijila *et al.*, 1992).

The increase in urban population during the present century and improvements in methods of milk preservation have led to large scale transportation of milk from the producer to the consumer areas (Mirkena, 2010). Raw milk collection and its transportation to the processing centers present a number of technical, economical and organizational problems in most developing countries in tropical regions (Mirkena, 2010). These have inevitably increased the risk of infection of many people from a common source. Lack of refrigeration facilities at the farm and household level, with high ambient temperature implies that raw

milk will easily be spoiled during storage and transportation (Gilmour, 1999). Diseases that commonly spread from the milk to human beings are tuberculosis, brucellosis, salmonellosis, listeriosis, campylobacteriosis, yersinosis, and other bacterial pathogens transmitted to humans include *streptococcus agalactiae*, *staphylococcus aureus* and *Escherichia coli* (Hahn, 1996).

Milk in most places in Nepal is consumed raw. Milk products such as yoghurt and butter are also produced using raw milk as a starting material. Hence, there exists the possibility of consuming milk, which has been contaminated with disease causing organisms. Hygienic quality control of raw milk and milk products in Nepal is not usually conducted on routine basis. Apart from this, door to door raw milk delivery in the urban and peri-urban areas is commonly practiced with virtually no quality control at all levels. So this study was conducted to identify the microbiological contamination of raw and pasteurized milks from the selected milk processing plant.

## METHODOLOGY

The samples required for this study were collected from a dairy having milk chain system of Kathmandu valley. A total of 50 samples were collected from farmers/milk producers and 5 samples were collected in each steps of milk chain system viz., collection centre (CO), chilling centre (CC), Reception (RP), Packaged milk (PM) of summer and winter season. A random sampling method was adopted during sample collection. As far as possible, the same lot of milk was used for analysis at different stages. The laboratory of Himalayan College of Agricultural Sciences and Technology (HICAST) was used for testing the samples. All samples were analyzed in the strict aseptic environment (spirit and flame sterilized). The milk samples were mixed thoroughly by gently inverting the milk vial 20 to 25 times. Serial dilution technique was applied prior to the pour plate technique to thin out the microbial population in the sample where it was necessary. Dilutions of milk sample were prepared by a series of sterile Quarter Strength Ringers Solution (QSRS). Enumeration of Coliform bacteria is based on the assumption that a single viable microbial cell forms a visible colony in VRBA media when diluted sample is incubated in optimum temperature. All colonies on plates were counted after incubation period. Every sample of milk had two plates of different consequent dilutions. The dilutions of the sample were selected such that the total number of colonies in one plate was between 30 to 300 (NDDDB, 2001). The average Coliform count of all milk samples were expressed as  $\log_{10}$  cfu/ml. Number of colony forming units per ml (cfu/ml) was calculated as per NDDDB (2001). Number of colony forming units (cfu/ml) =  $\sum_c / v (n_1 + 0.1 n_2) d$ . Altogether there were 10 treatments viz.,

summer-farmer, summer-collection center, summer-chilling center, summer-reception, summer-packaged milk, winter-farmer, winter-collection center, winter-chilling center, winter-reception and winter-packaged milk. 5 replications were done for each treatment. The data obtained were statistically analyzed by using Genstat (3.4.2). Analysis of variance (ANOVA) was performed. The differences among sample means were separated by use of the least significant difference (LSD) test (Gomez and Gomez, 1984).

## RESULTS AND DISCUSSION

### Socio-economic survey

Socio-Economic survey of farmers of Banepa revealed that 100% of the farmers did not get training related to milk production. Sixty five percent of the farmers did not have the knowledge of common disease and 100% of the farmer did not have the knowledge about coliform bacteria. 70% of the farmer sold last night milk and 67.5% of the farmers added unsanitized water in milk before selling. Only 45% of farmer trimmed their nails frequently while 100% of the farmers did not chill the milk after milking. Only 47.5% of farmers washed hands and utensils daily. 90% of the farmers washed udder before milking but 82.5% of the farmers did not wash udder after milking. Only 10% of the farmers cleaned their cattle daily.

Table 1. Coliform count

Season	Flowlevel	Mean Colony Count (log <sub>10</sub> cfu/ml)
Summer	Farmer	4.182
	Collection center	5.07
	Chilling center	5.44
	Reception at dairy	6.42
	Packaged milk	1.03
Winter	Farmer	1.96
	Collection center	3.90
	Chilling center	4.23
	Reception at dairy	5.36
	Packaged milk	0.70

### Effect of season

The coliform load reduced drastically in winter season by 27% but not reduced to acceptable limits. The reason in high reduction of coliform count on winter season was due to temperature effect. Bramley (1990) reported that some species of the genera making up the coliform group of bacteria are psychrotrophic and constitute 10–30% of the whole group of micro-organisms;

the majority of these coliforms are *Aerobacter* spp. (Salman and Hamad, 2011) did a similar study, the percentage of the highest count of more than 1100 cell/ml was higher in summer (17.1%) compared to 8.4% during winter. The coliform load in milk due to season differ significantly ( $p < 0.05$ ) (Table 2).

Table 2. Effect of season

Treatments	Values ( $\log_{10}$ cfu/ml)
Summer	4.44
Winter	3.23
P< 0.05	0.028
L.S.D	1.074

### Effect of flow level

The coliform goes on increasing from farmer to reception at dairy. The time lag between farmers to collection centre, collection center to chilling center and chilling center to reception is major factor responsible for the milk contamination. Fresh milk drawn from a healthy cow normally contains a low microbial load (less than 1000 per ml), but the loads may increase upto 100 fold or more once it is stored for sometimes at normal temperatures (Mirkena. 2010). After observing the milking practices at noon and evening, the researcher seriously felt the need of chilling vat and its lack was the major cause of milk degradation. Moreover, it was also found that milk had to be left for 10 to 15 hours at night before being transported to the chilling centre. Improper cooling and prolonged storage of milk can also influence bacterial count by increasing the rate of bacterial growth during storage of milk (Kagki *et al.*, 2007). In most of the cases, the narrow opening utensils were in practice for milking, handling and transportation. Apparently it was seen that cleaning and washing such utensils was almost impossible because of inaccessibility. In majority of cases, part of spoiled milk that deposited in the milking utensils might have contributed greatly in milk contamination. The coliform load in milk due to flowlevel differ significantly at  $p < 0.01$  (Table3).

Table 3. Effect of flowlevel

Treatments	Values ( $\log_{10}$ cfu/ml)
Farmer	3.07
Collection center	4.49
Chilling center	4.84
Reception	5.92
Packaged	0.87
P<0.01	<0.001
L.S.D	0.827

### Effect of treatment combination

The coliform count increased significantly from farmer to collection center. There was no significant increase in count from collection center to chilling center because milk immediately goes to chilling below 10<sup>0</sup>C at chilling centre. Only psychotropic organisms grow at that temperature. There is a significant increase in count from chilling center to reception at dairy. The coliform count decreased drastically during pasteurization of milk at dairy. So, there is very little number of microorganisms in packaged milk. There is a significant difference in treatment combination (flowlevel\*season) at p<0.05 (Table 4).

Table 4. Effect of treatment combination

Treatments	Value (log <sub>10</sub> cfu/ml)
Summer-Farmer	4.18
Summer-Collection	5.07
Summer-Chilling	5.44
Summer-Reception	6.48
Summer-Packaged	1.03
Winter-Farmer	1.96
Winter-Collection	3.90
Winter-Chilling	4.23
Winter-Reception	5.36
Winter-Packaged	0.70
P<0.05	0.03
L.S.D	0.78

### CONCLUSION

The results obtained in this study concluded that raw Cow's milk available to consumers was highly contaminated with the coliform. High and strict preventive measures like regular washing and sterilization of dairy equipment, utensils, milker's hands, and animal udders, pasteurization of milk before distribution to consumers and eradication of diseased animals from the herd are highly recommended. In this respect pasteurization and immediate cooling to 5°C of milk could be more effective. In the milk chain system, the bacterial load from collection centre to chilling centre was seen relatively similar. But other two different points were seen to be reformed urgently. Collection centre and its entire milking operation was questionable, similarly the chilling center's operation and tanker parties were also equally responsible for milk deterioration. Especially when the government or related authority tries to implement the quality based program, these two points need to be considered as the target in the milk chain system.

## REFERENCES

- Bramley, A.J., McKinnon, C.H. and Simpkin, D.L. (1990) 'The effect of udder infection on the bacterial flora of the bulk tank milk of ten dairy herds', *Journal of Applied Bacteriology*, 1, pp. 57-17.
- Buchanan, R.E. and Gibbon, N.E. (1984) *Bergey's manual of determinative microbiology*, Baltimore: William and Wilkins Co., Newyork.
- Coorevits, A., De Jonghe, V., Vandroemme, J., and Reekmans, R. (2008) 'Comparative analysis of the diversity of aerobic-spore-forming bacteria in raw milk from organic and conventional dairy farms', *System. Appl. Microbiol*, 31 (2), pp. 126-140.
- De. S. (2011) *Outlines of Dairy Technology (34<sup>th</sup> ed.)*. New Delhi, India: Oxford University Press.
- EU (1998) *Council directive. 92/46/EEC* (1).
- Gilmour, D. (1999) *Milking in small holder dairy in tropics*. ILRI, Nairobi Kenya, pp. 36-37.
- Godefay, B. and Molla, B. (2000) 'Bacteriological quality of raw milk from four dairy farms and milk collection center in and around Addis Ababa', *Berl.Munich. Tierarztl wschr*, 113, pp. 1-3.
- Gomez and Gomez. (1984) *Indian Standards: 4079 1967*. Indian Standard methods of testing dairy products, India.
- Hahn, G. (1996) *Pathogenic bacteria in raw milk-Situation and significance*. Symposium on bacteriological quality of raw milk, Wolfpassing. Austria, pp. 60-64.
- Kagki, D. M., Vancanneyt, M., Vandamme, P. and Cogan, T. M. (2007) 'Contamination of milk by enterococci and coliforms from bovine', *J. Appl. Microbiol*, pp. 1364-507.
- Kurwijila, R.L., Hansen, K.K., Macha, I.E, Abdallah, K. and Kadigi, H.J.S. (1992) 'The bacteriological quality of milk from hand and machine milked dairy herds in Morongo, Tanzania', *Journal of African Livestock Research*, 2, pp. 59-67.
- Mirkena, A.A. (2010) *Microbiological safety of pasteurized and raw milk from milk processing plants in and around Addis Ababa*. Dissertation submitted to the partial fulfillment of the requirements for the degree of Masters of Science in Environmental Science, Addis Ababa university, Addis Ababa.
- NDDB (2001) '*Laboratory hand book for dairy industry*'. National Dairy Development Board, Lalitpur.
- Government of Nepal. *Nepal Gazette*. (2001) 50 (42), pp. 1-4.
- Salman, A. M. A. and Hamad, I. M. (2011) 'Enumeration and identification of coliform bacteria from raw milk in Khartoum state, Sudan', *Journal of Cell and Animal Biology*, 5, (7), pp. 121-128.

## Adoption Analysis of Recommended Production Technologies for Potato in Pyuthan District

**\*Usha Adhikari and Binayak P Rajbhandari**

HICAST, Purbanchal University, Kathmandu

**\*Corresponding Author:** adhikariusha201@gmail.com

### ABSTRACT

*The present study was conducted from November to January 2021 in Pyuthan district. Altogether 100 respondents were selected by purposive sampling method. Study showed that 100 % of respondents were using improved varieties of potato and about 58% of respondents had adopted recommended seed rate and spacing in potato cultivation. Only 31% of respondents had taken training on potato cultivation techniques. Majority of the respondents (88%) were cultivating Cardinal and Desiree variety of potato followed by Kufri Jyoti (31%). Late blight was the major disease followed by viral disease. Red ant and white grub were the major pests. Majority of the potato growers used chemical management method followed by cultural and botanicals to manage diseases and insect pests. Only 67% of the respondents had adopted earthing up practices. Only 22% of farmers were adopting haulm pulling practices. Majority of the respondents (79%) produced 4-8 quintals/ropani potato; and the average yield was 6.71 quintals/ropani. The study revealed that association between training received and annual income had significant relation with the extent of adoption. Major problems faced by the potato growers were: i) unavailability of quality seed ii) incidence of disease, insect pests and rodent.*

**Key words:** Adoption analysis, quality seed, diseases, insect pest, staple food

### INTRODUCTION

Nepal is an agricultural country having diversified type of climatic condition. Agriculture is the mainstay of the economy accounting for one third of GDP (CBS, 2017). Major agricultural product includes paddy, maize, wheat, finger-millet, potato, lentils, tea etc. The total cultivated area of Nepal is about 3,091,000 hectares only.

Potato is an important staple food crop for food security. In Nepal, it occupies first position in term of productivity (16.05 t /ha), 2nd position in total production (3,112,947 ha), and 5th position in area of production (MOAD, 2018/19). Potato is cultivated in a wide variety of climates from subtropical to temperate regions in Nepal (Bajracharya & Sapkota, 2017). Because of the dry matter, edible energy, and edible protein content, it is grown worldwide in about 150 nations of the world as staple food. It is one of the major staple food crops

and source of income for smallholder farmers in high mountainous region of Nepal (Timsina, et al., 2011).

Pyuthan is situated in the Midwestern Nepal. Its elevation ranges from 350 m to 3659 m from mean sea level. The total area of district is about 125,922 ha, out of which cultivated land is 22,175 ha i.e. 51.8% of total land (DADO, 2017/18). Cultivated land in Pyuthan is classified into *khet* (low land) and *bari* (up land) based on irrigation facility and topography. In Pyuthan, *khet* (low land) and *bari* (up land) comprise 28.5% and 71.50% of cultivated land respectively (DADO, 2017/18). Potato is cultivated almost in all area of the Pyuthan district because of the suitable soil and climate. Nowadays majority of the farmers use improved variety for the higher yield and production. In Pyuthan, the total potato cultivated area is 1,062 ha, production is 16,622 Mt and productivity is 15.65 Mt/ha (MOAD, 2018/19).

## MATERIALS AND METHODS

The study was carried out in one municipality and two rural municipalities of Pyuthan district where farmers were involved in potato production. Out of 100 respondents, 35 respondents were selected from Pyuthan municipality, 35 respondents from Mallarani rural municipality and 30 respondents from Airawati rural municipality for household survey. Primary data were collected through field survey. Direct interview was done with the respondents through pretested questionnaire to meet the objectives of the study. Secondary data were collected from Agriculture Knowledge Center (AKC), Nepal Agricultural Research Council (NARC), Central Bureau of Statistics (CBS), HICAST library, National and International journals and different websites.

### Variables and measurement of adption of improved technologies

Six different potato production practices like seed rate, spacing, chemical fertilizer, earthing up, fungicides/insecticides and haulm pulling were taken as independent variables for adoption analysis. Depending upon the extent of adoption of improved production technologies the respondents were categorized into three catagories (Lamichhane et al., 2015): i) Low adopters (LA) from 0 to 33 percent; ii) Meadium (partial) adopters (MA) from 34 to 66 percent; and iii) High adopters (HA) from 67 to 100 percent.

### Data analysis

The obtained data was systematically arranged. The entire interview schedule filled during the field work was thoroughly checked, codes were designed and units were standardized wherever necessary before entering the data into the

computer. Various analytical softwares like SPSS, MS-EXCEL were used for the data analysis. A chi-square test for independence was used to determine whether there is a statistically significant relationship between the two independent variables.

$$\chi^2 = \sum \frac{(O_{ij} - E_{ij})^2}{E_{ij}}$$

Where,  $\chi^2$ =Chi-square value

$O_{ij}$  = observed frequency of each ijth term

$E_{ij}$ = indicates expected frequency of ijth term

i= 1, 2, 3..... r

j= 1, 2, 3.....k

This was tested at 0.05 level of probability for different degree of freedom.

## **RESULTS AND DISCUSSION**

### **Adoption of recommended production technologies of potato**

The table 1 reveals that majority of the respondents (61%) were adopting recommended seed rate. Similarly recommended spacing adopters were (58%) in the study area. Recommended dose of inorganic fertilizer adopters were (41%) only. Majority of the respondents (67%) used earthing up practices indicating that such growers were high adopters of that technology. It was also observed from the table that 58% of the respondents were using fungicides and insecticides in potato field indicating that such growers were the medium adopters of that technology. Study revealed that only 22% of the respondents were adopting haulm pulling practices in potato. This group of the potato growers fell into the category of low adopters of that technology.

Table 1. Adoption of recommended production practices of potato

SN	Recommended production practices of potato	Adoption (percentage)	Category of adopters
1	Seed rate	61	Medium adopter
2	Spacing	58	Medium adopter
3	Inorganic fertilizer	41	Medium adopter
4	Earthing up	67	High adopter
5	Fungicides and insecticides	58	Medium adopter
6	Haulm pulling	22	Low adopter

### **Association between training received and adoption**

Association between training received by respondents and extent of adoption level were statistically significant. It means there was association between training received by respondents and extent of adoption (Table 2).

### Association between respondents' annual income and adoption

Association between annual income of respondents from potato and extent of adoption were statistically significant (Table 3). It means there was association between annual income of respondents from potato and extent of adoption.

Table 2. Association between training received and extent of adoption

Training	Extent of adoption		Total (%)	Adoption category	Chi square value	P-value
	Low	Medium				
Not Received	5 (13)	26 (18)	31	Low	12.34*	0.00
Received	37 (29)	32 (40)	69	High		
Total	42	58	100			

Figures in the parentheses indicate expected frequency; \*Indicates significant at 0.05 level of significance

Table 3. Association between respondent's annual income and extent of adoption

Annual income	Extent of adoption		Total (%)	Adoption category	Chi square value	P-value
	Low	Medium				
Less than 15,000	11 (5.5)	2 (7.5)	13	Low	15.732*	0.00
15,000-60,000	31 (33.2)	48 (45.8)	79	High		
More than 60,000	0 (3.4)	8 (4.6)	8	Low		
Total	42	58	100			

Figures in the parentheses indicate expected frequency; \*Indicates significant at 0.05 level of significance

### Major problems of the potato growers and their priorities

The table 4 show that major problems faced by the potato growers during potato cultivation was unavailability of quality seed (79 %) followed by disease and insect pest problems (73%) and marketing problem (64%). Other problems included inadequate technical support (58%), storage problem (45%), lack of training (38%) etc. Prioritization of the problems revealed that three most important problems to be addressed immediately included: i) unavailability of quality seed; ii) Disease and insect and rodents problem; and iii) Marketing problem.

Table 4. Major problems of the potato growers (N=100)

Problems	Percentage	Prioritization
Inadequate technical support	58	IV
Unavailability of quality seed	79	I
Marketing problem	64	III
Lack of training	38	VI
Insufficient irrigation	24	VII
Shortage of insecticides/pesticides	23	VIII
Disease and insect and rodents problem	73	II
Storage problem	45	V

## CONCLUSION

This study has revealed insights about the lower adoption of improved potato production technologies resulting in relatively lower yield and production.

The study found that majority of the potato growers in Pythan used recommended seed rate (61%) and spacing (58%) and also performed earthing up practices (67%). Fifty eight percent of the growers used chemical methods for plant protection. Very few (22%) of potato growers had adopted haulm pulling practices; and 44% of the growers used inorganic fertilizers only.

Association between training and annual income had significant relation with the extent of adoption.

Major problem faced by the potato growers was unavailability of quality seed and incidence of disease and insect pest as well as rodent problem.

## REFERENCES

- Bajracharya, M. & Sapkota, M. (2017) Profitability and productivity of potato (*Solanum tuberosum*) in Baglung district, Nepal. *Agriculture and Food Security*.
- CBS. (2017) *Statistical Year Book* : Central Bureau of Statistics.
- DADO. (2017/18) *Pyuthan Agriculture Diary*. Pyuthan: DADO.
- Lamichhane, J. et al. (2015) Adoption analysis of improved maize technology in western hills of Nepal. *Journal of maize research and development*, 1(1): 146-152
- MOAD. (2018/19) *Statistical information on Nepalese Agriculture*. :Ministry of Agriculture and Livestock Development.
- Singh, R.P., Kumar, R. & Singh , N.P., (2005) Identification of pulling factors for enhancing the sustainable development of agriculture with special reference to Maize in India. *CAPSA Working Paper No 88*, UN, ESCAP.
- Timsina, K.P. (2011) Economics of potato production in Taplejung district of Nepal. Clinton, Pereire, A. B. & Eldredge, E. P. (2007) Irrigation best management practice for potato. *American journal of potato research*, 84, 29-37.
- Timsina, K.P. et al. (2012) Adoption analysis of rice varieties in Terai of Nepal. In *the Proceedings of 10<sup>th</sup> National Outreach Research Workshop*, Lumle, February 27-28, 2012. Khumaltar, NARC.

## Effects of Khesari Leaves (*Lathyrus sativus*) Inclusion in Broiler Diet on Growth Performances of Broiler Chicken

Luma N Pandey<sup>1\*</sup>, Md. Husneid Azad<sup>2</sup>, D K Yadav<sup>3</sup> & S Ghimire<sup>4</sup>

<sup>1</sup>National Animal Nutrition Research Center, Khumaltar, Lalitpur

<sup>2</sup>National Outreach Research Centre, Khumaltar, Lalitpur

<sup>3</sup>Directorate of Agricultural Research, Province N 2, Parwanipur, Bara

<sup>4</sup>Mahabharata Village Development Committee, Kavre

\*Corresponding Author: luma.pandey@yahoo.com

### ABSTRACT

An experiment was conducted at Directorate of Agricultural Research, Province N 2, Parwanipur, Bara for 42 days to evaluate the effect of Khesari (*Lathyrus sativus*) leaves feeding on broiler production. Altogether 120 day old Cobb-500 broiler birds were divided into 3 treatments with 4 replications (10 birds in each replication) by using completely randomized design. Experimental birds were provided adlib grower feed (B<sub>1</sub>) for 21 days and that after finisher feed (B<sub>3</sub>) for 21 days and had easily access to drinking water. Control group (T<sub>1</sub>) was provided concentrate mixture only, whereas in T<sub>2</sub> and T<sub>3</sub> groups concentrate mixture was replaced by Khesari leaves at the rate of 5 % and 10 %, respectively. The replacement was started from 14<sup>th</sup> days of experimentation to end day of trial to the treatment groups (T<sub>2</sub> and T<sub>3</sub>). Feed intake was recorded daily and body weight gain was measured in 7 days interval. Result showed non- significant difference ( $p>0.05$ ) in body weight among the diet group. Similarly, cumulative feed intake was also observed non-significant ( $p>0.05$ ) among diet groups. There was non-significant effect ( $p>0.05$ ) in feed intake during experimental period at 42 days between treatment groups. Similarly, mean FCR was observed similar among the treatment group ( $p>0.05$ ). Likewise, carcass and organ characteristics were not differed significantly. Hence, the result suggested that inclusion of Khesari leaves up to 10% of broiler diet could be a cost effective feeding management in poultry production.

**Key words:** Khesari leaves, growth performance, Broiler chicken

### INTRODUCTION

Broiler chickens (*Gallus gallusdomesticus*) are a gallinaceous domesticated fowl breed and raised specifically for meat production. The modern broiler industry is confronted with a range of commercial products for use in broiler diets to

increase performance and improve returns on investment. On the other hand, smallholders' poultry farming in remote and rural areas have some constraints in obtaining commercial feed. Forages (grasses and legumes) are natural resources which could be exploited in poultry feeding. This could be a sustainable and cheaper way of poultry raising. Moreover, their availability in rural areas, also not be in doubt. Including forage in poultry diet in recommended level could support farmers by reducing cost, maximize profit and sustain feed supply (Ndelekute *et al.*, 2018). Poultry can obtain a small amount of energy from forage, but utilize amino acids more efficiently found in forages (Buchanan *et al.*, 2007). It can provide supplemental minerals such as calcium which can utilize efficiently the poultry digestive system (Blair, 2008).

Khesari (*Lathyrus sativus*) could be prominent fodder specie for incorporating in poultry diet. It is also known as grass pea, is commercially an important legume crop, successfully cultivated in different parts of the world including, Europe, the Middle East, Northern Africa, South Asia and China. The Khesari leaves are rich in nitrogen which could be essential or vital for monogastric animals feeding when harvested at an advanced stage of maturity. It can be used for seed and green leaf for human consumption and forage for livestock feeding (Dixit *et al.*, 2016).

Several works have been continued on the utilization of forage on poultry diet since last few years. Ansari *et al* (2012) included neem (*Azadirachta indica*) leaf meal in broiler diet and found improved blood indices without any deleterious effects. Gadzirayi *et al* (2012) showed similar results to conventional commercial feeds in weight and growth rates when fed at the 25% inclusion level of mature *Moringa oleifera* leaf meal as a protein supplement to soyabean meal to broiler. Moreover, Pawpaw (*Carica papaya*) leaf meal was reportedly incorporated at the 2% level in the diet of finishing broilers (Onyimonyi *et al*, 2009). However, limited information was available regarding the utilization of Khesari forage as chicken diet. The Khesari leaves as a substitute of commercial concentrate feed in broiler diet had not been evaluated so far in Nepal, hence, the study was intended to evaluate the effects of different level of khesari leaves on production of broiler chicken.

## MATERIALS AND METHODS

### Experimental birds and feed management

The experiment was carried out on Cobb 500 broiler chickens at Poultry Research Unit of Directorate of Agricultural Research, Province N 2,

Parwanipur, Bara from 2<sup>nd</sup> December 2018 to 14<sup>th</sup> January 2019 (076/08/16 to 076/9/28 BS) for 42 days. One hundred thirty-five-day old birds were procured from Shivam hatchery, Birgung, Parsa and were allotted into three treatments with four replications having 10 birds in each replication by using Complete Randomized Design (CRD). All experimental birds were vaccinated with F1 vaccine @ one drop /bird against Ranikhet at the first week. The vaccination schedule was followed as referred by broiler vaccination protocol.

### Chemical analysis

Representative samples of compound feed and Khesari leaves were analyzed in the laboratory of National Animal Nutrition Centre, Khumaltar, Lalitpur for Dry Matter (DM), crude Protein (CP), crude Fibre (CF), organic matter (OM) and ash contents (TA). The DM was determined by oven drying at 100°C for 24 hrs. Crude protein of the samples was determined by using the Kjeldahl method. Ash content was determined by ashing at 550°C in a muffle furnace for 16 hrs (AOAC, 1980). Crude Ether of the samples was determined using the Van-Soest method (Goering, H.K. and Van Soest, 1970).

### Experimental diets

The following experimental diets were provided to the birds (Table 1).

Table 1. Experimental diet

Treatment	Diet
1	Adlib concentrate mixture
2	95 % concentrate mixture + 5% Fresh Khesari leaves (DM basis)
3	90 % concentrate mixture + 10% Fresh Khesari leaves(DM basis)

### Feeding regime

Concentrate mixture and Khesari leaves were given on group basis and were provided to the experimental birds twice a day (morning and evening) in *adlib* amount for both periods (starter–21 days and finisher – 21 days) of the experiment. Drinking water was provided in adequate amount. Khesari leaves were offered from 14<sup>th</sup> day of trial to T<sub>2</sub> and T<sub>3</sub> broilers group.

### Data analysis

Quantity of concentrate mixture given daily to the birds in groups weighed daily and refusal was weighed in the next morning for determining feed intake. The body weight gain was measured in group basis (replication-wise) in 7 days

interval in the morning before feeding. Obtained data were analyzed by using statistical package SPSS 16 version.

At 42<sup>nd</sup> days total 12 chickens, one from each replication were randomly selected, starved for 12 hours before slaughter, and slaughtered by severing the neck then dry de-feathered by hand plucking. The birds were eviscerated and the carcass weight of an individual bird was measured. The dressing percentage calculated as;

$$\text{Dressing \%} = \text{carcass wt.} / \text{live wt} \times 100$$

Dressed carcasses were further cut into parts to obtain carcass and organs.

## RESULTS AND DISCUSSION

### Chemical composition of concentrate mixture

The chemical composition of concentrate mixture and Khesari leaves is given in Table 2.

Table 2. Chemical composition of the compound feed (on DM basis)

Feedstuffs	DM	TA	OM	CP	CF
Feed (Starter)	90.47	6.15	93.85	22.16	3.69
Feed (Finisher)	88.60	4.58	95.42	19.37	4.28
Khesari leaves	21.7	10.5	69.4	24.2	25.8

### Cumulative feed intake

The average feed intake of experimental bird is presented in Table 3 and Khesari leaves intake in Table 4.

Table 3. Feed intake of the experimental bird /day, g (Mean ±SD)

TR T	Days							Cumulative feed intake
	0	7	14	21	28	35	42	
1	6.8±0.42	35±0	67.4±0.5	106.55±4.5	149.5±2.5	186.55±2.5	213±0	4541.95±28
2	6.1±4.7	35±0	68.0±0	111.0±0	152.0±0	189.0±0	211±0	4575±0.8
3	6.5±6.08	35±0	68.0±0	111.0±0	152.0±0	189.0±0	215±0	4573.7±1.5
Mean	6.48±6.03	35±0	67.8±1.2	109.5±1.5	151.17±0	188.2±0.8	213±0	4563.5±9.6
P value	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05

Mean feed intake of experimental birds was recorded 35 g in 7 days which reached 213 g at the end of experiment (42 days) which was non-significant ( $p > 0.05$ ) among diet groups. By the 28 days of experiment, highest feed intake was recorded for T<sub>2</sub> and T<sub>3</sub> (152 g) followed by T<sub>1</sub> (149.5 g). Similarly, at the 35 days of experiment, feed intake was higher in T<sub>2</sub> and T<sub>3</sub> group (189 g) followed by T<sub>1</sub> (186.55 g). Finally, at the 42 days of experiment, feed intake was higher in T<sub>3</sub> group (215 g) followed by T<sub>1</sub> (213 g). The cumulative feed intake was highest for T<sub>2</sub> (4575 g) followed by T<sub>3</sub> (4573.7g) and T<sub>1</sub> (4541.95g), respectively. There was non-significant effect in feed intake during 7, 14, 21, 28, 35 and 42 days of experimentation among diet groups.

Table 4. Feed intake (Khesari forage) of experimental bird/day (Mean±SEM)

TRT	Days						
	0	7	14	21	28	35	42
1	0	0	0	0	0	0	0
2	0	0	3.4±0	5.55±0	7.6±0	9.45±0	10.65±0
3	0	0	6.8±0	11.1±0	15.2±0	18.9±0	21.3±0
Mean	0	0	3.4±0.83	5.55±1.36	7.6±1.87	9.45±2.32	10.65±0
P-value			p<0.05	p<0.05	p<0.05	p<0.05	p<0.05

Mean Khesari intake of experimental birds was recorded 3.4 g in 14 days. Mean Khesari consumed recorded for T<sub>2</sub> (7.6 g) and T<sub>3</sub> (15.2 g) at 28 days of the experiment. By the 42 days of experiment, highest Khesari intake was recorded for T<sub>3</sub> (21.3 g) and T<sub>2</sub> (10.65 g). From beginning to end of the experimentation Khesari leaves intake was found to be significant ( $p < 0.05$ )

### Body weight and FCR of the Experimental Birds

The body weight experimental birds are given in Table 5.

Table 5. Body weight of experimental birds, g (Mean± SD)

TRT	Days							FCR
	0	7	14	21	28	35	42	
1	42.85± 0.56	136.8 ±1.93	364.87 ±2.1	762.5± 5.3	1278±1 4.8	1966.2± 39.56	2706.5 ±61.97	1.7
2	44.10± 1.34	139 ±2.07	365.75 ±8.2	739.37 ±7.77	1252.25 ±7.56	1837.35 ±13.02	2720± 21.6	1.71
3	42.35± 0.24	140.35 ±0.74	371.13 ±6.2	724.75 ±8.7	1203.25 ±6.93	1753.9± 10.56	2577.5 ±31.1	1.8
Mean	43.1± 0.5	138.7 ±0.98	367.25 ±3.27	742.2± 6.07	1244.5± 10.8	1852.49 ±29.34	2668± 29.14	1.74
P value	p>0.05	p>0.05	p>0.05	p<0.05	p<0.05	p<0.05	p>0.05	p>0.05

Table 5 showed that average body weight of experimental birds was 43, 138.7, 367.25, 742.2, 1244.5, 1852.49 and 2668 g for 0, 7, 14, 21, 28, 35 and 42 days, respectively. At the 7 days of experiment, highest body weight was noted for T<sub>3</sub> (140.35 g) followed by T<sub>2</sub> (139g). Similar trend observed in 14 days (371.13 and 365.75 g for T<sub>3</sub> and T<sub>2</sub>, respectively). In 21, 28 and 35 days of experimentation, highest body weight was found in T<sub>1</sub> (762.5, 1278 and 1966 g for 21, 28 and 35 days, respectively) followed by T<sub>2</sub> (739.37, 1252 and 1837 g for 14, 21 and 28 days, respectively). Similarly, in the end of the experiment (42 days), highest body weight was found in T<sub>2</sub> (2720 g) followed by T<sub>1</sub> (2706 g). The body weight of experimental birds from 7 to 42 days of experimentation was not affected by diet and was non-significant ( $p>0.05$ ). The FCR of T<sub>1</sub> and T<sub>2</sub> was found to be almost similar (1.7 and 1.71 kg for T<sub>1</sub> and T<sub>2</sub>, respectively). Lowest FCR was observed in T<sub>3</sub> group (1.8 kg). The FCR was also found to be non-significant among group ( $p>0.05$ )

### **Carcass and organ characteristics of broilers**

The carcass and organ characteristics of experimental birds are presented in Table 6.

Table 6. Carcass and organ characteristics of broilers fed varying level of Khesari forage (Mean±SEM)

S/N	Parameter	T1	T2	T3	P-value
1	Live weight, g	2170.5±232.4	2216.5±82.5	2283.3±130.8	$p>0.05$
2	Slaughter weight, g	2062.5±233.2	2125.5±76.5	2203.75±128.9	$p>0.05$
3	Head, g	47±3.7	46±1.8	50.5±2.1	$p>0.05$
4	Neck, g	76.5±8.1	63.5±4.3	59±3.7	$p>0.05$
5	Leg, g	86±13.9	80±4.2	82±6.3	$p>0.05$
6	Wings, g	142.5±12.3	150±7.9	150.7±9.8	$p>0.05$
7	Thigh, g	243.5±17.5	263.5±27.2	231.3±8.4	$p>0.05$
8	Drumstick, g	182.25±28	194±14	197±18.4	$p>0.05$
9	Breast, g	533.5±90.9	491.5±56.6	526±37.8	$p>0.05$
10	Back and rib, g	381±43.3	368±45.9	404±34.9	$p>0.05$
11	Intestine, g	118±24.04	124.5±16.4	158.2±25.1	$p>0.05$
12	Gizzard and proventricular, g	58±8.1	60±4.5	75.7±9.9	$p>0.05$
13	Liver, g	64±5.4	71.5±8.6	56±3.5	$p>0.05$
14	Heart, g	16.5±1.3	13±2.4	13.5±2.4	$p>0.05$
15	Dressing percentage	64.87	62.13	62.09	$p>0.05$

All the tested parameters were not differed significantly among the treatments ( $p>0.05$ ) which is presented in Table 6.

## DISCUSSION

Our experiment showed that highest feed intake was in T<sub>2</sub> group (4575 g) followed by T<sub>3</sub> (4573 g). Similarly, intake of Khesari leaves was higher in T<sub>3</sub> than that of T<sub>2</sub> entire experimental periods. Similar result was noted by Latif and Morris (1976), where autoclaved or heated Khesari was incorporated at 367 g/kg (10% of total diet) in a balanced chick diet. Growth and efficiency of food utilization were at least equal to those obtained with a maize- soya diet.

Similarly, Iheukwumereet *et al.* (2008) reported that 5% of cassava leaf meal could be included in diets for finisher broiler chickens without detrimental effects. In another study, led by Ayssiwede *et al.* (2010), fed *Leucaena leucocephala* leguminous forage to chicken diet and experiment showed that at 21% the *Leucaena* leaf meal did not impart negatively on feed intake, weight gain and feed: gain ratio. Moreover, Koçer *et al* (2018), Nkukwana *et al* (2014) and Gadziray *et al* (2012) fed *Moringa oleifera* leaf to broiler and found a similar results with non-significant effects on weight and growth performances.

Present study revealed that there was no significant effect on body weight gain and FCR in diet groups. However, Onunkwo and George (2015) reported improved weight gain and FCR of broiler at 7.5% level of moringa leaf meal inclusion in the diet. Such poor performance of broiler when fed high level of leaf meal might be due to increased fiber content of leaf meal resulting in low feed intake and insufficient nutrient digestion.

Present study showed that the characteristics of carcass and organs of broilers were not affected with the inclusion of Khesari leaves in broiler diet supporting the result of Iheukwumereet *et al* (2008) where they reported that 5 % inclusion level of cassava (*Manihot esculenta*,) leaf meal in broiler finisher diets had no deleterious effects on organ weight of birds. Contrary to the result, Sarker *et al.*, (2017), reported significantly greater breast meat weight in broilers fed *Moringa oleifera* leaf meal. Additionally, Kagya-Agyemang *et al* (2007) recommended not more than 5% inclusion level of *Gliricidia sepium* leaf meal in broiler diets, a progressive decrease in carcass dressing percentage was observed at higher inclusion rates with a 15% inclusion level having a significantly ( $p < 0.05$ ) lower carcass dressing percentage. The causes of these conflicting evidences might be the species of plant, maturity of plant, nutrient and anti-nutritional factors content in it, and inclusion level of forage in poultry diet.

## CONCLUSION

Khesari (*Lathyrus sativus*) leaves can be included in poultry diet for reducing feed cost. This experiment suggested that concentrate could be replaced at the rate of 10 % by Khesari leaves in broiler diet without any adverse effect on feed intake, weight gain, and carcass and organ characteristics of the broilers. However, further study could be recommended to validate this finding in farmer's field for wider dissemination of the technology.

## ACKNOWLEDGEMENT

The authors would like to express their most sincere gratitude and appreciation to NARC for funding to this research. Similarly, supportive role of Director (Mr Keshab Shrestha), Directorate of Agricultural Research, Province N 2, Parwanipur, Bara deserves high appreciation without that conduction of experiment was impossible. Similarly Narayan Das (Poultry attendant) and Dilip Shah (Technical officer) also deserve high appreciation for this research. Mr. Basanta Kumar Shrestha (Technical Officer) and his teams, National Animal Nutrition Research Center, Khumaltar, Lalitpur also deserve appreciation for their dedicated assistance in chemical analysis of feed ingredients.

## REFERENCES

- AOAC (1980) Official methods of analysis, Association of Official Analysis Chemists, Washington DC, U.S.A
- Ansari, J., S.H. Khan, A. Haq, M. Yousaf (2012). Effect of the levels of *Azadirachta indica* dried leaf meal as phytogenic feed additive on the growth performance and haemato-biochemical parameters in broiler chicks. *Journal of Applied Animal Resesearch*, 40: 336–34.
- Ayssiwede S.B., A. Dieng, C. Crysostome, W. Ossebi and J.L. Hornik (2010) Digestibility and metabolic utilization and nutritional value of *Leucaena leucocephala* leaves meal incorporated in the diets of indigenous Senegalese chickens. *International Journal of Poultry Science*, 9: 667-676.
- Blair, R. (2008) Nutrition and feeding of organic poultry, Oxfordshire, UK: CAB International Publishing
- Buchanan, N. P., Hott, J. M., Kimbler, L. B. and Moritz, J. S. (2007) Nutrient composition and digestibility of organic broiler diets and pasture forages. *Journal of Applied Poultry Research*, 16: 13-21
- Dixit, G. P., A. K. Parihar, A. Bohra and N. P. Singh (2016) Achievements and prospects of grass pea (*Lathyrus sativus L.*) improvement for sustainable food production. *The Crop Journal*, 4: 407-416
- Gadziray, C. T., B. Masamha, J. F. Mupangwa and S. Washaya (2012). Performance of broiler chickens fed on mature *Moringa oleifera* leaf meal as a protein supplement to soyabean meal. *International Journal of Poultry Science*, 11: 5-10.

- Goering, H.K. & Van Soest (1970). Forage fibre analysis apparatus, reagents, procedures and some application, ARS, USDA, Handbook N 397
- Latif, M. and R. Morris (1976) Use of Khesari (*Lathyrus sativus*) in chick diets. *British Poultry Science*, 17:539-546.
- Iheukwumere F.C., E.C. Ndubisi, E.A. Mazi and M.U. Oyekwere (2008) Performance, Nutrient utilization and organ characteristics of broilers fed cassava leaf meal (*Manihot sculanta*). *Pakistan Journal Nutrition*, 7: 13-16.
- Koçer, B., M. Bozkurt, G. Ege, A. E. Tüzün, R. Konak and O. Olgun (2018). Effects of a meal feeding regime and the availability of fresh alfalfa on growth performance and meat and bone quality of broiler genotypes. *British Poultry Science*, 59: 318-329. Retrieved from <https://doi.org/10.1080/00071668.2018.1440378>. doi:10.1080/00071668.2018.1440378.
- Kagya-Agyemang, J.K., G. Takyi-Boampong, M. Adjei, F.R. Karikari Bonsu (2007). A note on the effect of *Gliricidia sepium* leaf meal on the growth performance and carcass characteristics of broiler chickens. *Journal Animal Feed Science*, 16: 104–108
- Nkukwana, T. T., V. Muchenje, E. Pieterse, P. J. Masika, T. P. Mabusela, L. C. Hoffman and K. Dzama (2014). Effect of *Moringa oleifera* leaf meal on growth performance, apparent digestibility, digestive organ size and carcass yield in broiler chickens. *Livestock Science*, 161: 139-146.
- Ndelekwute, E. K., G. E. Enyenihi and I. P. Akpan (2018). Potentials and challenges of utilizing forage resources for chicken production. *Journal of Animal Science and Livestock Production*, 2.
- Onyimonyi, A. E. and O. Ernest (2009). An assessment of pawpaw leaf meal as protein ingredient for finishing broiler. *International Journal of Poultry Science*, 8: 995-998.
- Onunkwo, D. N and O. S. George (2015). Effects of *Moringa oleifera* leaf meal on the growth performance and carcass characteristics of broiler birds. *Journal of Agriculture and Veterinary Science*, 8: 63-66.
- Sarker, S. K., M. M. Rana, H. Khatun, S. Faruque, N. R. Sarker, F. Sharmin and M. N. Islam (2017). Moringa leaf meal as natural feed additives on the growth performance and meat quality of commercial broiler chicken. *Asian Journal of Medical and Biological Research*, 3: 240-244.

## Management Practice of Insect Pest on Rooftop Farming at Kathmandu

\*Uttam Shrestha<sup>1</sup> & Subeksha Shrestha<sup>2</sup>

HICAST, Purbanchal University, Kathmandu

\*Corresponding Author: [uttamshrestha55821@gmail.com](mailto:uttamshrestha55821@gmail.com)

### ABSTRACT

*The present study on “eco-friendly management practices of insect pest on rooftop farming at Kathmandu” was conducted in January to March 2021. The main objective of this study was to assess the information about management practices of insect pest on rooftop farming, its role in food security, urban environment and income saving by the rooftop farmer in the research area. Survey was conducted in Kathmandu valley where 100 respondents were selected for survey. The survey was conducted on simple random sampling technique. Both male and female were found to be involved in rooftop farming. The age group of respondents in between 40-50 was found to be maximum involvement in the study area. Municipality and different NGOs had conducted training on rooftop so; majority of the respondents (53%) has taken training on study area. The result showed that the major insect pest of the research site were aphids (87%), caterpillar, white grub, white fly, leaf minor, cutworm, fruit fly, snail, ants and rodents. For the management of these insect pests on rooftop, 86 respondents use pesticides where 90% use botanical pesticide and 10% use chemical pesticide and 14 respondents use traps. Botanical pesticides like jhol mal, bokasi mal, cow urine and bio-pesticides like neem oil and trichoderma are used in the study area. Majority of respondents 45% were able to save 500-1000 rupees per month. The practice of rooftop farming provides healthy food for family and help in management of kitchen waste as well as it helps to maintain good relationships between neighborhoods.*

**Key words:** organic, food security, random, training

### INTRODUCTION

Rooftop farming (RTF) is the production of fresh vegetables, herbs, fruits, edible flowers and possibly some small animals on rooftops for local consumption (Dubbeling & Massonneau, 2014). Roof tops represent large and undervalued surface area. Roof areas can represent up to 32% of the horizontal

surface of built-up areas (Oberndorfer et al. 2007). There are mainly three system of rooftop gardening. First one is container farming, which is cheaper form of roof farming. In the container farming system, few to no modifications are made to existing roof structure; containers-anything from plastic swimming pools to recycled-wood planters that can fill with soil, placed on rooftops and filled with soil and plants. The second one is an intensive gardening system, which is more sophisticated than container gardening and involves the installation of large amounts of soil and architectural considerations for weight bearing capacities. This system is more expensive than container gardening but can offer many benefits, like building insulation, storm-water retention. The third rooftop garden possibility is rooftop hydroponics, in which plants are grown in a soilless medium and fed a special nutrient solution. Rooftop hydroponics can be the lightest of the three options and may offer the possibility for faster plant growth and increased productivity (Nowak, 2004). Rooftop farming is the practice of utilizing the unused space of the roof for cultivating vegetables, fruits, spices etc. The practice of gardening on the rooftop may seem a small step but it is a road toward sustainability and combating the devastating climate change hazards (Kumar et al., 2019). Rooftop garden modulates the temperature on the roof as well as the room below the roof garden (Gupta, 2017). Green roofs can help to eradicate the adverse effects of UHI (Urban Heat Island) in the city and bring nature back to the urban area and also improve aesthetics and urban psychology, as well as reduce pollutant concentrations and noise (Hui, 2006).

In Nepal rooftop farming has been formally introduced in 2013 through public awareness campaigns and programs by Kathmandu Metropolitan, Environment and Public Health Organization, Clean Energy Nepal, along with many other NGOs and local organizations (Shakya 2017). In Nepal most of the rooftop farmers adopted a container farming system by using locally available compost manure and soil for cultivating vegetables.

Nepal is still struggling to be self-sufficient in food supply to a dense population due to loss of crops by pest attacks in the field and storage. In Nepal the average crop losses in the country due to various pests ranges from 25 to 35 percent (PPD, 2012). Most of the farmers of developing countries like Nepal prefer chemical pesticides for the management of insect pests. Misuse and over use of pesticide causes harmful effects to non-target organisms as well as human health and environments. For controlling pests and insects we can also use the concepts of Integrated Pest Management.

## **MATERIALS AND METHODS**

### **Study area and data collection**

Kathmandu, the capital and largest metropolitan city of Nepal was selected for the survey. The capital city, located at latitude 27.7°N and longitude 85.32°E, has a population of 2.5 million and covers an area of 899 km<sup>2</sup>. Kathmandu makes up the center of the biggest metropolitan agglomeration in the city in the Kathmandu Valley, which additionally incorporates Kirtipur, Lalitpur, Bhaktapur, Madhyapur Thimi, and more modest areas. Annual population growth rate per annum of KTM is 4.71 % in 2001 and 4.78 % in 2011 (CBS 2011). The relevant primary data was collected through household surveys; the interview was taken by visiting door to door of rooftop farming using semi structured questionnaire, which includes socio-demographic information and field observation. The field survey was done during January to March 2021. Interview time was set according to respondent's convenience. The secondary data used in this work was from secondary information such as books, journals, annual reports available at different academic institutes.

### **Data analysis**

The collected data were analyzed quantitatively and qualitatively. Analysis of collected information was based on the data obtained through interview and group discussion as well as observation in a descriptive and exploratory way. This information has been stored in the computer in the excel program. Analyzed data were then presented in tables and graphs by using computer software i.e Microsoft Excel.

## **RESULTS AND DISCUSSION**

### **Establishment of RTF**

Shakhya et al., (2017) has assumed that KMC households will currently accept RTF. The graph also showed that there was an increasing trend of practicing RTF in Kathmandu city. The survey showed that rooftop farming had been practiced for more than 20 years ago. After the earthquake of 2072 many houses have been constructed where they are practicing rooftop farming so, 48% of respondents establishing RTF in recent year (Figure 1). This shows that people are actively involved in RTF and would be adopting RTF in future.

### **Initial investment for RTF**

To establish a rooftop, different materials are required which may not get without cost. So a certain amount has to invest for rooftop farming. Investment depends on types of rooftop and farmers interest. In the survey 42% have

invested more than 10 thousand rupees whereas 25% invest only 500-1000 rupees (Figure 2). The farmers suggested that it is better to keep their vessels on iron table but it will be expensive. In the survey area most of the farmers reuse broken utensils to grow vegetables.

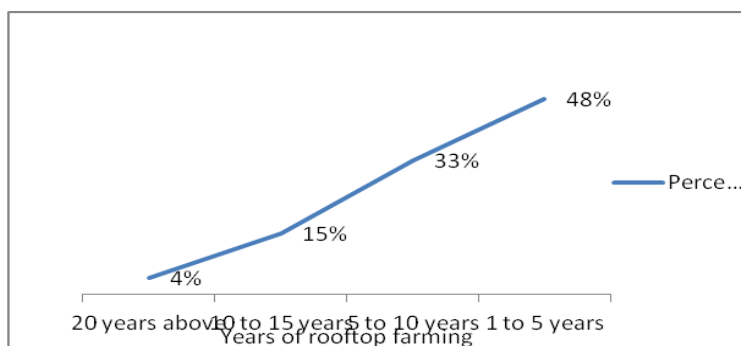


Figure 1. Period of rooftop farming (years)

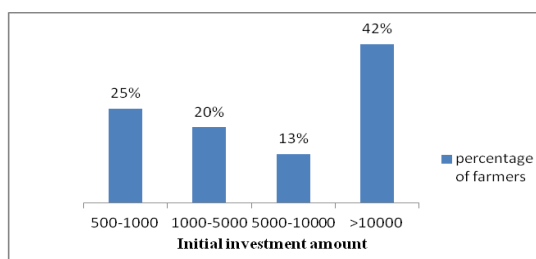


Figure 2. Distribution of respondents by Initial investment for RTF

### Materials used for growing plant

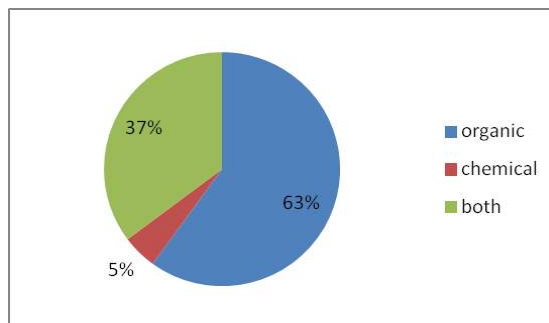
Most of the rooftop farmers used their renewable resources like jar, bottle, sack, fish crate, broken pots etc. for growing plants. 35% percent of respondents reused their materials for plantation whereas 57% combine renewable resources with modern plastic tools (Table 1). Only 8% of the rooftop farmers buy modern growing materials.

### Fertilizer used

Farm yard manure, compost, kitchen decomposable waste are organic fertilizer whereas urea, DAP, MOP are chemical fertilizer. Here 5% of the respondents used only chemical fertilizer and 63% used only organic fertilizer for cultivation (Figure 3). 37% of the respondents like to use both chemical and organic fertilizer as a source of plant nutrients.

**Table 1. Materials used for growing plant**

S.N	Materials	Percentage
1.	Renewable resources	35
2.	Renewable resources + modern plastic tools	57
3.	Only modern plastic tools	8



**Figure 3. Fertilizer used for rooftop farming**

### **Vegetables cultivation**

The highest cultivated vegetable on the roof was green leafy vegetables. 85% of rooftop farmers cultivate green leafy vegetables. Beans (82%) took second place on the list of vegetables. 62% of respondents had cultivated tomatoes, 55% cultivate cauliflower. Rooftop farmers also practice cultivation of cucumber (52%), bitter gourd (43%). (Bharti et al., 2015) have also reported that the rooftop farming technique of vegetable production is a better opportunity to grow different types of vegetables. Similar trends were seen in the study too.

### **Fruit cultivation**

Among the cultivated fruits crop, the most cultivated fruit was lemon which had been cultivated by 32% of the respondents, on the other hand kumquat was cultivated by 26%. Rooftop farmers also cultivate guava (23%), orange (20%) whereas mango was only cultivated by 8% of respondents (Table 3).

### **Spices cultivation**

Within the survey area there were altogether 8 spices crops which were in growing practice of rooftop farmers. 88% of the respondents had cultivated coriander followed by 82% chilli, 74% garlic, 63% onion and so on as shown in table 4. Gupta & Mehta (2017) has reported that most households cultivate coriander and mint. Similarly the survey data also shows a similar trend.

Table 2. Vegetables grown in RTF

S. N	Nepali name	English name	Scientific name	Percentage
1.	Saag	Broad leaf mustard, garden cress, spinach	<i>Brassica juncea</i> , <i>Lepidium sativum</i> , <i>Spinacia oleracea</i>	85
2.	Simi	Beans	<i>Phaseolus vulgaris</i>	82
3.	Golveda	Tomato	<i>Solanum lycopersicum</i>	62
4.	Cauli	Cauliflower	<i>Brassica oleracea</i>	55
5.	Kakro	Cucumber	<i>Cucumis sativus</i>	52
6.	Tite karela	Bitter Gourd	<i>Momordica charantia</i>	43

Table 3. Fruits grown in RTG

S.N	Nepali name	English name	Scientific name	Percentage
1.	Kagati	Lemon	<i>Citrus limon</i>	32
2.	Muntala	Kumquat	<i>Citrus japonica</i>	26
3.	Amba	Guava	<i>Psidium guajava</i>	23
4.	Suntala	Orange	<i>Citrus reticulata</i>	20
5.	Aap	Mango	<i>Mangifera indica</i>	8

### Major insects pest of rooftop farming

The survey showed almost all farmers had insect pest problems. Aphid, most troubling pest with 87% followed by caterpillars (62%). 43% of the respondents reported the soil dwelling white grub insect and 33% white fly, causing problems for the rooftop farmers (Table 5).

### Management technique of insect pest

In the survey area most of the respondents were participate on rooftop farming which was conduct by municipality and NGO so, 52% use only botanical pesticide like neem oil, jhol mal, ash, cow urine, trichoderma. 17% use only trap like yellow sticky tarp, pheromone trap, bottle trap, funnel trap. 6% use only chemical pesticide like rogor, malathion, nuvan and 3% use both botanical and chemical pesticide, whereas 22% use both botanical and trap for insect pest management (Figure 4). According to the farmers neem and neem extract are more effective to overcome insect pest. Tang et al. (2002) has also reported that neem extract is safer for beneficial organisms and effective against insect pest. Similarly the study also shows the same trends.

### Tools used while spraying pesticides

In the survey area 77 (90%) of the respondents use botanical pesticide like neem oil, jhol mal, bokasi mal, ash, trichoderma, cow urine and 9 (10%) use chemical pesticide like nuvan, malathion, rogor (Figure 5). For the application of such

pesticide 25% use hand sprayer, 5% use knapsack sprayer and 30% use watering can whereas 40% use bottles and jugs.

Table 4. Spices grown in RTF

S.N	Nepali name	English name	Scientific name	Percentage
1.	Dhaniya	Coriander	<i>Coriandrum sativum</i>	88
2.	Khursani	Chilli	<i>Capsicum annum</i>	82
3.	Lasun	Garlic	<i>Allium sativum</i>	74
4.	pyaja	Onion	<i>Allium cepa</i>	63
5.	Pudina	Mint	<i>Mentha spicata</i>	42
6.	Adhuwa	Ginger	<i>Zingiber officinale</i>	13
7.	Besar	Turmeric	<i>Cucurma longa</i>	5
8.	Tejpat	Indian bay leaf	<i>Cinnamomum tamala</i>	2

Table 5. Incidence of major insect pest in RTF

S.N	Major insects	Percentage
1.	Aphid	87
2.	Caterpillars	62
3.	White grub	43
4.	White fly	33
5.	Leaf miner	31
6.	Cut worm	24
7.	Fruit fly	15
8.	Snail	11
9.	Ants	9
10.	Rodents	3

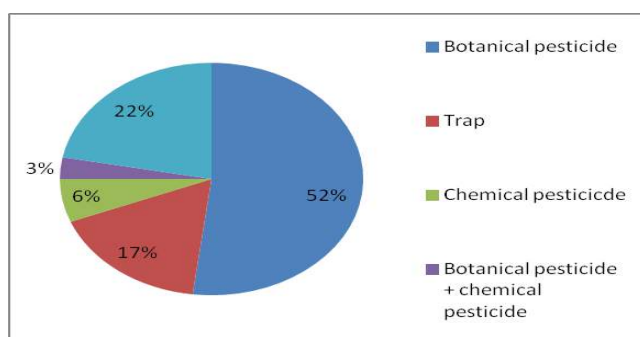


Figure 4. Respondents using management technique of insect pest

### Uses of personal protective equipments

In this study, masks, hats, gloves, overall cover dress, trousers were considered as a major PPEs. The most popular PPEs were masks as indicated by the majority of the respondents 84% followed by gloves 32% and overall cover dress 22% respectively (Figure 6). Around 15% respondents don't use any PPEs while spraying pesticide and working on the rooftop.

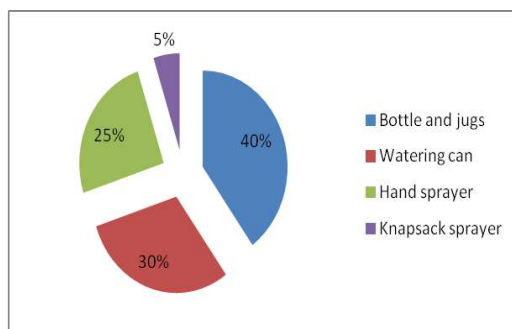


Figure 5. Tools used while spraying pesticides

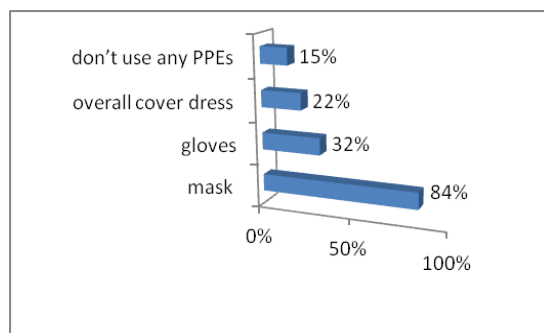


Figure 6. Use of personal protective equipments

### Time of pesticide application

In line with the timing of pesticide application, out of 86 pesticide applicants, 49(57%) farmers used pesticides after the presence of insect pest. Twenty six percent households used pesticide after insect destroying crops and 15(17%) indicated that they use pesticides even before insect attack (Table 6). According to respondents they sprayed botanical pesticide, once a week on leaves as well as on soil surface. Those farmers, who are using chemical pesticide, sprayed according to agro-vet prescription and on severity of pest.

### Waiting time after pesticides use

In the present study, out of 86 pesticide used respondents, those who are using botanical pesticide like neem oil used to wait less than 7 days, cow urine user waits for 3 days and jhol mal user respondents wait at least 5 days (Table 7). Those respondents who use chemical pesticides used to wait more than a week.

Table 6. Timing of pesticide application

S.N	Timing of pesticide application	Frequency	Percentage
1.	Before insect attack	15	17
2.	Presence of insect	49	57
3.	After insects starts destroying crops	22	26
	Total	86	100

Table 7. Waiting time after pesticide use

S.N	Pesticides	Waiting time (days)
1.	Neem oil	<7
2.	Cow urine	3
3.	Jhol mal	5
4	Chemical Pesticides	>7

### Net income after establishing rooftop farming

Rooftop farming could save some money as people have available vegetable produced on their rooftop. Forty five percent of the respondents were able to save 500 to 1000 NRE/ month while 22% of the respondents were able to save 1000 to 1500 NRE/ month (Table 9).

Table 8. Net income in a month after establishing rooftop farming

S.N	Saving after establishing rooftop farming (NRs)	Percentage
1.	500-1000	45
2.	1000-1500	22
3.	1500-2000	13
4.	Don't have any record	20

## CONCLUSION

Rooftop farming has been practiced from long years back; although there is a lot of benefit from rooftop farming, Still rooftop farming has been practiced only by the urban people in a subsistence way. Rooftop farming has important role in ensuring food / nutrition security and income.

## REFERENCES

- Bharti, V., Sukhdhane, K. S., & Remya, L. (2015) Rooftop micro organic farm: A promising initiative to enhance the vegetable production. *Indian Horticulture Journal*.5(3/4), 114-116.

- CBS. (2012) *National Population and Housing Census 2011(National Report)*. Government of Nepal, National Planning Commission Secretariat, Central Bureau of Statistics, 1, 1–278. Retrieved from <http://cbs.gov.np/?p=2017>
- Dubbeling, M., & Massonneau, E. (2014). Rooftop agriculture in a climate change perspective. *Urban Agriculture Magazine*, (27), 28–32.
- Gupta G., & Mehta P (2017). Roof top farming a solution to food security and climate change adaptation for cities. *In: Climate Change Research at Universities* (pp. 19-35). Springer, Cham. DOI: [https://doi.org/10.1007/978-3-319-58214-6\\_2](https://doi.org/10.1007/978-3-319-58214-6_2)
- Hui SCM (2006) Benefits and potential applications of green roof systems in Hong Kong, *In Proc. Of the 2nd Megacities International Conference 2006*, 1-2 December 2006, Guangzhou, China, pp. 351-360.
- Kumar JR, Natasha B, Suraj K, Kumar SA, & Manahar K (2019) Rooftop Farming: an Alternative to Conventional Farming for Urban Sustainability. *Malaysian Journal of Sustainable Agriculture*3(1): 39–43. DOI:<https://doi.org/10.26480/mjsa.01.2019.39.43>
- Nowak, M. (2004) *Urban agriculture on the rooftop*. Seniors honors thesis, Cornell University.
- Oberndorfer E, Lundholm J, Bass B, Coffman RR, Doshi H, Dunnett N, Gaffin S, Köhler M, Liu KKY, Rowe B (2007) Green roofs as urban ecosystems: ecological structures, functions, and services. *Bioscience* 57(10):823–833. <https://doi.org/10.1641/B571005>
- Shakya, S., Shrestha, J., and Kansakar, L.K. (2017) Productive reuse of organic waste in rooftop farming: A case study from Kathmandu Metropolitan City. *Journal of Environment and Public Health*, 1(1), 40-44.
- Tang, Y. Q., Weathersbee III, A. A. and Mayer, R. T. 2002. Effect of neem extract on the brown citrus aphid (Homoptera: Aphididae) and its parasitoid *Lysiphlebus testaceipes* (Hymenoptera: Aphididae). *Env. Entomol.* 31:172-176.

## A Survey on Insect Pests of Bitter Gourd and Their Management Practices Adopted By the Farmers in Thakre Rural Municipality, Dhading

Sarmila Bidari<sup>1\*</sup>, Subeksha Shrestha<sup>1</sup>, Arun Acharya<sup>2</sup> & Sagar Bidari<sup>1</sup>

<sup>1</sup>Himalayan College of Agricultural Sciences and Technology

<sup>2</sup>Locus Agri Ventures Pvt. Ltd

\*Corresponding Author: sharmilabidari123@gmail.com

### ABSTRACT

*The study was conducted with total 100 farmers interviewed. It was found that majority of farmers belong to 30-45 age groups and most of them were males. The major occupation of the study area was agriculture (86%). Out of total respondents, 44% percent have irrigation facilities by river or stream. Majority of respondents take the seed and inputs from agro-vets. The Bitter gourd variety used was PALI FIHybrid Green Long. The study showed that insect pests were the major problems (43%) and key insect pests attacking bitter gourd were fruit fly, red pumpkin beetle, spotted beetle, cucurbits stink bugs, blister beetle, aphids, white fly, etc. Fruit fly shows the highest incidence (33%) followed by aphids (21%) and red pumpkin beetle (14%) and causes high economic loss. However, various attempts were made to reduce the damage. Farmers use mechanical, botanical and chemical methods as a pest management strategy. About 87% of respondent use chemical methods for controlling the pests, 7% use mechanical methods and 3% use cultural and biological methods each. Commonly used insecticides were cypermethrin, dichlorovos, dimethoate, malathion, endosulfan. For mechanical methods they use yellow sticky traps, pheromone traps i.e. cue lure. In case of botanical methods, they use neem based pesticide, cow urine, etc. Farmers were cognizant about the importance of IPM but they don't follow it because of ease of chemicals. The indiscriminate use of chemical pesticides has resulted in pest resistance, resurgence and sometimes outbreak. Farmers need formal and informal trainings about proper diagnosis and safe use. Awareness of the farmers should be increased which will have larger effect on adoption of new technology.*

**Key words:** Cucurbits: Bitter Gourd, Insect pests, Pesticides, Management

### INTRODUCTION

The Cucurbitaceae family encompasses over 800 species of plants known collectively as gourd or cucurbits. Bitter gourd is one of the important vegetable crops which falls under the family Cucurbitaceae. *Momordica charantia* (bitter melon/ bitter apple/ bitter gourd/ bitter squash/ balsam pear) is a tropical and subtropical vine (Behera, et al., 2010). Its many varieties differ substantially in the shape and bitterness of the fruit which is attributed to nontoxic alkaloid

momordicine (Walters, et al., 1988). Bitter gourd is attacked by a number of insect pests at different growing stages that may cause defoliation, damage roots, contribute to poor crop stand, transmits bacterial and viral diseases and generates wound that help the invasion of fungal pathogens (Dhillon, et al., 1991). Major insect pests include: fruit fly, red pumpkin beetle, cucurbit stink bug, spotted beetle, etc. Insect pest infestation brings about the heavy loss through reduction in yield, lowered quality of products and increased cost of production. Besides, expenditure incurred on materials and equipment to apply control measures. Effective and economic pest management requires the use of cultural, mechanical, physical, biological and chemical methods. Most of the farmers are unaware about the knowledge of IPM and in case of pest infestation, they use pesticides directly without any prescription and knowing the economic threshold level. These types of pesticides applied by the farmers cause more pest outbreak and also the pests become more resistance to the pesticides. Bitter gourd is becoming popular among the farmers for its cultivation and consumption and emerging commercial vegetable crops which helps to improve the livelihood of the farmers. It has been found that the Bitter gourd is being cultivated in Terai, Hills and high Hills with the production of 45-50 metric ton per hectare (Krishi Diary, 2076). In Dhading district, the area of production is about 269 hectare along with the production of 3188 metric ton (Bhandari, 2019). But, due to the attack of insect pests, the farmers face the problem of yield loss and they have to deal with a huge economic loss. To counter this, there is a heavy use of easily available toxic chemicals which have adverse effect in the health and environment (Wilson et al., 2001). Therefore, it is very important to assess the impact of insect pests and develop the economical, ecological and environment friendly management approaches without hampering the quality of the products (Kafle et al., 2014). So, knowing the different kinds of pest attack and their management practices adopted by the farmers is most important part. Moreover, if there is need of correction in their pest management practices, it should also be done immediately.

## **MATERIALS AND METHODS**

The survey study on "A survey on insect pests of bitter gourd and their management practices adopted by the farmers" was conducted in Thakre Rural Municipality, Dhading district. It includes total of 11 wards.

The questionnaire survey was conducted from 2076/02/31 to 2076/05/16 in Thakre Rural Municipality, Dhading district. The total duration of the study was two and half months.

The total sample size was 100 households. Sampling was carried out by using random sampling method such that they represent almost total of the Bitter gourd cultivating households. The study was based on the primary data collected during the survey and secondary data collected through various available and published resources.

Primary data were collected with the help of semi-structured questionnaire. The questionnaire was developed to gather all the relevant information required to meet the specific objectives. It was done by field visiting and interviewing the respondents personally. Besides these, interaction with the key informant (JTAs, Agriculture officers) and observation were also used as other important tools for this study. Photographs were also taken during interview and visit. A set of semi-structured questionnaire was prepared intending to document the information about the pests of Bitter gourd and their management practices adopted by the farmers. Household heads were selected and interviewed as far as possible. In the absence of the household heads, other senior family members were interviewed. Beside this, the general information about the respondents and the household members like age, educational attainment, family size, main occupation, total land under cultivation, annual income, etc. were also included in the questionnaire to understand the socio-economic condition of the respondents. Secondary data were collected from books, journals, research papers, magazines and annual publications of different institutions and related documents published by NARC, DADO, MoAD and HICAST. Moreover, other statistical data were reviewed from Central Bureau of Statistics (CBS) and also internet sources.

Data were analyzed using Microsoft-Excel. Socio-economic, farm characteristics of the respondents and technical aspect of insect pest occurrence and their management practices were described using simple descriptive statistics like frequency, range, etc. and were presented in the form of pie-charts, bar graphs, tables, etc.

## **RESULTS AND DISCUSSION**

### **Cropping pattern**

Different vegetables were found to be cultivated by the farmers in different locations at different seasons. Almost all the farmers found to follow same cropping pattern (Rice/Maize and vegetables).

**Table No 1. Cropping pattern**

S.N.	Cropping Patterns
1.	Rice- Cabbage+ Cauliflower- Cucumber
2.	Maize+ Cowpea+ Soybean- Leafy vegetables+ Pumpkin
3.	Rice- Pumpkin+ Maize- Cauliflower or Cabbage- Rice
4.	Maize+ Bitter gourd or Cucumber or Gourd- Potato or Onion or garlic- Rice
5.	Rice- Fallow-Bitter gourd or Cucumber or bottle gourd- cole crops

**Average land holding and irrigation facility**

It was found that 12 % of respondents had 1-5 ropanies of land followed by 30 % of respondents having 6-10 ropanies land holding and 58 % of respondents had land holding more than 10 ropanies. Overall, it was found that farmers generally had large areas for farming, but the bitter gourd production was done in relatively less area. According to the survey, the source of irrigation of all the farmers was river or stream, canal and rainwater. About 44% of irrigation was through river or stream, 53% of irrigation was through canal and only about 3% was through rain water. The survey showed that almost every farmer had got the irrigation facilities and very few of them were relied on rain water.

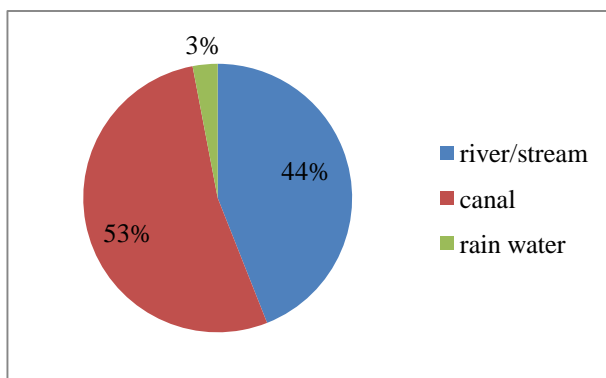


Figure 2. Irrigation facilities

**Major problem of bitter gourd farming**

Among various problems of commercial farming, insect pest ranked the highest, followed by diseases attack, lack of quality seeds, labor, transportation, etc. Around 43% was insect pest problem, 31% disease attack, 13% low quality seeds, 9% labor problem and 4% transportation problem. In this area, there was no any problem about the market as it is near from the valley.

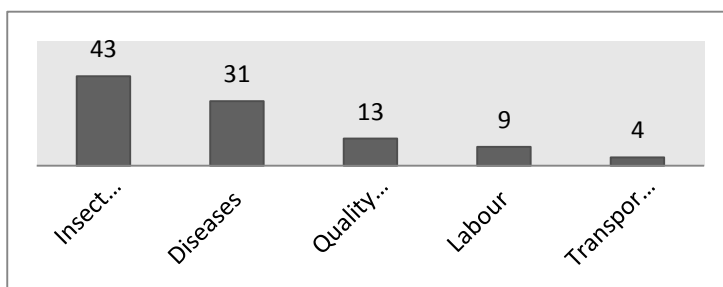


Figure 3. Major problems of Bitter gourd

### Status of insect pest of bitter gourd

Majority of farmers (80%) were tired of problems created by fruit fly in the production of bitter gourd. It was found more problematic in fruiting periods. After that, aphids and red pumpkin beetle were other problematic insect pests in bitter gourd. According to the farmers, red pumpkin beetle is more problematic in seedling, vegetative and reproductive stages. The figure shows that fruit fly was the most occurring insect followed by aphids. About 33 % of loss was caused by fruit fly being the major insect pest of the bitter guard. About 21% of loss was caused by aphids in their field, 14% of loss was caused by red pumpkin beetle, 9% by cucurbit stink bug, 7% by cutworm, 6% by blister beetle, 6% by Epilachna beetle and 4% by white fly. The insect pests like cut worm, Epilachna beetle and white fly were found to be less problematic than other insect pests.

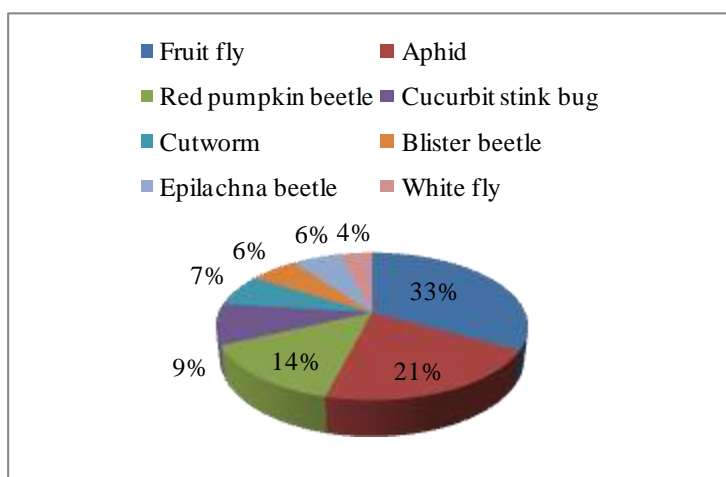


Figure 4. Status of insect pests of Bitter gourd

### Management practices adopted by the farmers

The study shows that farmers mostly used chemicals for controlling the insect pests. About 87% of the respondents used chemical methods for controlling the pests. About 7% of respondents use mechanical methods like pheromone traps, yellow sticky traps, food bait, lure etc. followed by botanical methods (3%) like neem based pesticides, cow urine, jholmal, etc. and 3% farmers adopted cultural methods like field sanitation, deep ploughing, etc.

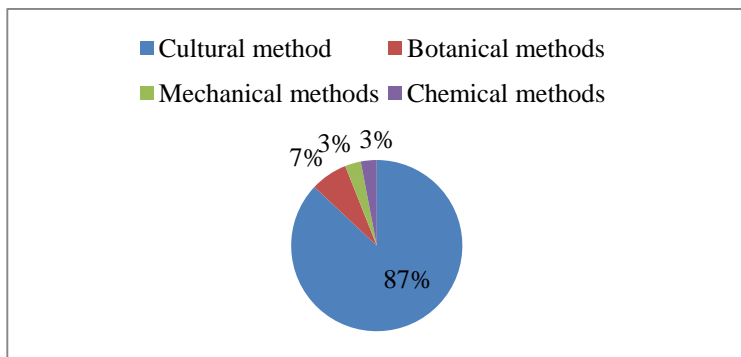


Figure 5. Management practices adopted by the farmers

### Common chemical pesticides used by the farmers

It was found that farmers seldom use cultural, botanical, as well as mechanical management practices. They preferred to use chemical pesticides which were available at local Agro-vets and agro-vets at Kalimati, Kathmandu. Different types of pesticides ranged from medium toxic to high toxic which were commonly used by growers in the survey area. Of which, Cypermethrin was the highest followed by Dichlorovos.

Table 2. Major chemicals used by farmers

S.N.	Trade name	Common name	Formulation
1.	Nuvan, Kingvan, Doom	Dichlorovos	80% EC
2.	Goldcyp-10, Sherpa-10	Cypermethrin	10% EC
3.	Roger, Rogoban	Dimethoate	(30%) EC
4.	Carbine	Chlorpyrifos + Cypermethrin	(50%+5%) EC
5.	Suryathion	Malathion	50% EC
6.	Metacid	Methyl parathion	50% EC
7.	Thiodan	Endosulfan	35% EC

### Spraying of pesticides

According to the knowledge of farmers towards the pesticides, all the respondents followed proper spraying method in Bitter gourd. The study showed

that majority of respondent used knapsack sprayer. It was found that majority of respondent (65%) sprayed the pesticides with the beginning of infestation (Figure 6). They didn't use pesticides on the basis of interval periods rather they depends on incidence of crop pest.

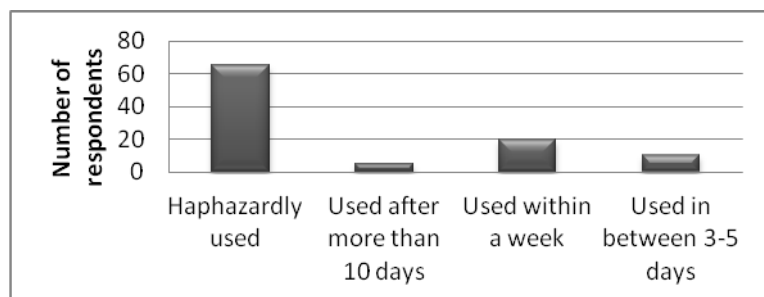


Figure 6. Spraying interval of pesticides

## CONCLUSION

Although the average land holding was more than 10 ropanies, lesser of the area was allocated for bitter gourd in the rice, maize and vegetables cropping pattern. Bitter gourd cultivation faced a lot of obstacles; insect pests were the main culprit in the study area. Among various insects, fruit fly was the major pest followed by aphids and red pumpkin beetle. Insect pests like cut worm, epilachna beetle and white fly were found to be less problematic than other insect pests. Because of the severity of damage and loss, farmers adopted different management strategies. Chemicals, mainly cypermethrin, dichlorovos and dimethoate, mechanical methods like pheromone traps, yellow sticky traps, food bait and lure, botanicals like neem based pesticides and cultural methods were adopted.

Easy availability at local agro-vets and lack of awareness and/or negligence of the integrated pest management (IPM), farmers freely used toxic and even banned chemicals. Majority of the respondents reported that the pest status was increasing each year; and they were facing problems of pest resistance and pest resurgence.

## REFERENCES

- Behera T.K, Behera S, Bharathi L.K, John K.J, Simon P.W, Staub J.E, (2010). *Horticulture reviews* 37, 101, (2010). Wiley Online Library.
- Bhandari P, (2019). *Financial and Institutional Analysis of Vegetable Co-operatives in Dhading District of Nepal*. Acta Scientific Agriculture. Vol. 3, Page no. 133.
- Dhillon N.P.S and Wehner T.C, (1991). Host plant resistance to insects in cucurbits germplasm resources, genetics and breeding. *Tropical Pest Management*, 37 (4), 421-428.

- Kafle L, Bhattarai S, Tiwari S, Yang J.T, GC Y.D and Katuwal M, (2014) *Integrated Pest Management in Nepal*, Conference Paper December, DOI, 10 (2.1), 2563, 2324.
- Krishi Diary, (2076). *Cultivated areas and the production amount*. Nepal Government, Ministry of Agriculture and Livestock Development, Hariharbhawan, Lalitpur. Page no. 175
- MoAD (2018). *Nepal Agritech*, Ministry of Agriculture Development
- Walters T.W, Walters D.S.D, (1988). *Balsan-pear (Momordicacharantia, Cucurbitaceae). Economic Botany*, 42(2), 286-288.
- Wilson C and Tisdell C, (2001). Why farmers continue to use pesticides despite environmental, health and sustainability costs. *Ecological Economics*, 39:3, 449-462.

## **Efficacy of Bio-Rational Pesticides and Chemical Pesticides against Cabbage Aphid (*Brevicoryne brassicae*. L) Under Laboratory Conditions**

**\*Prativa Thapa and Subeksha Shrestha**

Himalayan College of Agricultural Sciences and Technology (HICAST),  
Kirtipur, Kathmandu

**\*Corresponding Author:** Prativathapa18@gmail.com

### **ABSTRACT**

*The study was conducted from 18<sup>th</sup> December, 2020 to 11<sup>th</sup> February, 2021, at National Entomology Research Center, NARC, Khumaltar. The main objective of the study was to observe effectiveness of bio rational pesticides and chemical pesticides against cabbage aphids under laboratory condition. For efficacy test of bio rational and chemical pesticides against cabbage aphid, two methods were used. In both leaf dip and leaf spray method, experiment was laid out in Completely Randomized Design (CRD). Seven treatments with three replications each for efficacy test of chemicals and bio rational pesticides in both methods were used. In each replication 20 aphids were treated. For efficacy test of bio rational pesticides 7 treatments i.e., neem oil, Beauveria bassiana, Botanical Extract, citrus peel alkaloids + fatty acids, tobacco extract, soap water and one control was used. Likewise, for efficacy test of chemical Pesticide& treatments i.e., Imidacloprid, Cypermethrin, Deltamethrin, Chlorantranilprole, Dimethoate, Acetamiprid and one treatment was used. Mortality rate of aphids were recorded at 24, 48, 72 and 96 hours after treatment. Data were entered in MS-Excel, analysis of data collected under laboratory condition was done by using GenStat for the one-way analysis of variance. In both leaf dip and leaf spray bioassay for efficacy test of bio rational pesticides, Citrus peel alkaloids + fatty acids were found more effective followed by botanical extracts and neem oil. For efficacy test of chemical pesticides, in both leaf dip and leaf spray bioassay for efficacy test of chemical pesticides Imidacloprid show maximum mortality rate of cabbage aphids followed by Acetamiprid and Dimethoate.*

**Keywords:** Cabbage aphid, efficacy test, bio rational pesticides, chemical pesticides, mortality rate

### **INTRODUCTION**

Cabbage is one of the most important vegetable crops; and is universally cultivated as a garden, general farm crop. Market for cabbage, like that for potatoes, is continuous throughout the year; and this tends to make it one of the staple vegetables (Naughton *et al.*, 2009). Nutritionally cabbage is most important crop for consumption as it contains Vitamin C, Calcium and crude

protein at pre harvest stage (Ojetayo *et al.*, 2011) According to recent statistics (MoAD, 2018/2019), the total area of cabbage cultivation was 30,331 hectares with production of 519,061 metric tons with average yield of 17.11 metric tons per hectare in Nepal.

Cabbage is susceptible to insect pest infestations in the field, which causes huge loss to the growers. According to Baidoo & Adam, (2012), the major insect pests infesting cabbages are diamondback moth (*Plutella xylostella*), the cabbage webworm (*Helula undalis*), cabbage white butterfly (*Pieris brassicae*), cabbage aphid (*Brevicoryne brassicae*), cabbage looper (*Trichoplusia ni*) and green peach aphids (*Myzus persicae*). Among them, Cabbage Aphid, *Brevicoryne brassicae* L. is regarded as the most important pest of cabbage. Blackman & Eastop, (2000), insisted that, cabbage aphids mostly attack growing parts of the host plants such as tips, flowers, developing pods, leaves and eventually cover the whole plants at high population. According to Lashkari *et al.*, 2007, cabbage aphids have direct and indirect damaging effects to cabbage crops. The direct damage caused by this pest is by sucking cell sap, secrete honey dew which result into sooty mold formation on leaves and shoots and indirect damaging effect is as a vector of 20 plant viral diseases in a wide range of plant. Under favorable circumstances, aphid's populations increase very rapidly by making dense colonies on all parts of plants. The economic impact of aphid damage can be from 80% yield losses to complete crop failure, if attack comes at seedling stage (Singh *et al.*, 1987).

There are different methods for controlling insect pests in the field- Cultural control, Mechanical control, Biological control, Chemical control etc. Generally, the cultural practices such as site selection, intercropping practices, crop rotation, seed selection and sowing date can minimize the invasion of insect pests in the crops (Mwanauta *et al.*, 2015). For instance, aphid infestations in *Brassica oleracea* is reduced by early sowing time (Baidoo & Adam, 2012). In cabbage production, biological control is involved in the control of cabbage insect pests. Gupta & Dikshit, 2010, reported that, the most widely known microbial pesticides are varieties of the bacterium *Bacillus thuringiensis* (Bt) which control certain insects in cabbage, potatoes and other crops. Chapman, *et al.*, 1981, reported that ladybird beetles, family Coccinellidae, both adults and larvae feeds on aphids and as a consequence reduce the populations of aphids in the cabbage field. Botanical pesticides have been used as alternatives to synthetic insecticides to control cereal crop insect pests in the field and in the storage because they pose little threat to the environment, to ecosystems and to human health. Various chemical insecticides are also used to control insect pests

of cabbage. To achieve maximum control of pest by using chemical pesticides, proper surfactant proportions in combination with well-adjusted spray equipment are important (Kessing & Mau, 1991). However, the reports by De Bon *et al.*, 2014 and Weinberger & Srinivasan, 2009, indicated that, many synthetic pesticides used are persistent in the environment, threaten the human health, kills non-target organisms and destroy the ecosystem.

There are many alternative control options to manage the insect pests by use of biocontrol agents, microbials, and botanicals (Lowery & Isman, 1994; Milner, 1997; Singh *et al.*, 2007; Bugg *et al.*, 2008). These bio-rational or low risk pesticides are being used to replace the conventional ones. Bio-rational insecticides are synthetic or natural substances that are more effective to control insect pests with having low toxicity to non-target organisms and the environment (Hara, 2000). Hence, this study is focused on efficacy test of both bio rational pesticides and chemical pesticides against cabbage aphid (*B. brassicae*) under laboratory condition.

## MATERIALS AND METHODS

### Study site

The experiment was conducted in laboratory of National Entomology Research Centre, NARC, Khumaltar to study the comparative efficacy of bio rational and chemical pesticides against cabbage aphid (*Brevicoryne brassicae*) under laboratory condition.

### Plant rearing and aphid culture

The adult aphids of *Brevicoryne brassicae* were collected from farmers field located at Khumaltar, Lalitpur and were released to young cabbage plants grown in potting soil-filled plastic trays and were then covered with nylon mesh net. In order to increase the infestation by cabbage aphids, plants were supplied with more nitrogen fertilizer and exposed to sunlight with little watering. For bio assay, Cabbage seeds were germinated in plastic seedling trays containing a proper mix of loamy soil, compost and coco peat. After growing for 4 weeks, seedlings in the primary leaf stage were transplanted in plastic pots (8cm in diameter). Plants were kept with proper care and were irrigated as needed. Healthy plants were selected for experimental purpose.

## Experimental design

The comparative efficacy test of bio rational pesticides and chemical pesticides were assessed under laboratory condition. The experiment was laid in Completely Randomized Design (CRD) and comparison was done

## Layout of leaf dip and leaf spray bioassay

For the laboratory experiment of efficacy of bio rational and chemical pesticides against cabbage aphid, two methods were used. In both leaf dip and leaf spray method, experiment was laid out in Completely Randomized Design. Seven treatments with three replications each for efficacy test of chemicals and bio rational pesticides in both methods were used. In each replication 20 aphids were treated. This made one treatment consists total of 60 aphids. Hence, a total of 420 aphids were treated for each efficacy test in each bio assay.

## Treatment details and doses

### For efficacy test of bio rational pesticides

Table 1. For Efficacy test of bio-rational pesticides against cabbage aphids

S.N	Treatments	Trade Name	Active Ingredients	Dosage ml or g per litre
1.	T1	Nimbecidine	Neem oil, Azadirachtin 300ppm	6
2.	T2	Tagveria	<i>Beauveria bassiana</i> 1.15% WP (1x10 <sup>8</sup> CFU/g)	3
3.	T3	Dada guard	Aloe vera 30.05w/w, Clove oil 0.10w/w, Garlic oil 1.00% w/w, Neem oil 2.00%w/w, Garlic Extract 1.00% w/w	0.5
4.	T4	Larvosin	Extract of Vitex and Citrus peel alkaloids 6%. Plant origin Fatty Acids 35%	2
5.	T5	Tobacco extract	Cured tobacco leaves	60
6.	T6	Pear dish washer	Soap water	1.5
7.	T7	Control	Distilled water	-

## For Efficacy test of chemical pesticides

Table 2. Treatments for efficacy test of chemical pesticides against cabbage aphids

S.N	Treatments	Trade name	Active Ingredients	Dosage ml or g per litre
1.	T1	G-care	Imidacloprid 20%	0.2
2.	T2	Cyper 10	Cypermethrin 10% EC	1
3.	T3	Decis	Deltamethrin 2.8 w/w	1
4.	T4	Allcora	Chlorantraniliprole 18.5%	0.3
5.	T5	Rogor plus	Dimethoate 30% EC	1
6.	T6	EKKA	Acetamiprid 20 SP	0.1
7.	T7	Control	Distilled water	-

### Leaf spray bioassay

Cabbage seedlings at their primary leaf stage were transplanted in the plastic pots. When, the cabbage plants attain the fourth true leaf stage they were used for leaf spray bioassay. Accurate dilutions of the test compounds were prepared in the beakers. Then the pesticide dilutions were filled in hand sprayers. The young cabbage plants were then sprayed with pesticides until runoff. Sprayed plants were then left to air dry for 2 hours. Once the pesticides deposit was dried, the pots were kept above plain white paper and with the help of camel brush, 20 aphids were released in each plant. A total of 7 treatments were maintained with 3 replications for each efficacy test of bio rational and chemical pesticides. Then the pots were carefully placed in ventilated cages. The observed mortality of aphids was recorded at 24, 48, 72 and 96 hours after treatment.

### Mortality assessment

The mortality of aphids was assessed after 24, 48, 72 and 98 hours after treatment based on the mobility of body parts and change in the color of the body. The data were recorded and were expressed as percent mortality .

$$\text{Mortality \%} = \frac{\text{total no of dead aphids}}{\text{total no of aphids}} \times 100$$

### Statistical analysis

The number of dead aphids was recorded at 24, 48, 72 and 92 hours after treatment regularly. MS Excel was used for data entry and the analysis of data was done using GenStat. For comparing the mean values Duncan's multiple range test (DMRT) at 5% level of significance was done. Moreover, MS word was used for report preparation and MS power point was used for presentation.

## RESULTS AND DISCUSSION

### Efficacy of bio-rational pesticides by leaf dips method

In efficacy test, Analysis of Variance (ANOVA) indicates that treatments are statistically significantly effective in causing mortality of aphid. Table 3 shows number four treatment (T<sub>4</sub>) i.e., extract of citrus alkaloids and plant origin fatty acids @ 2ml per liter of water was found more effective having about 90 % mean mortality rate than other treatments followed by botanical extract (T<sub>3</sub>), neem oil (T<sub>1</sub>), *Beauveria bassiana* (T<sub>2</sub>), tobacco extract (T<sub>5</sub>) and soap water (T<sub>6</sub>) respectively. T<sub>3</sub> has constant rate of mortality in all-time series. T<sub>2</sub> had low mortality rate in 24 hours but gradually increased in 92 hours. T<sub>5</sub> and T<sub>6</sub> showed more mortality at 24 HAT but gradually decrease afterwards.

Table 3. Mortality percentage of cabbage aphids at different Hours After Treatment (HAT) for efficacy test of bio rational pesticides by leaf dip method

S.N	Treatments details	Mortality % at 24 HAT	Mortality % at 48 HAT	Mortality % at 72 HAT	Mortality % at 96 HAT	Mean mortality %
1	Neem oil (T <sub>1</sub> )	60.00 <sup>c</sup>	76.67 <sup>cd</sup>	86.67 <sup>de</sup>	93.33 <sup>de</sup>	79.17 <sup>cd</sup>
2.	<i>Beauveria bassiana</i> (T <sub>2</sub> )	58.33 <sup>c</sup>	68.33 <sup>bc</sup>	78.33 <sup>cd</sup>	85.00 <sup>cd</sup>	72.50 <sup>c</sup>
3.	Botanical extract (T <sub>3</sub> )	63.33 <sup>cd</sup>	71.67 <sup>c</sup>	85.00 <sup>cde</sup>	95.00 <sup>e</sup>	78.75 <sup>cd</sup>
4.	Citrus peel alkaloids + fatty acids (T <sub>4</sub> )	78.33 <sup>d</sup>	88.33 <sup>d</sup>	95.00 <sup>e</sup>	98.33 <sup>e</sup>	90.00 <sup>d</sup>
5.	Tobacco extract (T <sub>5</sub> )	56.67 <sup>c</sup>	71.67 <sup>c</sup>	75.00 <sup>c</sup>	80.00 <sup>c</sup>	70.83 <sup>c</sup>
6.	Soap water (T <sub>6</sub> )	40.00 <sup>b</sup>	55.00 <sup>b</sup>	58.33 <sup>b</sup>	66.67 <sup>b</sup>	55.00 <sup>b</sup>
7.	Control (T <sub>7</sub> )	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>
8.	F value	24.859	34.059	87.344	141.873	67.56
9.	P value	<.001	<.001	<.001	<.001	<.001
10.	SE (±)	5.04	4.96	3.45	2.89	3.66
11.	LSD	15.29	15.05	10.47	8.76	11.09
12.	CV%	17.1	13.9	8.7	6.8	9.9

### Efficacy of bio-rational pesticides by leaf spray method

In efficacy test by leaf spray method, the analysis of Variance (ANOVA) indicates that treatments are statistically significantly effective in causing mortality of aphid. Table 4 shows number four treatment (T<sub>4</sub>) i.e., extract of

citrus alkaloids and plant origin fatty acids @ 2ml per liter of water was found more effective having about 76.25% mean mortality rate than other treatments followed by botanical extract (T<sub>3</sub>), neem oil (T<sub>1</sub>), *Beauveria bassiana* (T<sub>2</sub>), soap water (T<sub>6</sub>) and tobacco extract (T<sub>5</sub>) respectively. T<sub>3</sub> and T<sub>4</sub> did not show significant different with each other. Likewise, T<sub>5</sub> and T<sub>6</sub> were at par with each other.

Table 4. Mortality percentage of cabbage aphids at different Hours After Treatment (HAT) for efficacy test of bio rational pesticides by leaf spray method

S.N	Treatments details	Mortality % at 24 HAT	Mortality % at 48 HAT	Mortality % at 72 HAT	Mortality % at 96 HAT	Mean mortality %
1	Neem oil (T <sub>1</sub> )	45.00 <sup>cd</sup>	68.33 <sup>cd</sup>	71.67 <sup>cd</sup>	73.33 <sup>cd</sup>	64.58 <sup>cd</sup>
2.	<i>Beauveria bassiana</i> (T <sub>2</sub> )	28.33 <sup>b</sup>	58.33 <sup>bc</sup>	63.33 <sup>bc</sup>	71.67 <sup>cd</sup>	55.42 <sup>bc</sup>
3.	Botanical extract (T <sub>3</sub> )	53.33 <sup>de</sup>	68.33 <sup>cd</sup>	76.67 <sup>cd</sup>	76.67 <sup>cd</sup>	68.75 <sup>d</sup>
4.	Citrus peel alkaloids + Fatty acids (T <sub>4</sub> )	66.67 <sup>e</sup>	75.00 <sup>d</sup>	80.00 <sup>d</sup>	83.33 <sup>d</sup>	76.25 <sup>d</sup>
5.	Tobacco extract (T <sub>5</sub> )	36.67 <sup>bc</sup>	50.00 <sup>b</sup>	55.00 <sup>b</sup>	58.33 <sup>b</sup>	50.00 <sup>b</sup>
6.	Soap water (T <sub>6</sub> )	43.33 <sup>bcd</sup>	51.67 <sup>b</sup>	55.00 <sup>b</sup>	56.67 <sup>b</sup>	51.67 <sup>b</sup>
7.	Control (T <sub>7</sub> )	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>
8.	F value	18.059	24.953	38.74	73.889	67.56
9.	P value	<.001	<.001	<.001	<.001	<.001
10.	SE (±)	4.96	5.04	4.36	3.39	3.69
11.	LSD	15.05	15.29	13.24	10.29	11.19
12.	CV%	22.0	16.4	13.2	9.4	12.2

### Efficacy of chemical pesticides

In efficacy test by leaf dip method, the analysis of Variance (ANOVA) indicates that treatments are statistically significantly effective in causing mortality of aphid. Table 5 shows number one treatment (T<sub>1</sub>) i.e., Imidacloprid @ 0.2 ml per liter of water was found more effective having about 95 % mean mortality rate than other treatments followed by Acetamiprid (T<sub>6</sub>), Dimethoate (T<sub>5</sub>), Deltamethrin (T<sub>3</sub>), Cypermethrin (T<sub>2</sub>) and Chlorantraniliprole (T<sub>4</sub>) respectively. T<sub>1</sub>, T<sub>5</sub> and T<sub>6</sub> did not show significant difference with each other. Likewise, T<sub>2</sub> and T<sub>3</sub> were at par with each other.

### Efficacy of chemical pesticides by leaf spray method

In efficacy test by leaf spray method, the analysis of Variance (ANOVA) indicates that treatments are statistically significantly effective in causing mortality of aphid. Table 6 shows number one treatment (T<sub>1</sub>) i.e., Imidacloprid @ 0.2 ml per liter of water was found more effective having about 86.67 %

mean mortality rate than other treatments followed by Acetamiprid (T<sub>6</sub>), Dimethoate (T<sub>5</sub>), Cypermethrin (T<sub>2</sub>), Deltamethrin (T<sub>3</sub>) and Chlorantraniliprole (T<sub>4</sub>) respectively. T<sub>1</sub>, T<sub>5</sub> and T<sub>6</sub> did not show significant difference with each other. Likewise, T<sub>3</sub> and T<sub>4</sub> were at par with each other.

**Table 5. Mortality percentage of cabbage aphids at different Hours After Treatment (HAT) for efficacy test of chemical pesticides by leaf dip method**

S.N	Treatments details	Mortality % at 24 HAT	Mortality % at 48 HAT	Mortality % at 72 HAT	Mortality % at 96 HAT	Mean mortality %
1.	Imidacloprid (T <sub>1</sub> )	90.00 <sup>e</sup>	93.33 <sup>d</sup>	98.33 <sup>d</sup>	98.33 <sup>d</sup>	95 <sup>d</sup>
2.	Cypermethrin(T <sub>2</sub> )	80.00 <sup>cd</sup>	81.67 <sup>c</sup>	83.33 <sup>c</sup>	85.00 <sup>c</sup>	82.50 <sup>c</sup>
3.	Deltamethrin (T <sub>3</sub> )	76.67 <sup>c</sup>	81.67 <sup>bc</sup>	85.00 <sup>c</sup>	88.33 <sup>c</sup>	82.92 <sup>c</sup>
4.	Chlorantraniliprole (T <sub>4</sub> )	65.00 <sup>b</sup>	71.67 <sup>b</sup>	71.67 <sup>b</sup>	75.00 <sup>b</sup>	70.83 <sup>b</sup>
5.	Dimethoate (T <sub>5</sub> )	85.00 <sup>de</sup>	90.00 <sup>cd</sup>	95.00 <sup>d</sup>	96.67 <sup>d</sup>	91.67 <sup>d</sup>
6.	Acetamiprid (T <sub>6</sub> )	88.33 <sup>e</sup>	91.67 <sup>cd</sup>	96.67 <sup>d</sup>	98.33 <sup>d</sup>	93.75 <sup>d</sup>
7.	Control (T <sub>7</sub> )	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>
8.	F value	148.902	105.513	189.417	311.700	244.98
9.	P value	<.001	<.001	<.001	<.001	<.001
10.	SE(±)	3.67	4.54	3.563	2.817	2.148
11.	LSD	7.878	9.74	7.643	6.042	6.515
12.	CV%	6.5	7.6	5.8	4.5	5.0

**Table 6 . Mortality percentage of cabbage aphids at different Hours After Treatment (HAT) for efficacy test of chemical pesticides by leaf spray method**

S.N	Treatments details	Mortality % at 24 HAT	Mortality % at 48 HAT	Mortality % at 72 HAT	Mortality % at 96 HAT	Mean Mortality %
1	Imidacloprid (T <sub>1</sub> )	76.67 <sup>c</sup>	83.33 <sup>d</sup>	90.00 <sup>d</sup>	96.67 <sup>e</sup>	86.67 <sup>c</sup>
2.	Cypermethrin(T <sub>2</sub> )	60.00 <sup>bc</sup>	68.33 <sup>bcd</sup>	73.33 <sup>bc</sup>	81.67 <sup>cd</sup>	70.83 <sup>bc</sup>
3.	Deltamethrin (T <sub>3</sub> )	56.67 <sup>b</sup>	60.00 <sup>b</sup>	68.33 <sup>b</sup>	75.00 <sup>bc</sup>	65.00 <sup>b</sup>
4.	Chlorantraniliprole (T <sub>4</sub> )	56.67 <sup>b</sup>	61.67 <sup>bc</sup>	63.33 <sup>b</sup>	65.00 <sup>b</sup>	61.67 <sup>b</sup>
5.	Dimethoate (T <sub>5</sub> )	73.33 <sup>bc</sup>	76.67 <sup>bcd</sup>	83.33 <sup>cd</sup>	93.33 <sup>de</sup>	82.92 <sup>c</sup>
6.	Acetamiprid (T <sub>6</sub> )	70.00 <sup>bc</sup>	81.67 <sup>d</sup>	93.33 <sup>d</sup>	95.00 <sup>de</sup>	85.00 <sup>c</sup>
7.	Control (T <sub>7</sub> )	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>	0.00 <sup>a</sup>
8.	F value	19.455	19.968	42.091	57.046	34.42
9.	P value	<.001	<.001	<.001	<.001	<.001
10.	SE(±)	8.36	9.09	7.01	6.36	5.14
11.	LSD	17.92	19.49	15.05	13.65	15.60
12.	CV%	18.2	18.0	12.6	10.8	13.8

## Discussion

### For efficacy test of Bio rational pesticides

The results of this study for efficacy test of bio rational pesticides for both leaf dip and leaf spray showed that the extract of citrus peel alkaloids and fatty acids was found more effective closely followed by Neem oil, Botanical extract and *Beauveria bassiana*. This result is consistent with the ones found by Bouchelta *et al.*, 2003; Gakuru & Foua, 1996 who indicated that alkaloids control the sucking pest at higher level. Dheeraj *et al.*, 2013, reported that potassium fatty acids are effective in controlling sucking pests like aphids, whiteflies etc. According to Loizzo *et al.*, 2012, Citrus peel contains diverse phytochemicals, including polyphenols and terpenes, citral, limonene and fenchone which are effective in pest control.

Neem oil and botanical extracts were also found effective causing more than 75 % mortality of aphids by leaf dip and 64% in leaf spray bio assay. This result was in line with that of Adhikari, 2011, who reported that neem product i.e., Neembicidine was effective in reducing aphid population. A group of researchers reported that there was reduction in 55 % aphid population after 168 hours of 1<sup>st</sup> spray of neem product. (Akbar *et al.*, 2014; Ghosh; 2017; Thapa *et al.*, 2019). Likewise, Lowry & Isman also reported that crude formulation of neem seed extracts contains limonoids with anti feedant mode of action. These findings are in agreement with those of Tang *et al.*, 2002 & Das *et al.*, 2008 who reported that insecticides based on plant extracts would be used effectively against aphid infestation on various crops. According to Gaukar, 2013, the action of bio constituents is exerted on insect development and survival therefore plant extracts can be considered as potential biopesticides as their phytochemical are able to reduce aphid population.

*Beauveria bassiana* also showed effective performance for causing mortality of aphids. This study was in line with that of Khanal *et al.*, 2020 who found 67.50 % mortality of mustard aphids by leaf spray method and 70.84 % of aphid mortality by leaf dip by use of *Beauveria bassiana*. According to Frang *et al.*, (2012), *B. bassiana* was associated with higher aphid mortality rate due to mycosis by specific hydrolytic enzymes that degrade the insect cuticle such as proteinase, chitinase and lipase.

### For efficacy test of chemical pesticides

In our study we found Imidacloprid, Acetamiprid and Dimethoate as most effective chemical insecticide for management of cabbage aphids. All these

three insecticides caused mortality more than 90 % in leaf dip bioassay and 80 % in leaf spray bioassay. The finding of this study corroborates with the finding of Elango. K *et al.*, 2017, who stated Imidacloprid as most effective pesticide causing maximum mortality of aphid in both contact bio assay and leaf dip bio assay test. Muhammad Aslam & Munir Ahmed, 2002, reported that there was effective control in the population of cabbage aphid with use of Imidacloprid. Likewise, Ahmed *et al.*, 2020, reported that acetamiprid was highly effective against aphid. Acetamiprid interacts with nicotinic acetylcholine receptors at the central and peripheral nervous system, resulting in excitation and paralysis followed by death of aphids (Ghanim & Ishaya, 2009).

Experiment conducted by Zeb *et al.*, 2016, found that the effect of Acetamiprid and Imidacloprid were at par with each other. A.R. Horowitz *et al.*, 1998, reported that Acetamiprid had higher foliar activity, Imidacloprid was shown to have somewhat higher efficacy against adult white flies in laboratory. They also suggested these two insecticides should not be used interchangeably; Imidacloprid is appropriate for soil application while Acetamiprid is more effective when applied to foliage of plants. Nyaupane *et al.*, (2020) reported that dimethoate was useful in control of cabbage aphids in cabbage field but found that natural enemies population was reduced drastically.

## CONCLUSION

In this research, in both leaf dip and leaf spray method citrus peel extract alkaloids + fatty acids showed maximum mortality followed by plant extract and neem oil. Likewise, in case of efficacy test of chemical pesticide Imidacloprid showed maximum mortality closely followed by Acetamiprid and Dimethoate in both leaf dip and leaf spray method. Thus, it can be concluded that there was no difference in result of both leaf dip and leaf spray bio assay for efficacy test of bio rational and chemical pesticide, although maximum mortality rate was found in leaf dip method.

Likewise the most effective bio rational pesticide having maximum mortality rate observed under laboratory condition was citrus peel extract alkaloids + fatty acids (Trade name: Larvosin). In case of most effective chemical pesticide having maximum mortality rate in different time series was Imidacloprid (Trade name: G- care). Likewise, it can also be concluded that although bio rational pesticides have comparatively less mortality rate than chemical pesticide, but in eco- friendly point of view bio rational pesticides are also equally effective for pest management.

## ACKNOWLEDGEMENT

The authors would like to thank Senior Scientist, Mr Ajay Shree Ratna Bajrachyarya and other staffs of National Entomology Research Centre, NARC, Khumaltar for their support to carry out this experiment successfully in time.

## REFERENCES

- Adhikari, J. (2011). Biology and management of *Brevicoryne brassicae* (L) (Homoptera: Aphididae) on broccoli in Lalitpur, Nepal. MSc. Thesis, Tribhuvan University, Nepal.
- Ahmed, K., Thapa, R., Regmi, R., Thapa, R.B & Gautam. B. (2020). Efficacy and profitability of using different IPM measures for control of cauliflower aphid (*Brevicoryne brassicae*) in different genotypes of cauliflower in Chitwan district, Nepal. *Journal of Agricultural Sci*,1(2): 80-87.
- Akbar, M., Rana, H. & Perveen, F. (2014). Management of Cauliflower Aphids through environment friendly bio insecticides. *Pakistan Entomologist*, 36(1): 25-30
- Baidoo, P. & Adam, J. (2012). The Effects of Extracts of *Lantana camara* (L.) and *Azadirachta indica* (A. Juss) on the Population Dynamics of *Plutella xylostella*, *Brevicoryne brassicae* and *Hellula undalis* on Cabbage. *Sustain. Agric. Res*, 1: 229–234.
- Blackman, R. L. & Eastop, V.F. (2020). Aphids on the World's Crops: An Identification and Information Guide; John Wiley & Sons Ltd.: Hoboken, NJ, USA.
- Bouchelta, A., Blenzer A., Beavougui A.J.P. & Lakhlifi, T. (2003). Etude de activite insecticide des extraits de *Capsicum Frutescens* (Solanaceae) sur *Bemissia Tabaci*. *Journal of Entomology*, 17:19-28.
- Bugg, R. L., Colfer, R. G., Chaney, W. E., Smith, H. A., & Cannon, J. (2008). Flower flies (Syrphidae) and other biological control agents for aphids in vegetable crops. *J. vegetable*, 45:66-70.
- Chapman, R., Bernays, E. & Simpson, S. (1981). Attraction and repulsion of the aphid, *Cavariella aegopodii*, by plant odors. *J. Chem. Ecol*, 7: 881–888
- Das, B., Pankjol, C., Kumar, S. & Maitur, R.M (2008). Aphicidal activity of some indigeneous plant extract against bean aphid (*Aphis craccivora*). *Journal of Agri. Sci*, 81: 153-159.
- De Bon, H., Huat, J., Parrot, L., Sinzogan, A., Martin, T., Malezieux, E. & Vayssieres, J.F. (2014). Pesticide risks from fruit and vegetable pest management by small farmers in sub-Saharan Africa. A review. *Agron. Sustain. Dev*, 34: 723–736.
- Dheeraj, J., Susan., V.P. & Nisha, S. (2013). Fatty acids metallic salt and pyrethroids-environmentally friendly pesticides. *International Journal of Scientific Research and Reviews*, 2(1): 43-51.
- Elango, K., Sridharan, S., Saravanan, P.A. & Balkrishna, S. (2017). Laboratory evaluation of insecticide & pesticide against *Aphis punicae* *Parsseni*. *Agri Sci*, 5(5): 1810-1812.
- Frang, M.G., Johnson, J.B. & Kish, L.P. (2012). Virulence of *Verticillium lecani* and an aphid derived isolate of *Beauveria bassiana* (Fungi: Hymphomycetes) for six species of cereal infesting aphids. Vol.19: 815-820
- Gakuru, S. & Foua, B.K. (1996). Effects of plant extracts on cow pea weevil (*Callosobruchus malculatus*) and the rice weevil (*Sitophilus oryzae*). *Cah. Agric* 5(1): 39-42.
- Gaukhar, R. (2013). Cow urine: A potential Bio pesticide. *Indian Journal of Economic Entomology*, 75(3): 212-216.
- Ghanim, M & Ishaaya, L. (2009). Effects of acetamiprid in control of sucking pests. *Agri sci*, 33: 16-78.

- Ghosh, K.S. (2017). Seasonal Incidence of Aphids (*Aphids gosypi*) infesting tomato (*Lycopersicon esculentus* L) and their management by using botanical pesticides. *Journal of Agriculture Science*, 5(3): 14-17.
- Gupta, S. & Dikshit, A. (2010). Biopesticides: An eco friendly approach for pest control. *J. Biopestic*,3:186–188.
- Hara, A. H. (2000). Finding alternative ways to control alien pests-Part 2: New insecticides introduced to fight old pests. *Hawaii Landscape*, 4(1): 5-8
- Horowitz, A.R., Medelson, Z., Weintraub, P.G. & Ishaya, I.(1998). Comparative toxicity of foliar and systemic application of acetamiprid and imidacloprid against cotton whitefly *Bemisia tabaci*. *Mycol, Res*, 88: 437-442.
- Kessing, J.L.M. & Mau R.F.L. (1991). Cabbage aphid (*Brevicoryne brassicae* L.), Crop Knowledge Master. Department of Entomology, Honolulu, Hawaii.
- Khanal, D., Maharjan, S., Lamichhane, J., Neupane, P., Sharma, S. & Pandey, P. (2020). Efficacy of Bio rational compounds against Mustard and English Grain aphid under laboratory condition in Nepal. *Advances in Agriculture*, 6:7-13
- Lashkari, M.R., Sahragard, A. & Ghadamyari, M. (2007). Sublethal effects of imidacloprid and pymetrozine on population growth parameters of cabbage aphid, *Brevicoryne brassicae* on rapeseed, *Brassica napus* L. *Insect Sci*, 14: 207–212.
- Loizzo, M.R., Tundis, R., Bonesi, M., Menichi, F., De luca, D., Colica C. & Menichini, F. (2012). Evaluation of *Citrus aurantifolia* peel and leaves extract for their chemical composition, antioxidant and anti- cholinesterase activities. *J Sci Food Agric*. 92 (15): 2960-2967.
- Lowery, D. T., & Isman, M. B. (1994). Insect growth regulating effects of neem extract and azadirachtin on aphids. *Entomologia Experimentalis et Applicata*, 72(1): 77-84.
- McNaughton, S.A., Marks, G.C. & Nutr, J.B. (2019). Inclusion in Summer. An issue of small farmers. Vol 5 :90.
- MoAD, (2018/19), *Statistical information on Nepalese agriculture (2018/19)*, Government of Nepal, Ministry of Agriculture and Livestock Development (MoAD), Planning and Development Cooperation Coordination Division, Statistics and Analysis Section, Singha Durbar, Kathmandu, Nepal.
- Milner, R. J. (1997). Prospects for biopesticides for aphid control. *Entomophaga*,42 (1-2): 227-239
- Muhammad, A & Munir, A. (2002). Effectiveness of some insecticides against cabbage aphid, *Brevicoryne brassicae* (Linnaeus) (homoptera: aphididae). *Journal of agriculture science*,13: 145-150
- Mwanauta, R.W., Mtei, K.M. & Ndademi, P.A. (2015). Potential of Controlling Common Bean Insect Pests (Bean Stem Maggot (*Ophiomyia phaseoli*), Ootheca (*Ootheca bennigseni*) and Aphids (*Aphis fabae*) using Agronomic, Biological and Botanical Practices in Field. *Agric. Sci*, 6: 489–497.
- Nyaupane, S., Tiwari, S., Thapa, R.B & Jaishi, S. (2020). Testing of bio rational and synthetic pesticides to manage cabbage aphid (*Brevicoryne brassicae*) in cabbage field at Rampur, Chitwan. *Agr Sci*, 4(2): 29-30
- Ojetayo, A.E., Akanbi, W.B. & Olabiyi, T.I., (2011). Effect of fertilizer types on nutritional quality of two cabbage varieties before and after storage. [www.m.elewa.org](http://www.m.elewa.org), Issue 2011.
- Singh, B. & Bakheta, D.R.C. (1987). Screening and breeding techniques for Aphid resistance in *Oleiferous Brassica*: A review. Oilcrops Network, International Development Research Centre, Canada, 50:87-99.
- Singh, T. R., Singh, M. P., Singh, K. I., Devi, T. B., & Singh, N. G. (2007). Comparative efficacy of certain neem products and conventional insecticides against *Lipaphis erysimi*(Kalt.) and their safety to its natural enemies in rapeseed. *Indian Journal of Entomology*, 69(3): 259-268.
- Tanq, Y.Q., Weathersbee, A.A & Mayer, R.T. (2002). Effect of neem seed extract on the brown citrus aphid and its parasitoid *Lysiphaleous testaceipes*. *J. Ento*,31: 171-176.

- Thapa, R., Bista, K., Bhatta, H., Bhandari, S., Acharya, S. & Sapkota, B. (2019). Comparative performance and economic efficiency of different pesticides against okra jassids. *Journal of Entomology and Zoology Studies*, 7(5): 525-531
- Weinberger, K. & Srinivasan, R. (2009). Farmers' management of cabbage and cauliflower pests in India and their approaches to crop protection. *J. Asia Pac. Entomol.*, 12:253–259
- Zeb, Q., Naem, M., Khan, S.A. & Ahmad, S. (2016). Effect of insecticides on the population of aphids, natural enemies and yield components of wheat. *Agri. Sci.* 48:1839-1848

## Effects of Seasons and Feed on Serum Minerals of Goats Reared in Mid- Hills of Nepal

<sup>1</sup>Luma N. Pandey, <sup>2</sup>N.R. Devkota, <sup>3</sup>B.N. Devkota, <sup>\*</sup>3S.R. Barsila and  
<sup>1</sup>M.R. Tiwari

<sup>1</sup>Nepal Agricultural Research Council, Khumaltar, Kathmandu

<sup>2</sup>Gandaki University, Pokhara, Nepal

<sup>3</sup>Agriculture and Forestry University, Rampur, Chitwan, Nepal

**\*Corresponding Author:** sbarsila@gmail.com

### ABSTRACT

Goats in Nepal are mostly reared in low input systems, based on natural forest and fodder trees feeding, resulting poor growth and production performance. Effect of such feeding practice, especially on the blood serum minerals is largely not known. This research was done with the objective to know the effects of seasonal variation on status of major minerals with respect to available feeding materials on goats. A 2×3× 3 factorial combination of treatments were used in a Randomized Complete Block Design, each treatment was replicated for four times. Factors combined included-season (summer and winter); dietary factors (fodder tree leaves feeding only, fodder tree leaves plus maize grain feeding, and feeding fodder tree leaves plus compound feed), and goat breed (Khari, Crossbred and Boer). A 30 days experiment was done. Blood serum was collected from each goat at the end day of the experiment, and assayed seven major minerals from the serum. Results showed that Ca, P, Mg, Se and Cu during winter season were significantly lower ( $p<0.05$ ) than during summer and were deficit to the goat's requirements. Serum Se was highly deficit at each scenario of diet used for both the seasons. The Zn and Mn requirements, was, however, met for all treatments under investigation for both the seasons. Compound feed supplemented goat had significantly higher level of P, Se and Zn ( $p<0.05$ ), but was not sufficient to meet the dietary requirements. These findings clearly revealed that blood serum status of major minerals of the goats varied seasonally with the pronounced deficit during winter season. Thus supplementation of major minerals mixture especially during winter and Se throughout the year in the diet of goat can be provisioned in middle hills of Nepal to improve productive and reproductive efficiency.

**Key words:** Goat, Minerals, Serum, Feed, Supplementation

### INTRODUCTION

Goats are one of the most dominating and popular livestock species reared by most of the marginal farmers in Nepal which is also considered precious sources of cash to quench household needs, especially during a crisis (Rajwar, 2012).

They are reared in low input systems based on natural forest and cultivated fodder trees, often not fed any concentrate unless it is absolutely required and there is no practice of mineral supplementation to basal diet. Since, the goat production influenced greatly by optimal level of essential and trace mineral in the body (Sharma et al., 2009; McDowell & Conrad, 1977). The mineral content evaluation of both feed and blood serum is a very important mineral requirement appraisal where feed is given traditionally without supplements. The serum minerals values of farm animals are influenced by age, sex, breed, climate, geographical location, season, day length, feed supply, life habit of species, the present status of an individual, and other factors ((Suttle, 2010). The blood mineral assessment of goats in the present study are indicative of the nutritional stress (Larson,1978) and provide a hint for future studies while for improving the minerals as supplement. Measuring the blood mineral attributes may well be less time-consuming and further be less costly than any other nutritional assessments in goat herds (Haenlein, 1980).

Fodder, mainly from natural forest (tree fodder) and cultivated fodder tree are often fluctuates seasonally both in terms of quantity and quality (Lukuyu et al. 2016). The Seasonal changes of biomass production and limiting nutritional factors is of crucial in maintaining productive performance of goats. Especially, during the dry winter periods, there has been inadequate and poor nutritive feed supply in general in the hills of Nepal (Tulachan & Neupane, 1999; Singh, 2020). The middle hills of Nepal are at high feed pressure, with more than 24.09 % feed deficit (Singh & Singh, 2019) with seasonal variation (Raut et al., 2000). Since the nutrient deficiency are likely to occur to the animals (Singh, 2004) it could results in poor growth and production performance (Orden et al, 1999), for example to the goats as well. The regular unavailability of quality feed resources, have been a serious constraint to increase animal production, but inadequate attention has been given to improve the feed quality in Nepal (Singh, 2020). The mineral factors associated with production and productivity of goat has not been properly addressed yet in Nepal (Tiwari et al, 2012). Thus, this research was done with the objective to investigate the status of blood serum level of major minerals with respect to season, breed and variation in diet of goats to help optimize nutritional strategies, including the need for mineral supplementation in the diet.

## **MATERIAL AND METHODS**

**Research site:** The research was conducted at Goat Research Station (GRS), Bandipur, which could be represented of the middle hills of Nepal. It ranges from 800 to 1200 meter above the mean sea level. The precipitation is an

average of 2000 mm per year with an average of 85% relative humidity; and the maximum and minimum temperature of the site is 32<sup>0</sup> C and 8<sup>0</sup> C, respectively, (GRS, 2020).

**Fodder selection:** Most commonly used fodder species for goat feeding were selected in summer (April- September} and winter (October–March) seasons from the GRS farmland. Commonly used top five fodder species for each season were identified and used in goat feeding experiment. They were as fallows;

a. Summer fed fodder species:

1. *Ficus cunia Buch.*, commonly known as ‘Khanayo’
2. *Bauhinia purpurea*, commonly known as ‘Tanki’
3. *Castanopsis indica*, commonly known as ‘Katus’
4. *Ficus glaberrima Bl.*, commonly known as ‘Pakhuri’
5. *Ficus roxburghii wall.*, commonly known as ‘Nimaro’

b. Winter fed fodder species:

6. *Shorea robusta*, commonly known as ‘saal’
7. *Terminalia elliptica*, commonly known as ‘Saaj’
8. *Mangifera indica*, commonly known as ‘Mango’
9. *Arundinaria intermedia*, commonly known as ‘Nigalo’
10. *Litsea polyantha*, commonly known as Khanayo as ‘Kutmiro’

**Animal Selection and Management:** GRS has maintained herds of approximately 650 heads of goats where different breeds of goat i.e., Khari, crossbred boar (50 %, cross with Khari) and pure breed boar. A total of 36 healthy goats (12 goats from each above breed) of similar age and body weight were selected from the concerning flock and equally divided into respective treatment. Diet requirement was calculated @ 4 % DM feed of body weight. Diet was offered in group. Concentrate ration was provided in morning, and fodder were provided in 3 split doses in three times with *adlib* Water.

#### **Treatments and design used**

A 2×3× 3 factorial combination of treatments were used in a Randomized Complete Block Design, each treatment was replicated for four times. Factors combined included-two seasons (summer and winter); three dietary factors (seasonal fodder tree leaves only, seasonal fodder tree leaves plus 150 g. maize grain/animal/day-as of farmer practice, and seasonal fodder tree leaves plus 150 g. compound feed (Table 1) /animal/day-mineral mixture fortified); and three

goat breeds (Khari, 50% crossbred of and Khari and Boer, and Boer only). A 30 days experiment was done in both seasons.

Table 1. Composition of Compound feed used in goat feeding

Feed ingredients	Parts	CP
Maize grit	46.5	4.802
Rice bran	20	2.074
Soybean cake	20	7.886
Mustard cake	10	3.181
Minerals mixture	2	0
Salt	1.5	0

### **Sample collection**

Blood sample were collected at the end day of experiment in both the seasons. Ten ml of blood, drawn from jugular vein of each of the experimental animal, were kept in 15 ml polypropylene tubes, and were set aside for 2 hrs. at 37<sup>0</sup>C to clot for serum separation. Serum sample stored in 2 ml vials at a temperature of -20 until used for mineral analysis (Tatsumi et al. 2002).

### **Minerals analysis**

All minerals were analyzed in a laboratory of Water Engineering & Training Centre (P) Ltd situated at Ratopool Kathmandu. Firstly, all samples were prepared by acid digestion (nitric acid) in a certain volume and various test methods applied for minerals determination. The Atomic Absorption Spectrometry (AAS; Agilent, model: 240FS AA) was used for determining Mg, Zn, Cu and Mn content by following the procedure directed by 3114 C., APHA, 23<sup>rd</sup> edition where Hydride Generator was added to the equipment (GH-AAS) for Se determination (APHA, 2005). Similarly, Ca was determined by the same AAS in accordance with 3111 D, APHA, and 23<sup>rd</sup> edition. But, P was analyzed by UV - Visible Spectrophotometer (Thermo Scientific, Model: GENESYS 10SUV-VIS) as described in 4500-P E. APHA, 23<sup>rd</sup> edition (APHA, 2005).

### **Statistical analysis**

The data were collected during the course of time and on the basis of individual goat observations, the population means for each character was computed. Data entry was done in excel sheet. Serum minerals means were tested between seasons, among diets and among breed with interactions by analysis of variance using the R-studio version 4.1.1. The accepted level of significance was  $p < 0.05$  for all analyses. The data are presented as means  $\pm$  S.E.

### **Reference Value**

The reference values for minerals in goat serum were cited from various literatures (Table 2). These values were compare to the values came from the

result of serum analysis in the Laboratory which was applicable to know either the mineral requirement to the goats were met or not.

Table 2. Reference values for minerals content in goat serum from selected literature

Minerals	Reference range	Reference cited
Ca (mg/l)	80 – 120	NRC (2007); Khan et al 2007; Pugh and Baird (2012) Unubol etal, 2016; Schweinzer etal, 2017;
P (mg/l)	40 - 80	NRC (2007); Yatoo etal,2013; Samardija, 2011; McDowell, 1997; Puls (1994)
Mg (mg/l)	18 – 35	NRC (2007), Schweinzer etal, 2017, Pugh and Baird (2012), Idexx Vet Med Labor Gmbt, Ludwigsnurg, Germany, Samardija, 2011, Unubol etal, 2016, Yatoo etal 2013
Se (ug/l)	62-158	Idexx Vet Med Labor Gmbt, Ludwigsnurg, Germany
Cu (mg/l)	0.8- 1.5	NRC (2007); McDowell, 1997, Unubol etal, 2016, Schweinzer etal, 2017
Zn (mg/l)	0.8 – 1.2	NRC (2007), Yatoo etal,2013, Idexx Vet Med Labor Gmbt, Ludwigsnurg, Germany
Mn (mg/l)	0.03- 0.09	Unbol et al, 2016, Schweinzer et al, 2017

## RESULTS AND DISCUSSION

### **The effect of diet, breed, season and their interaction to serum minerals concentration**

The overall results of the analysis of variance related to blood serum concentration with respect to the diet, season and breed has been presented in Table 3. Accordingly, it is well revealed that diet had effect ( $p < 0.001$ ) to P, Se and Zn, but not to the Ca, Mn and Cu whereas breed differences was significant only for Mn content. Likewise season had significant impact to the P, Ca, Mg, Cu, Mn ( $p < 0.001$ ) and Zn ( $p < 0.01$ ) (Table 3).

There was no significant interaction of diet  $\times$  breed ( $p > 0.05$ ) for all minerals under consideration whereas interactions among diet  $\times$  season was significant ( $p < 0.05$ ) for P content. Meanwhile, P, Ca, Mg, Se and Cu content in all the treatments were below the reference range during winter whereas such lower range was only pronounced for Se content during summer (Table 2). Mn and Zn had significant effect for breed  $\times$  season whereas interactions of diet  $\times$  breed  $\times$  season was non-significant ( $p > 0.05$ ) for all minerals under consideration (Table 3).

### **Effect of diets on serum minerals concentration**

Supplementation with mineral mixed compound feed on fodder tree leaves basal diet (Diet 3) had significant effect on P, Se ( $p < 0.001$ ) and Zn ( $p < 0.05$ ) content whereas maize grain supplementation on the basal diet (Diet 2) had only

significant effect for P ( $p < 0.001$ ) and Zn ( $p > 0.05$ ) content. Rest of the minerals were not differed significantly ( $p > 0.05$ ) among the dietary treatment group (Table 4).

Table 3. Analysis of variance of minerals concentration in serum due to the effect of diet, breed, season and their combination

Parameters	P	Ca	Mg	Se	Cu	Mn	Zn
Diet	0.00022 ***	0.4807	0.45115	<2e-16 ***	0.80576	0.40276	0.00715 **
Breed	0.54788	0.5875	0.04882 *	0.42589	0.99453	0.81178	0.18375
Season	1.96e-09 ***	<2e-16 ***	1.58e-14 ***	0.10544	1.966e-11 ***	0.00055 ***	0.00589 **
Diet *Breed	0.42711	0.1812	0.15301	0.46232	0.09445	0.81835	0.57498
Diet *Season	0.00064 ***	0.3558	0.54298	0.08929	0.35699	0.0707	0.01489 *
Breed * Season	0.94273	0.6298	0.00502 **	0.49823	0.103	0.56355	0.02510 *
Diet * Breed * Season	0.55582	0.2066	0.84894	0.56328	0.45109	0.73077	0.33146

Significance Codes: '\*\*\*' =  $p < 0.001$ , '\*\*' =  $p < 0.01$ , '\*' =  $p < 0.05$ .

Findings of this study also revealed similar status of minerals in blood serum ( $p > 0.05$ ) except Mg among the goat breeds (table 3) whereas Khari was superior to other breeds in Mg content ( $p < 0.05$ ). The results also revealed below the reference range for Se and Cu content (Table 2) in all treatments with different dietary composition (Table 4) and breeds of goat.

Table 4. Effect of different diets on major minerals concentration of blood serum

Serum Minerals (Mean $\pm$ S.E.)								
		P (mg/l)	Ca (mg/l)	Mn (mg/l)	Se (ug/l)	Cu (mg/l)	Zn (mg/l)	Mn (mg/l)
Reference range		40-80	80-120	18-35	62-158	0.8-1.5	0.8-1.2	0.03-0.09
Diet	Diet 1	55.97 $\pm$ 4.28 <sup>b</sup>	168.51 $\pm$ 29.74	23.79 $\pm$ 3.30	0.04 $\pm$ 0.01 <sup>b</sup>	0.60 $\pm$ 0.10	0.98 $\pm$ 0.09 <sup>b</sup>	0.18 $\pm$ 0.03
	Diet 2	71.46 $\pm$ 3.42 <sup>a</sup>	152.00 $\pm$ 23.46	26.55 $\pm$ 3.22	0.04 $\pm$ 0.00 <sup>b</sup>	0.57 $\pm$ 0.09	1.59 $\pm$ 0.21 <sup>a</sup>	0.13 $\pm$ 0.03
	Diet 3	70.40 $\pm$ 3.12 <sup>a</sup>	171.15 $\pm$ 29.98	26.84 $\pm$ 2.85	0.93 $\pm$ 0.2 <sup>a</sup>	0.54 $\pm$ 0.08	1.73 $\pm$ 0.25 <sup>a</sup>	0.16 $\pm$ 0.03
LSD (=0.05)		7.79	34.17	5.31	0.07	0.18	0.48	0.08
CV (%)		20.39	35.98	35.61	34.55	53.70	58.71	84.57
Sig.		***	Ns	Ns	***	Ns	**	Ns

Diet 1 = Fodder with no concentrate; Diet 2 = Fodder with maize grit supplementation and T3  
Diet 3 = Fodder with mineral mix concentrate supplementation. Mean value with different superscript letter within same row are significantly different at  $p < 0.05$ .

Table 5. Effect of different seasons on major mineral concentration of blood serum

		Minerals (Mean $\pm$ S.E.)						
		P (mg/l)	Ca (mg/l)	Mn (mg/l)	Se (ug/l)	Cu (mg/l)	Zn (mg/l)	Mn (mg/l)
		40-80	80-120	18-35	62-158	0.8-1.5	0.8-1.2	0.03-0.09
Season	Summer	76.48 $\pm$ 2.22 <sup>a</sup>	283.49 $\pm$ 14.35 <sup>a</sup>	37.19 $\pm$ 1.87 <sup>a</sup>	0.36 $\pm$ 0.08	0.88 $\pm$ 0.44 <sup>a</sup>	1.15 $\pm$ 0.07 <sup>b</sup>	0.10 $\pm$ 0.01 <sup>b</sup>
	Winter	55.41 $\pm$ 3.00 <sup>b</sup>	44.28 $\pm$ 1.81 <sup>b</sup>	14.26 $\pm$ 1.41 <sup>b</sup>	0.31 $\pm$ 0.07	0.26 $\pm$ 0.06 <sup>b</sup>	1.72 $\pm$ 0.22 <sup>a</sup>	0.21 $\pm$ 0.03 <sup>a</sup>
	LSD (=0.05)	6.36	27.90	4.33	0.05	0.14	0.39	0.06
	CV (%)	20.39	35.98	35.61	34.55	53.70	58.71	84.57
	Significance	***	***	***	Ns	***	**	***
Mean value with different superscript letter within same row are significantly different at p<0.05.								

### Effect of seasons on serum minerals concentration

Findings showed significant effect of season for minerals content (Table 5). Accordingly, the P, Ca, Mg, and Cu content in the blood serum was higher during summer season whereas Zn and Mn content were more visible during winter season ( $p < 0.05$ ). However, no distinct effect of season was found in the case of Se ( $p > 0.05$ ). The Zn and Mn content during winter and Se content for both the seasons were found below the reference range (Table 2; Table 5).

## DISCUSSION

Supplementation with mineral mixed compound feed on fodder tree leaves basal diet (Diet 3) enhanced level of the minerals content which is comparable to the various previous findings. Abdelrahman et al., (2014) reported that increased level of Zn in growing Naemi lambs with trace minerals supplementation on palm kernel cake was beneficial. Likewise Moyano et al. (2020) reported higher Ca and P content in mineral supplemented grazing sheep; and Lima et al. (2021) also observed higher concentrations of Ca, Cu, Co and Mo in minerals supplemented goats than those not supplemented (control group). Furthermore, Kwak et al. (2016) observed the improved bioavailability and retention of Zn and Cu when supplementing the microbial culture and trace minerals in sheep. In our experiment as well maize grain supplementation on fodder tree leaves basal diet (Diet 2) had abundant P but low in Ca content and also low in trace minerals as with most cereal grains (Teklic, et al., 2013) that could be one of the reasons for higher P content and similar Ca and other trace minerals content in

Diet 1. However, compound feed (Diet 3) might have positive impact to release more of P, Se and Zn due to mineral fortified concentrate in nature.

The minerals, *i.e.* P, Ca, Mg, Zn and Mg met the goat requirements in all diet which is also supported by the findings of Bakshi and Wadhwa (2007) as the authors clearly indicated that leaves of *M. azedarach*, *M. alba* or *L. leucocephala*, supplemented with mineral mixture and common salt could serve as an excellent complete feed for small ruminants. Moreover, Azim, et al. (2011) considered that fodder tree leaves and shrubs are good source of nutrients (proteins, fats, carbohydrates, fiber and minerals) and can be used as substrates deficit in either of these nutrients for livestock grazing. Osti et al, (2006) also supported in this line that the combination of fodder trees leaves, grasses, legumes and concentrate could be complete ration for buffaloes reared in the hills of Nepal. Our findings are in line with these results that further rectifies the findings.

The highly deficit of selenium as revealed in our results might be due to Se deficit soil and fodder, a complex relationship between soil, plant and animal (Kumaresan et al, 2009; McDowell and Conrad, 1990). Supporting in this view, Andersen, (2007) and Spallholz et al, (2008) had also postulated the fact that the selenium deficiency is common in Nepal. Additionally, Shrestha et al (2005) reported a significant increase in the fertility of goats given Se supplements in Dhanusha district. However, selenium toxicity in buffalo was reported in Darchula and Baitadi district of Nepal (Khanal and Knight, 2010). These findings needs cautious interpretation with further verification through research works.

The Mg content in Khari goat seemed higher than the cross bred, and Boer. This might be related also to the genetic differences. In this line Szigeti et al. (2015) observed significant breed differences in the case of Ca, Mg, and Cu content in cattle. Mioc et al. (2010) and Field et al. (1969) also identified that breed difference was source of variation for Ca, P, and Mg content in blood serum of sheep. However, our findings did not entirely support the fact that all minerals might not be well varied as per the breed as Ca, P, Cu, Se, Zn and Mn content in the blood serum were not significantly different ( $p>0.05$ ; Table 3 ) among the breeds of goats.

Several researchers (Orden, 1999 in goat; Yokus and Kurt, 2004 in sheep; Rumosa et al., 2012 Nguni goat; Sowande et a.l, 2008 in goat & sheep, Inbaraj et al., 2017in goat; Shah et al., 2017 in cattle; Mohammed et al., 2017 in goat)

have well reported that season could influence requirement levels of animal for minerals. Such findings further matches with research study of other authors (Usha et al, 2018 in cattle; Yokus, & Cakir, 2006 in sheep; Olmedo-Juárez et al., 2012 in goat), as these authors reported the higher concentration of Ca, P, Mg, Cu in summer serum. Moreover, Khan et al (2003) in sheep and goat, Shah et al (2017) in dairy cattle, and Olmedo-Juárez et al. (2012) in non-lactating goats found higher mineral concentration in rainy season. Feeding minerals rich fodders to the goats during summer season might have resulted such scenario. In summer, especially when rainy season begins, fodder and fodder trees grows in moist soil which could increase the mineral solubility, resulting enhanced the mineral uptake by fodder (Shalhevet, J., 1973).

## **CONCLUSION**

Based on these findings it could be concluded that mineral status of the goats reared in middle hills of Nepal varied seasonally. Generally, Most of the minerals concentration in goat serum in winter season are lower and deficient to meet goat requirement than the summer season. The mineral Se was highly deficient in both season and Cu was deficient in winter which could not be managed by supplementing maize grain or commercial mineral mixture fortified compound feed, so Se supplementation through injection might be needed in both season for all breed of goat to cope the highly Se deficit situation. Similarly, other minerals i.e., Ca, P, Mg, Se and Cu should be supplemented, only in winter season, to the all goat breeds better for nutrient management strategy.

## **ACKNOWLEDGEMENTS**

Authors would like to acknowledge the whole team of GRS, Bandipur for their help and support in conducting the research during the entire period. The laboratory technician of NANRC, Khumaltar, and the laboratory of Water Engineering & Training Centre (P) Ltd are duly acknowledged for their help. The authors are also grateful to Mr. Suraj Singh for assessing data management and analysis.

## **REFERENCES**

- Abdelrahman, M.M., Aljumaah, R.S., Alyemni, A.H., Moez, A., Hassan, M. and Al-Saiady, M.Y., 2014. Effect of palm kernel cake and trace minerals on performance of growing Naemi lambs. *Research Opinions in Animal and Veterinary Sciences*, 4(5), pp.268-272.
- Andersen, P., 2007. A review of micronutrient problems in the cultivated soil of Nepal. *Mountain research and development*, 27(4), pp.331-335.
- APHA (2005) Standard Methods for the Examination of Water and Wastewater. 21st Edition, American Public Health Association/American Water Works Association/Water Environment Federation, Washington DC.

- Azim, A., Ghazanfar, S., Latif, A. and Nadeem, M.A., 2011. Nutritional evaluation of some top fodder tree leaves and shrubs of district Chakwal, Pakistan in relation to ruminant's requirements. *Pakistan Journal of Nutrition*, 10(1), pp.54-59.
- Bakshi, M.P.S. and Wadhwa, M., 2007. Tree leaves as complete feed for goat bucks. *Small Ruminant Research*, 69(1-3), pp.74-78.
- Field, A. C., Wiener, G. and Wood, J. (1969) "The concentration of minerals in the blood of genetically diverse groups of sheep: II. Calcium, phosphorus, magnesium, potassium, sodium and chlorine concentrations for three hill-breeds and their crosses at pasture," *The Journal of Agricultural Science*. Cambridge University Press, 73(2), pp. 267–274.
- GRS (2020). Annual Report of Goat Research Station (GRS), Bandipur, Tanahun.
- Haenlein, G.F.W., 1980. Mineral nutrition of goats. *Journal of Dairy Science*, 63(10), pp.1729-1748.
- Inbaraj, S., Kundu, A., De, A.K., Sunder, J. and Sejian, V., 2018. Seasonal changes in blood biochemical and endocrine responses of different indigenous goat breeds of tropical island agro-ecological environment. *Biological Rhythm Research*, 49(3), pp.412-421.
- Khan, Z.I., Ashraf, M., Ashraf, M.Y. and Hussain, A., 2003. Mineral status of livestock (Goats and Sheep) based on soil, dietary components and animal tissue fluids in relation to seasonal changes and sampling periods in specific region of Pakistan. *Journal of Animal and Veterinary Advances*.
- Khan, Z.I., Hussain, A., Ashraf, M., Ashraf, M.Y. and McDowell, L.R., 2007. Macromineral status of grazing sheep in a semi-arid region of Pakistan. *Small Ruminant Research*, 68(3), pp.279-284.
- Khanal, D.R. and Knight, A.P., 2010. Selenium: its role in livestock health and productivity. *Journal of Agriculture and Environment*, 11, pp.101-106.
- Kumaresan, A., Bujarbaruah, K.M., Pathak, K.A. and Ramesh, T., 2010. Soil–plant–animal continuum in relation to macro and micro mineral status of dairy cattle in subtropical hill agro ecosystem. *Tropical animal health and production*, 42(4), pp.569-577.
- Kwak, W.S., Kim, Y.I., Choi, D.Y. and Lee, Y.H., 2016. Effect of feeding mixed microbial culture fortified with trace minerals on ruminal fermentation, nutrient digestibility, nitrogen and trace mineral balance in Sheep. *Journal of animal science and technology*, 58(1), pp.1-8.
- Larson, B.L., 1978. The dairy goat as a model in lactation studies. *Journal of Dairy Science*, 61(7), pp.1023-1029.
- Lima, J.M., Vale, R.G., Sousa, R.D.S., Nunes, T.L., Gameleira, J.D.S., Cavalcante, J.M., Minervino, A.H.H., Ortolani, E.L. and Barrêto Júnior, R.A., 2021. Seasonality Effects on the Mineral Profile of Goats Farmed in the Semiarid Region of Brazil. *Veterinary Sciences*, 8(1), p.8.
- Lukuyu, M.N., Njehu, A., Mwilawa, A., Lukuyu, B.A., Omoro, A.O. and Rao, J., 2016. A study to understand fodder markets and fodder trading patterns in MoreMikiT sites and other selected regions in Tanzania.
- McDowell, L.R. and Conrad, J.H., 1977. Trace mineral nutrition in Latin America [ruminants]. *World Animal Review*.
- McDowell, L.R. and Conrad, J.H., 1990. Mineral imbalances of grazing livestock in tropical countries. *International Journal of Animal Sciences*, 5(1), pp.21-32.
- Mioč, B., Vnučec, I., Prpić, Z., Pavić, V., Antunović, Z. and Barać, Z., 2010. Effect of breed on mineral composition of meat from light lambs. *Italian Journal of Animal Science*, 8(sup3), pp.273-275.
- Mohammed, A., Khan, A., Pargass, I., Bridgemohan, P., Edwards, A.E., Stewart, H.S., Youssef, F.G. and Sieuchand, S., 2017. Serum Mineral Levels in Goats of Various Physiological Stages in the Dry and Wet Seasons in Central Trinidad. *Микроэлементы в медицине*, 18(2), pp.17-27.
- Moyano Tapia, J.C., Leib, S.A., Marini, P.R. and Fischman, M.L., 2020. Effect of Mineral Supplementation on the Macromineral Concentration in Blood in Pre-and Postpartum Blackbelly Sheep. *Animals*, 10(7), p.1206.

- NRC 2007. Nutrient Requirements of Small Ruminants. NRC- NAP- Washington. pp. 347.
- Olmedo-Juárez, A.G.U.S.T.I.N., Rojo, R., Salem, A.Z.M., Vázquez-Armijo, J.F., Rebollar-Rebollar, S.A.M.U.E.L., Albarran, B. and Lugo, J., 2012. Concentration of some elements in blood serum of nonlactating goats in a subtropical region of southwest of Mexico state. *Tropical and Subtropical Agroecosystems*, 15(1), pp.71-75.
- Orden, E.A., Serra, A.B., Serra, S.D., Aganon, C.P., Cruz, E.M., Cruz, L.C. and Fujihara, T., 1999. Mineral concentration in blood of grazing goats and some forage in Lahar-Laden area of Central Luzon, Philippines. *Asian-Australasian Journal of Animal Sciences*, 12(3), pp.422-428.
- Osti, N.P., Upreti, C.R., Shrestha, N.P. and Pandey, S.B., 2006, April. Review of nutrients content in fodder trees leaves, grasses and legumes available in buffalo growing areas of Nepal. In *Proc. Vth Asian Buffalo Congress, Nanjing, China* (pp. 366-371).
- Puls, R., 1994. Mineral levels in animal health: diagnostic data 2nd ed. British Columbia: Sherpa International.
- Pugh, D.G. and Baird, N.N., 2012. *Sheep & Goat Medicine-E-Book*. Elsevier Health Sciences.
- Rajwar, N. B. (201, April). National goat development strategies and outcomes. In Proceedings of the National Workshop on Research and Development Strategies for Goat Enterprises in Nepal (pp. 1-6).
- Raut, Y., D. R. Pradhan, R. S. Pande and A. S. Ranjit. 2000. Pasture development situation and its constraints for livestock production in Nepal. Proceedings of the 3rd National Animal Science Convention, Kathmandu, Nepal. August 27-28, 2000. Nepal Animal Science Association, Nepal. Pp. 78-84.
- Rumosa Gwaze F., Chimonyo M., Dzama K., 2012. Effect of season and age on blood minerals, liver enzyme levels, and faecal egg counts in Nguni goats of South Africa. *Czech J. Anim. Sci.*, 57: 443-453.
- Samardžija, M., Dobranić, T., Lipar, M., Harapin, I., Prvanović, N., Grizelj, J., Gregurić Gračner, G., Dobranić, V., Radišić, B. and Đuričić, D., 2011. Comparison of blood serum macromineral concentrations in meat and dairy goats during puerperium. *Veterinarski arhiv*, 81(1), pp.1-11.
- Schweitzer, V., Iwersen, M., Drillich, M., Wittek, T., Tichy, A., Mueller, A. and Krametter-Froetscher, R., 2017. Macromineral and trace element supply in sheep and goats in Austria. *Veterinárni medicína*, 62(2), pp.62-73.
- Sharma, M.C., Tiwari, R. and Kumar, P. 2009. Area specific mineral mixture: need and importance. *Vet. Commun.* 4: 3- 8.
- Shalhevet, J., 1973. Effect of mineral type and soil moisture content on plant uptake of <sup>137</sup>Cs. *Radiation Botany*, 13(3), pp.165-171.
- Shrestha, S.P., Rymer, C., Jayaswal, M.L., Lama, N., Neupane, K.P. and Jha, V.N., 2005. Supplementation of selenium: A strategy to increase fertility in goats. *Micronutrients in South and South East Asia*, p.43.
- Shah, O.S., Amin, U., Baba, A.R., Hussain, T., Dar, Z.A., Nabi, S.U. and Malik, H.U., 2017. Studies on seasonal changes in mineral concentrations of cross breed cattle in Kashmir valley. *Journal of Entomology and Zoology Studies*, 5(6), pp.1818-1831.
- Singh, S.B. and Singh, N., 2019. Nepal livestock feed balance and strategies to address the feed deficit. *J Agric Forest Univ*, 3, pp.159-171.
- Singh, S.B., 2020. Protein Deficiency—A Challenge to Livestock Productivity Enhancement In Nepal. *Journal of Agriculture and Forestry University*, 4, p.243.
- Singh, B., 2004. *Altitudinal variation in relation to seed, seedling and fodder quality of Celtis australis L.: A promising agroforestry tree-crop of Central Himalaya (Garhwal & Kumaon), India* (Doctoral dissertation, Dphil Thesis, HNB Garhwal University, Srinagar Garhwal, Uttaranchal, India).

- Sowande, O.S., Odufowora, E.B., Adedokun, A.O. and Egbeyale, L.T., 2008. Blood minerals in wad sheep and goats grazing natural pastures during wet and dry seasons. *Archivos de zootechnia*, 57(218), pp.275-278.
- Spallholz, J.E., Mallory Boylan, L., David Robertson, J., Smith, L., Rahman, M.M., Hook, J. and Rigdon, R., 2008. Selenium and arsenic content of agricultural soils from Bangladesh and Nepal. *Toxicological and Environ Chemistry*, 90(2), pp.203-210.
- Suttle, N.F., 2010. Mineral nutrition of livestock. Cabi head office Okfordshire, UK.
- Szigeti, E., Kátai, J., Komlósi, I. and Szabó, C., 2015. Effect of breed and sampling place on the mineral content of cattle hair. *Poljoprivreda*, 21(1 SUPPLEMENT), pp.59-62.
- Tatsumi, N., Miwa, S., & Lewis, S. M., 2002. Specimen collection, storage, and transmission to the laboratory for hematological tests. *International journal of hematology*, 75(3), 261.
- Teklić, T., Lončarić, Z., Kovačević, V., & Singh, B. R. (2013). Metallic trace elements in cereal grain—a review: how much metal do we eat? *Food and Energy Security*, 2(2), 81-95.
- Tiwari, M.R., Shrestha, B.K., Mandal, P. and Panday, L.N., 2012. Growth Performance of Khari Goats on Supplementation of Urea Molasses Mineral Block (UMMB) in Fodder Based Diets. *Nepal Journal of Science and Technology*, 13(2), pp.29-32.
- Tulachan, P.M. and Neupane, A., 1999. *Livestock in mixed farming systems of the Hindu-Kush-Himalayas. Trends and sustainability*. ICIMOD.
- Ünüböl, S. A., Aypak, S., Voyvoda, H., Güven, G., Dereli, E. F., Tosun, G., & Gülçe, A. G. (2016). Comparative Analysis of Serum Mineral Levels and Parasite Load in Goats Naturally Infected with Gastrointestinal Nematodes. *Turkiye parazitolojii dergisi*, 40(3), 141-146
- Usha, S., Mohanty, T.K. and Senthilkumar, P., 2018. Effects of Physiological Status and Season on Blood Biochemical and Mineral Profile of Holstein Friesian Cross Bred Cattle.
- Yattoo, M.I., Saxena, A., Kumar, P., Gugjoo, M.B., Dimri, U., Sharma, M.C., Jhambh, R., Yattoo, M.I., Saxena, A., Kumar, P. and Gugjoo, M.B., 2013. Evaluation of serum mineral status and hormone profile in goats and some of their inter-relations. *Veterinary World*, 6(6), pp.318-320.
- Yokus, B., Cakir, D.U. and Kurt, D., 2004. Effects of seasonal and physiological variations on the serum major and trace element levels in sheep. *Biological trace element research*, 101(3), pp.241-255.
- Yokus, B. and Cakir, U.D., 2006. Seasonal and physiological variations in serum chemistry and mineral concentrations in cattle. *Biological Trace Element Research*, 109(3), pp.255-266.

# Epidemiology of Highly Pathogenic Avian Influenza in Nepal

<sup>1\*</sup>Sujata Pokharel, <sup>1</sup>Upendra Man Singh, and <sup>2</sup>Surendra Karki

<sup>1</sup>HICAST; and <sup>2</sup>FAO

\*Corresponding Author: sujata.pokharel@gmail.com

## ABSTRACT

Avian influenza (AI) is caused by the Orthomyxoviridae (Influenza A) virus. It causes disease in avian species, including domestic and wild birds. Occasionally, humans can also get infected. Avian influenza virus (AIV) has two proteins Hemagglutinin (H) (H1- H16) and Neuraminidase (N) (N1- N9) in their surface, the combination of which produces subtypes of AIVs. This virus can be highly pathogenic or low pathogenic depending upon its ability to kill birds. Generally, subtypes H5 and H7 are highly pathogenic. In Nepal, first outbreaks of HPAI H5N1 occurred in 2009 and there have been more than 250 outbreaks since then. The objective of this study is to understand the epidemiology of HPAI in Nepal. Open sourced data from the World Organisation for Animal Health (OIE) from 2009- 2021 March for Nepal was extracted and collected using Microsoft Excel 2019. The data were processed in pivot table's function in Excel; and visualized through different graphs. Maps were created using open sourced software QGIS 3.16.8 to show the spatial pattern. In Nepal, the first outbreak of HPAI H5N1 was reported in 2009, and the maximum number of incidents was notified in 2013. The HPAI cases were mostly occurring in the spring and winter in Nepal. Strain H5N1 is predominant, while H5N8 was first recorded in domestic poultry in 2021. Spatially, HPAI have been reported from 25 districts of Nepal with the highest incidents reported from Bagmati province and Kathmandu district. Species-wise, commercial and backyard poultry are mostly affected. In summary, HPAI strains and incidents are increasing worldwide, and demands for more surveillance at poultry level. It is suggested to conduct economic analysis also in the future studies to understand the losses caused by HPAI outbreaks globally and in Nepal.

**Key words:** Avian influenza, HPAI H5N1, HPAI H5N8, Bird flu, Outbreaks, Global, Nepal

## INTRODUCTION

Avian influenza (AI) is an infectious, systemic viral disease affecting several species of food producing birds as well as pet birds and wild birds and is caused by specific strains of influenza A (Swayne & Suarez, 2000).

### The Virus

Influenza viruses are part of the Orthomyxoviridae family and are enveloped negative-sense single-stranded RNA viruses with segmented genomes (Capua and Alexander, 2004). Influenza A viruses are small (80 to 120 nm in diameter),

pleomorphic particles on initial isolation, and generally become spherical later (Webster *et al.*, 1992). The proteins in a virus can be divided into two proteins, i.e., surface proteins and internal proteins. The surface proteins include the Haemagglutinin (HA), Neuraminidase (NA), and matrix two proteins. The antigenicity difference is due to the combination of HA and NA, i.e., HA(x)NA(y) influenza virus subtypes (Webster *et al.*, 1992). The diversity of influenza A virus phenotype can originate from two mechanisms; antigenic drift and antigenic shift (Li *et al.*, 2019).

According to clinical disease and molecular signature within their HA segment, AI virus are classified into two groups low-pathogenic avian influenza virus (LPAIV) and high-pathogenic avian influenza virus (HPAIV) (Pantin-Jackwood and Swayne, 2009). The virus is considered to be an HPAIV if it causes at least 75% mortality in four to eight-week-old chickens when birds are injected intravenously, or the virus has an intravenous pathogenicity index (IVPI) in six-week-old chickens of greater than 1.2 (Everest *et al.*, 2020). According to the World Organisation for Animal Health (OIE), AIV is defined as “an infection of poultry caused by any influenza A virus with high pathogenicity (HPAI) and by H5 and H7 subtypes with low pathogenicity (H5/H7 LPAI). HPAI may result in flock mortality as high as 100%. HPAI has been restricted to H5 and H7, but not all viruses of these subtypes cause HPAI. Regardless of their pathogenicity, all H7 and H5 subtypes should be reported to OIE as they have the potential to mutate into the HPAI virus. LPAI causes a much milder disease consisting primarily of mild respiratory illness, depression, and egg production problems in laying birds (Capua and Alexander, 2004).

### **Scenario of Nepal**

In 16 January 2009, Nepal faced the first localized outbreak of HPAI H5N1 among backyard poultry in the eastern part of country Jhapa (a district bordering India and close to Bangladesh), followed by a second outbreak in another area in February of the same year (Karmacharya *et al.*, 2015). Although the positive serum sample of avian influenza antibodies was detected on October 13, 2005, which was the H9N2 subtype, this was the first evidence of an avian influenza virus infection in Nepal (Pant and Selleck, 2007). Since the detection of an outbreak, there have been many additional outbreaks in Nepal. On March 24, 2019, the first human case of Influenza A (H5N1) was recorded in Nepal. National Public Health Laboratory (NPHL) has reported no additional infection with this virus since then (World Health Organization, 2019). Illegal trade of poultry and poultry products and migration of wild birds across the porous border places Nepal in danger of AI (Karmacharya *et al.*, 2015).

## **MATERIALS AND METHODS**

This is a descriptive epidemiological study of HPAI globally from 2004-2020 and Nepal from 2009 to 2021 March. In other words, a descriptive epidemiological study of HPAI was done to understand the temporal and spatial patterns of highly pathogenic avian influenza in Nepal. Open data of HPAI outbreaks were collected from the OIE website from the year 2009 to 2021 in Nepal. The data were collected in Microsoft Excel 2019 and made graphs and pivot tables using the same Excel version. The maps, which show spatial patterns by shadowing the geographical regions in diverse colors, were designed using the open-access software QGIS version 3.16.4 to show the spatial distribution of HPAI in the world and Nepal.

## **RESULTS AND DISCUSSION**

### **HPAI scenario in Nepal**

#### **1. HPAI outbreaks recorded according to year**

Nepal faces the first outbreak of HPAI in 2009, where only two episodes were recorded. The outbreaks climb, reaching 203 in 2013 and then drop dramatically in 2014, where only one outbreak was recorded. From that, there were no outbreaks for two years, i.e., 2015 and 2016. HPAI reappeared in 2017, but outbreaks were minimum, and outbreaks are still on in Nepal (Figure 1).

#### **2. HPAI outbreaks according to season**

The HPAI outbreaks are recorded mainly in the spring and winter seasons except for 2013, where eruptions are recorded in July and August, i.e., the summer season. The outbreaks of 2013 were primarily due to improper biosecurity measures on the farm (Figure 2).

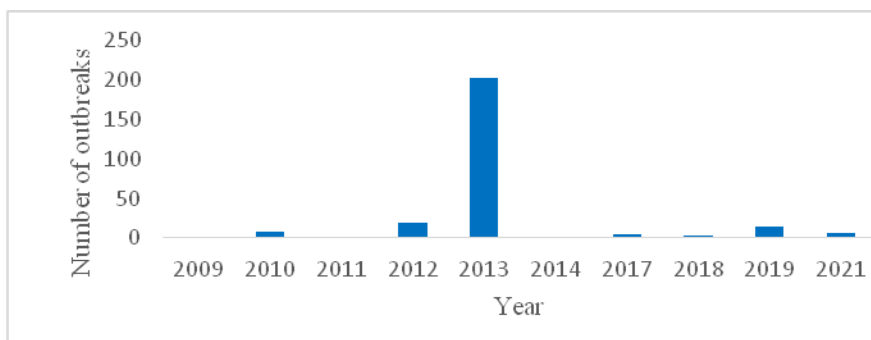


Figure 1. Number of HPAI outbreaks according to year in Nepal

### 3. HPAI Outbreaks according to strain and year

The HPAI outbreaks in Nepal are mainly caused by the strain H5N1 and H5N8. H5N1 strain was recorded since 2009, but H5N8 was first reported in 2017 where only two episodes were recorded. The maximum outbreaks in Nepal are recorded due to H5N1, and the recent attacks of 2021 are due to the H5N8 (Figure 3).

### 4. HPAI outbreaks recorded according to Province

Among seven provinces of Nepal, six provinces have faced the outbreak of HPAI till now. Province no 3, i.e., Bagmati, have met the highest HPAI outbreaks, whereas Karnali and Sudarpaschim have faced minimum outbreaks (Figure 4).

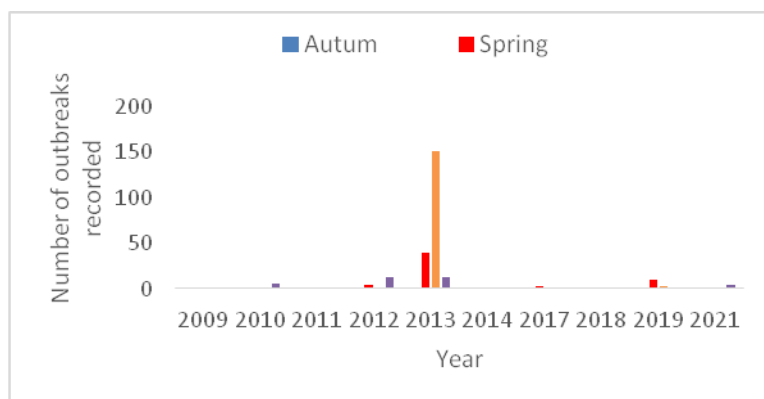


Figure 2. Number of HPAI recorded according to season

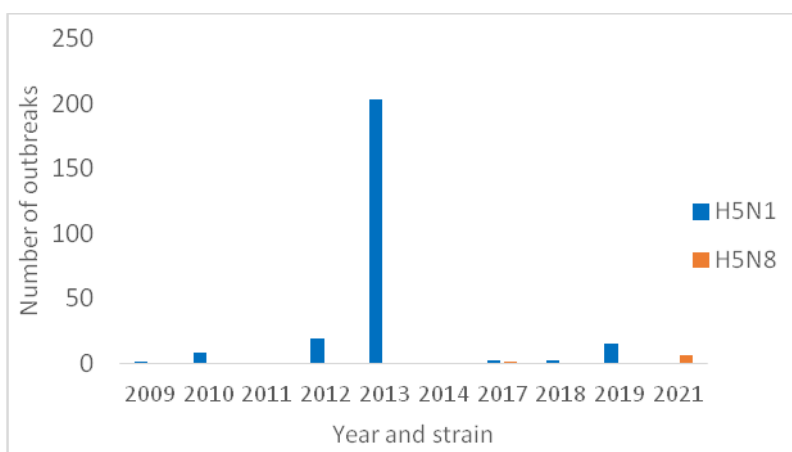


Figure 3. Number of HPAI according to the Strain and Year

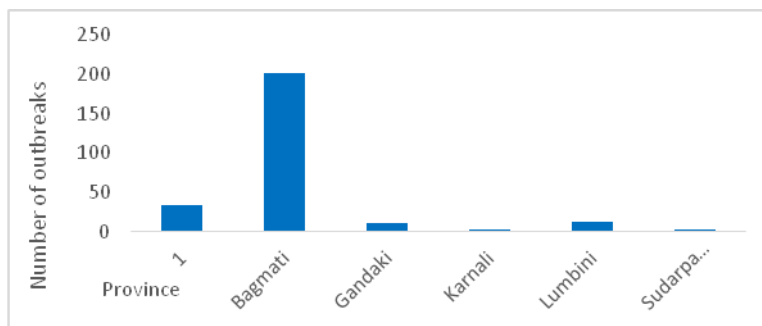


Figure 4. Number of HPAI outbreaks according to province

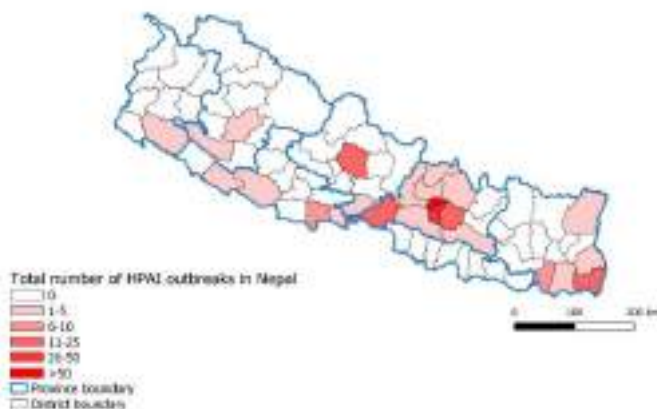


Figure 5. Spatial distribution of HPAI in Nepal

### **Spatial distribution of HPAI in Nepal by year**

The spatial pattern of HPAI shows that the first outbreak of HPAI in Nepal was in Jhapa (a district bordering India and close to Bangladesh) in 2009, where only two episodes of disease were recorded. The number of districts affected by the HPAI outbreak reached seven in 2010, but in 2011 the outbreaks decreased, and only one district was affected. In 2013, HPAI outbreaks spread into 15 districts, where the maximum number of HPAI outbreaks was recorded, i.e., 203 outbreaks and a maximum number of outbreaks were recorded from Kathmandu, Lalitpur, and Bhaktapur. In 2014, only one district faced the outbreak of HPAI, and in 2015, 2016, and 2020 there were no cases of HPAI. Up to 2021 March, HPAI had spread in four districts.

Campaign informing about risks of HPAI and motivating for protective behaviors started in Nepal after HPAI hit Asia in 2003 and was raised after it

entered Nepal (Neupane *et al.*, 2012). The government of Nepal has been implementing a prevention and control program for H5N1 since 2007 (Karki *et al.*, 2015). However, an HPAI outbreak was recorded in the backyard poultry in 2009 in a district bordering India. The virus has either come from Nepal and India's open border through the illegal transport of poultry and poultry products or may have by wild migratory birds. As in 2009, HPAI outbreaks were present in the neighboring country, i.e., India. Nepal is always at risk of HPAI due to the open border and the illegal transport of poultry and poultry products. The H5N1 strain is more prevalent, and recent episodes are caused by H5N8. Generally, HPAI outbreaks mainly occur in the winter season, but in 2013 massive outbreaks were seen in the summer season in July and August. These outbreaks may result from poor biosecurity in the farm and the transport of poultry and poultry products from infected zones to infection-free sites. The highest number of outbreaks recorded in Kathmandu, Bhaktapur, Chitwan may be due to many poultry farms compared to other districts. HPAI outbreaks in Nepal are infecting the Backyard poultry, commercial poultry farms. The high incidence of Backyard poultry involved may be due to they have direct contact with other birds (Fallah Mehrabadi *et al.*, 2016). The record of wild birds infected through the HPAI is less in Nepal may be due to the less testing done in the wild birds. Strict quarantine measures for the import and export of poultry and its product should be applied. AI can cause an influenza pandemic just like corona is doing these days if they mutate and efficiently transfer from human to human when a human is infected. Human infected with avian influenza has high death rate.

## **CONCLUSION**

Descriptive epidemiology showed that H5N1 has caused large number of outbreaks in 2013 and Bagmati province was mostly affected. Maximum number of outbreaks was centralized in the Kathmandu district. H5N8 strain is causing recent outbreaks.

## **SUGGESTIONS**

It is better to conduct economic analysis in the future studies to understand the losses caused by HPAI outbreaks globally and in Nepal. More surveillance at poultry level should be done

## **REFERENCES**

- Capua, I. and Alexander, D. J. (2004) 'Avian influenza: Recent developments', *Avian Pathology*. Taylor & Francis Group, pp. 393–404. doi: 10.1080/03079450410001724085.
- D.E. Swayne & D.L. Suarez (2000) 'Review: Highly pathogenic avian influenza.', *Rev. sci. tech. Off. int. Epiz.*, 2014(20/01/14), pp. 463–482. Available at: [http://www.oie.int/wahis\\_2/public/wahid.php/Reviewreport/Review/viewsummary?fupser=&dothis=&reportid=14249](http://www.oie.int/wahis_2/public/wahid.php/Reviewreport/Review/viewsummary?fupser=&dothis=&reportid=14249).
- Everest, H. *et al.* (2020) 'The evolution, spread and global threat of H6Nx avian influenza viruses',

*Viruses*. doi: 10.3390/v12060673.

- Fallah Mehrabadi, M. H. *et al.* (2016) 'Sero-survey of Avian Influenza in backyard poultry and wild bird species in Iran—2014', *Preventive Veterinary Medicine*, 128, pp. 1–5. doi: 10.1016/J.PREVETMED.2016.01.031.
- Karki, S. *et al.* (2015) 'Cost-benefit analysis of avian influenza control in Nepal', *OIE Revue Scientifique et Technique*, 34(3), pp. 813–827. doi: 10.20506/rst.34.3.2397.
- Karmacharya, D. *et al.* (2015) 'Surveillance of Influenza A Virus and Its Subtypes in Migratory Wild Birds of Nepal', *PLOS ONE*. Edited by G. Zhang, 10(7), p. e0133035. doi: 10.1371/journal.pone.0133035.
- Li, Y. T. *et al.* (2019) 'Avian influenza viruses in humans: Lessons from past outbreaks', *British Medical Bulletin*. Oxford University Press, pp. 81–95. doi: 10.1093/bmb/ldz036.
- Neupane, D. *et al.* (2012) 'Knowledge, attitudes and practices related to avian influenza among poultry workers in Nepal: A cross sectional study', *BMC Infectious Diseases*, 12(1), p. 76. doi: 10.1186/1471-2334-12-76.
- Pant, G. R., & Selleck, P. W. (2007). Surveillance for avian influenza in Nepal 2004-2005. *Avian Diseases*, 51(SUPPL. 1), 352–354. <https://doi.org/10.1637/7649-051806r.1>
- Pantin-Jackwood, M. J. and Swayne, D. E. (2009) 'Pathogenesis and pathobiology of avian influenza virus infection in birds', *OIE Revue Scientifique et Technique*, 28(1), pp. 113–136. doi: 10.20506/rst.28.1.1869.
- Webster, R. G. *et al.* (1992) *Evolution and Ecology of Influenza A Viruses*, *MICROBIOLOGICAL REVIEWS*. Available at: <http://mbr.asm.org/>.
- World Health Organization (2019) 'Information on Avian Influenza A (H5N1) Identified in Human in Nepal', *Searo*. Available at: [https://www.who.int/nepal/news/detail/01-05-2019-information-on-avian-influenza-a-\(h5n1\)-identified-in-human-in-nepal](https://www.who.int/nepal/news/detail/01-05-2019-information-on-avian-influenza-a-(h5n1)-identified-in-human-in-nepal) (Accessed: 12 February 2021).

# A Study on Productive, Reproductive and morphological traits of doe in different eco-zones of Rolpa district

Md Husneid Azad<sup>1</sup> and Md S. Ali<sup>2</sup>

National Outreach Research Centre, Khumaltar, Kathmandu

National Buffalo Research Program, Tarahara, Sunsari

Corresponding Author: azadhusneid@hotmail.com

## ABSTRACT

*Goat is a domesticated small ruminant, primarily reared by small farmers for meat production, across the country. Productivity of goat is often low, which could be related to several genetic and non-genetic factors. A field study was carried out to characterize, evaluate and estimate the effect of non-genetic factors on the productive and reproductive performance of hill goats during December, 2015 to August 2016 in different eco-zones at Rolpa district of mid-western Nepal. Altogether 482 dams of different age groups were identified for this study. Morphological attributes, productive, and Reproductive performance were collected based on field monitoring and measurements within different altitudes of Rolpa district. Least square analysis was performed using Harvey (1990) computer software package, and means were compared using DMRT. Results revealed the mean age of first heat in does (299 days), age at first kidding (493 days), gestation length (150 days), kidding interval (251 days), postpartum estrus (91 days), and the kidding rates were (1.54 per doe). Altitude of location significantly influenced ( $P<0.001$ ) along with parity ( $P<0.05$ ) with respect to the age of first heat in does. Significance difference of kidding interval ( $P<0.05$ ) was significantly influenced within different altitude of goat farming. Similarly, colour and altitude of location also significantly differed ( $P<0.05$ ) with respect to kidding rates of does. Performance of low altitude goat flocks was better than mid and high altitude goat flocks in Rolpa district in terms of production and reproduction traits. This result could be attributed to superior genotype along with better management practices followed by the farmers in Rolpa district.*

**Keywords:** Doe, weaning, kidding interval, parity, altitude

## INTRODUCTION

Goat farming is being the most popular means of self-employment among the youths in Nepal. Current statistics regarding to goat population indicated that there are more than 11.64 million of goats in the country (MOAD, 2018). Among the agricultural commodities; livestock plays an important role in agricultural development and economic upliftment of the country. Goat farming has been practiced by a large section of population in rural areas of Nepal. The recent population of goat is about 11.64 million and total meat contribution was 6.9

thousand metric ton per year (MOAD, 2018). The rate of increment in goat population during last 15 years (2008 to 2018) was reported 3.74 percent per year contributing about 20.1% to the total meat production in the country (MOAD, 2018). Goats breed in Nepal are quite different with locational difference. There are gradients of topography, environment and climatic conditions vary from South to North, and each breed evolved is acclimatized corresponding to each topographical zone (Pradhan and Gurung 1985). In Nepal there are four commonly documented breed of goats as *Chyangra*, *Sinhal*, *Khari* and *Terai* goats. Chyangra goats are found in 2400 meters in high Himalayans, while Sinhal found in high hill ranging 1500-3000 meters from sea level. Khari are available across the hills of Nepal while Terai goats are available in terai region of Nepal. *Chyangra* (1%), *Sinhal* (16%), *Khari*/hill goat (56%) and remaining 27% are of Terai and other breeds (Pokharel and Neopane, 2008). The general objective of this study was to compare the productive and reproductive performances of goats covering low, mid and high altitude of Rolpa District under farmer managed condition. This study also estimated contribution of non-genetic factors to the production and reproduction of goats. This study helps to find the production system of goats in relation to problems and potentially of goat farming with the scope of improving overall efficiency; to find out the key issues regarding goat production systems in hills of Nepal.

## MATERIALS AND METHODS

This section deals with the site of study, data collection and recording procedures, data analysis techniques, description of data sets and models used for analyzing the recorded traits

### Site selection

The data were collected on the basis of Pocket areas of goats distributed within different altitude at Rolpa district. The selected high altitude areas were Jaimakshala and Pakhapani followed by mid altitude locations like Gairigaun and Libang and low altitude locations like Masina and Jhenam. The elevations of high, mid and low altitude from the sea level in Rolpa district are at the range of 3639, 1375 and 701 m asl, respectively.

### Time and location of the study

This study was carried out from September, 2015 to August 2016 in Rolpa district of mid-western Nepal. Rolpa covers an area of 1,879 km<sup>2</sup> with population (2016) of 221,177. Rolpa is drained southward by the Madi River from a complex of 3,000 to 4,000 meter ridges about 50 kilometers south of the Dhaulagiri Himalaya (Statoids, 2014). The Rolpa district lies at the height

of 701m to 3639 meters above the sea level. The total area is 189385 hectare out of which 59854.5 hectare land is used for crop farming, forest consists 84474 hectare, pasture consists 32698.8 hectare, wild plants and forages 9620.8 hectare and rivers and rocks 1251.9 hectares. The average temperature in Rolpa district is maximum (31.2 Celsius), minimum (3.6 Celsius) and annual rainfall is 441mm (CBS, 2016).

### **Sampling procedure and sample size**

The datas were collected on the basis of Pocket areas of goats distributed within different altitude at Rolpa district. The selected high altitude VDCS were (Jaimakshala and Pakhapani) followed by mid altitude VDCS (Gairigaun and Libang) and low altitude VDCS (Masina and Jhenam). The elevations of high, mid and low altitude from the sea level in Rolpa district are at the range of 3639, 1375 and 701 m respectively. The elevation of selected areas for this research low, mid and high altitudes were 800-1000, 1200-1400 and 1500-1800 m respectively from the sea level. The two wards were selected from each VDCS. From each ward at least 40 does with reproductive and productive parameters were recorded. Altogether 482 dams of different age groups were identified for this study. The productive parameters includes in does were body weight, wither height, body length, heart girth, teat length and udder circumference. The reproductive parameters of does were parity, age at first heat (puberty), age at first kidding, gestation length, kidding interval and post-partum estrus. Within the population, in each selected site, sampling goats were identified randomly. A data recording format was developed to collect data and information related to growth performance, reproductive performance, litter traits, morphological traits and production system of hill goats reared in the study area.

### **Statistical analysis**

Collected data were entered in the computer using MS- Excel and converted into text documents i.e. Text (MS-DOS). To study the main causes of variation and effects of non-genetic factors on productive and reproductive traits, as well as to overcome the difficulty of disproportionate subclass numbers, data were analyzed by least squares procedure using Harvey, (1990) which is based on least squares technique of variance analysis. The pair wise comparison of the least square mean comparison was made using DMRT (Duncan's Multiple Range Test) (Duncan, 1955).

### **Models used to analyze the collected data**

A fixed effect model given by Handerson (1953) was used to analyze the body weights of kids at different stages of growth.

### **Model I (fixed effect model) for dam weight, body measurements and reproductive traits**

$$Y_{ijklmn} = \mu + a_i + b_j + c_k + d_l + e_{ijklmn}$$

Where,  $\mu$  is the overall mean

$a_i$  is the effect of  $i^{\text{th}}$  altitude ( $i=1,2$  and  $3$ )

$b_j$  is the effect of  $j^{\text{th}}$  type of breed ( $j = 1, 2$  and  $3$ )

$c_k$  is the effect of  $k^{\text{th}}$  type of colour ( $l= 1,2,3$  and  $4$ )

$d_l$  is the effect of parity ( $k= 1,2,3,4,5,6,7$  and  $8$ )

$e_{ijk}$  is the random element assumed (error mean) to be normally and independently distributed among the sampled population.

## **RESULTS AND DISCUSSION**

This chapter describes the study results focusing to the growth performance, morphological traits, reproductive traits, and litter traits as well as production systems of goats.

### **Body weight of does**

The mean body weight of doe was  $38.26 \pm 0.61$  as mentioned in Table 1. The data's were collected and analyzed from one to seven year old does. Joshi and Shrestha (2003) reported that the average body weight of Khari, Khapari and Khabari does were 20-40,  $34.4 \pm 10.2$  and  $27.4 \pm 6.6$  kg, respectively.

### **Body length of does**

The overall mean body length of one to seven years Khari, Khapari and Khabari does were  $74.29 \pm 0.99$  cm as mentioned detail in below Table 2. The body lengths of does were studied between one to seven years in this research. Body size and shape measured objectively could improve selection for growth by enabling the breeder to recognize early maturing and late maturing animals of different sizes (Akpa *et al.*, 2013). Where genetic evaluation has still limited use, identification of some descriptive linear traits may be useful and farmers' friendly tools for selecting goats with desirable characters

### **Heart girth of does**

The overall heart girth of one to seven years Khari, Khapari and Khabari does were  $74.21 \pm 0.66$  cm. Joshi and Shrestha(2003) reported the chest girth of Khari, Khapari and Khabari does were  $67.1 \pm 0.0$ ,  $77.8 \pm 2.7$  and  $70 \pm 3.5$  cm respectively. The numbers of kids above five months age were found in less number during data collection. So, they were not analyzed in this research. The factors effecting overall heart girth are presented in Table 3.

Table 1. Least square means for body weight (kg) of does in Rolpa, Nepal

Factors	LS±SE	NO	Significant Level
Overall	38.26 ±0.61	482	
Altitude			***
LA	39.40 ±0.72 <sup>a</sup>	162	
MA	37.55 ±0.65 <sup>ab</sup>	160	
HA	36.81 ±0.77 <sup>b</sup>	160	
Breed			**
Khari	34.73 ±0.63 <sup>b</sup>	223	
Khapari	39.23 ±0.67 <sup>a</sup>	180	
Khabari	37.80 ±0.82 <sup>a</sup>	79	
Colour			NS
Black	38.80±0.66	192	
Brown	38.02±0.64	183	
White	38.87±0.10	41	
Mixed	37.33± 0.87	66	
Parity			***
1	35.14 ±0.45 <sup>b</sup>	189	
2	36.27 ±0.37 <sup>b</sup>	282	
3	43.36 ±0.16 <sup>a</sup>	11	

Note: \*\*significant at 1% (P<0.01) \*\*\*significant at 0.1% (P<0.001), NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

### Wither height of does

The average wither height of does from one to seven years was 68.19 ±1.85 cm. Joshi and Shrestha (2003) reported that the wither height of Khari, Khapari and Khabari breed were 55.9±0.3, 69.0±1.8 and 57.1±3.4 cm respectively. The various factors affecting the wither height of does was presented in below Table 4.

Table 2. Least square means of body length (cm) measurements of the does

Factors	LS±SE	NO	Significant Level
Overall	74.29 ±0.99	482	
Altitude			***
LA	70.53±1.68 <sup>b</sup>	162	
MA	70.10±1.06 <sup>b</sup>	160	
HA	73.20±1.27 <sup>a</sup>	160	
Breed			NS
Khari	68.67±1.04	223	
Khapari	70.77±1.09	180	
Khabari	61.40±1.34	79	
Colour			NS
Black	75.05±1.09	192	

Brown	74.52±1.04	183	
White	75.15±1.62	41	
Mixed	72.39± 1.42	66	
Parity			NS
1	73.81±0.73	189	
2	75.23±0.66	282	
3	73.78±0.25	11	

Note: \*\*\*significant at 0.1% (P<0.001), NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

Table 3. Least square means of hearth girth (cm) measurements of the does

Factors	LS±SE	NO	Significant Level
Overall	74.21 ±0.66	482	
Altitude			***
LA	75.10 ±0.73 <sup>a</sup>	162	
MA	74.54 ±0.66 <sup>a</sup>	160	
HA	72.99 ±0.78 <sup>b</sup>	160	
Breed			*
Khari	73.5 ±0.67 <sup>b</sup>	223	
Khapari	75.10 ±0.68 <sup>a</sup>	180	
Khabari	73.99 ±0.83 <sup>ab</sup>	79	
Colour			NS
Black	74.44±0.68	192	
Brown	74.80±0.66	183	
White	74.70±1.04	41	
Mixed	75.46± 0.88	66	
Parity			*
1	73.02 ±0.45 <sup>a</sup>	189	
2	74.34 ±0.38 <sup>a</sup>	282	
3	75.28 ±1.67 <sup>b</sup>	11	

Note: \* significant at 5% (P<0.05), \*\*\*significant at 0.1% (P<0.001), NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

### Teat length of does

The overall average teat length of goats was 6.19±1.39 cm. The various factors effecting the teat length of does are presented in Table 5. Hashan *et al.* (2010) reported Jamunapari 8.5cm ±1.5cm long teat length. Fasukovi *et al.* (2014) reported local Bulgarian breed 2 to 8 years of age, weighing 45-60 kg. Sixty teats were examined by ultrasonography using a 7.5 MHz linear transducer and the “water bath” technique

Table 4. Least square means for wither height (cm) of does in Rolpa

Factors	LS±SE	NO	Significant Level
Overall	68.19 ±1.85	482	
Altitude			NS
LA	68.93±2.18	162	
MA	68.22±1.98	160	
HA	67.41±2.31	160	
Breed			NS
Khari	68.04±1.93	223	
Khapari	68.58±2.05	180	
Khabari	67.99±2.51	79	
Colour			NS
Black	68.07±1.98	192	
Brown	68.60±1.93	183	
White	68.70±1.19	41	
Mixed	67.38± 1.04	66	
Parity			NS
1	67.94±1.34	189	
2	67.79±1.09	282	
3	68.85±1.9	11	

Note: NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

Table 5. Least square means for teat length (cm) of does in Rolpa district

Factors	LS±SE	NO	Significant Level
Overall	6.19 ±1.39	482	
Altitude			*
LA	5.76 ±1.67 <sup>b</sup>	162	
MA	7.03 ±1.47 <sup>a</sup>	160	
HA	5.79 ±1.80 <sup>b</sup>	160	
Breed			NS
Khari	5.96±1.52	223	
Khapari	6.37±1.47	180	
Khabari	6.22±1.93	79	
Colour			**
Black	5.30 ±1.52 <sup>b</sup>	192	
Brown	5.43 ±1.47 <sup>b</sup>	183	
White	8.10 ±2.31 <sup>a</sup>	41	
Mixed	5.89 ± 1.77 <sup>ab</sup>	66	
Parity			NS
1	6.37±1.01	189	
2	6.03±0.83	282	
3	5.13±1.4	11	

Note: \* significant at 5% (P<0.05), \*\*significant at 1% (P<0.01), NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

Ultrasound measured parameters were teat canal length and diameter, diameter in the region of Furstenberg's rosette, widest teat cistern diameter and teat wall thickness. Ultrasound scans were done during the 1st, 3rd and 5th months of lactation. The experiment revealed the mean teat length of goat to be 6.75 cm.

### Udder circumferences of does

The following section describes the detail about the udder circumferences of does representing Rolpa district. The average udder circumference from one to seven year old does in this study was  $29.46 \pm 1.43$  cm. The various factors affecting the udder circumference of does are presented in Table 6. The udder is a very important gland in reproducing animals and for milk production. Several studies have confirmed that udder and teat characteristics are important determinants of milk yield and ease of milking or milking ability in dairy animals (Akpa *et al.*, 2013). Udder and teat characteristics have been shown to be influenced by several factors such as genotype, breeding and management systems (Milerski *et al.*, 2006). Abul *et al.* (2013) also reported udder circumference of West African dwarf goats on average  $22.60 \pm 0.78$  cm reared under semi-intensive and  $22.69 \pm 0.82$  cm reared under extensive systems of management. This result is similar finding with this study.

Table 6. Least square means for udder circumference (cm) of doe in Rolpa

Factors	LS±SE	NO	Significant Level
Overall	29.46 ±1.43	482	
Altitude			***
LA	31.90 ±1.80 <sup>a</sup>	162	
MA	32.76 ±1.60 <sup>a</sup>	160	
HA	23.74 ±1.93 <sup>b</sup>	160	
Breed			NS
Khari	29.33±1.52	223	
Khapari	29.79±1.67	180	
Khabari	29.28±2.05	79	
Colour			***
Black	29.92 ±1.67 <sup>a</sup>	192	
Brown	30.86 ±1.60 <sup>a</sup>	183	
White	30.88 ±2.51 <sup>a</sup>	41	
Mixed	26.21 ± 2.18 <sup>b</sup>	66	
Parity			NS
1	29.64±1.09	189	
2	29.03±0.88	282	
3	29.71±1.60	11	

Note: \*\*\*significant at 0.1% ( $P < 0.001$ ), NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

### Age at first heat on does

This is an important economic trait of goats that determines their productive lifespan. The overall age at first heat of does was  $299.19 \pm 0.83$  days. Fauque *et al.* (2010) studied reproductive traits of black Bengal goats at Bangladesh. The good management system might be the cause to show the early signs of heat in does. The study revealed that the age at first heat range between 123-294 days. He studied age at first heat in three consecutive seasons. On first, second and third season the age at first heat in does were recorded as 152.29, 216.16 and 193.2 days respectively. The effects of season and feeding level on age at first heat were significant ( $P < 0.01$ ) but rearing system did not affect ( $P > 0.05$ ) the age at first heat. Amin *et al.* (2000) also observed the age of first heat in randomly bred Black Bengal goat to be  $241.23 \pm 15.18$  days. The factors effecting age at first heat on does are presented in below Table 7.

### Age at first kidding

The overall age of first kidding age of hill goats was  $493.99 \pm 0.81$  days as mentioned detail in Table 8. This finding is somewhat closely resemblances with the findings of Joshi and Shrestha(2003) where the author reported that the age at first kidding of Khari, Khapari and Khabari goats were 478, 577 and 564 days respectively. However, Pandey (2009) reported that the age at first kidding of Khari, Khapari and Khabari goats were 549, 696 and 588 days respectively. The age at first kidding was reported in between 387-693 days among the various production patterns and goat breeds (Zarkawi and Abu-Saker, 2013).

Table 7. Least square analysis of means (days) of first heat in does at Rolpa

Factors	LS $\pm$ SE	NO	Significant Level
Overall	299.19 $\pm$ 0.83	482	
Altitude			***
LA	288.62 $\pm$ 0.39 <sup>b</sup>	162	
MA	331.76 $\pm$ 0.35 <sup>a</sup>	160	
HA	289.15 $\pm$ 0.42 <sup>b</sup>	160	
Breed			***
Khari	298.54 $\pm$ 0.34 <sup>b</sup>	223	
Khapari	323.71 $\pm$ 0.37 <sup>a</sup>	180	
Khabari	300.01 $\pm$ 0.45 <sup>b</sup>	79	
Colour			NS
Black	297.36 $\pm$ 0.36	192	
Brown	300.10 $\pm$ 0.15	183	
White	319.28 $\pm$ 0.54	41	
Mixed	279.71 $\pm$ 0.47	66	
Parity			*
1	316.8 $\pm$ 0.24 <sup>a</sup>	189	
2	294.62 $\pm$ 0.20 <sup>b</sup>	282	
3	292.80 $\pm$ 0.88 <sup>b</sup>	11	

Note: \* significant at 5% ( $P < 0.05$ ), \*\*\*significant at 0.1% ( $P < 0.001$ ), NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

### Gestation length

The overall mean gestation length of hill goat as reflected in this study was  $150.04 \pm 0.11$  days, with the range of 147 to 154 days. This finding was also in agreement with the results of study conducted by Pokharel and Neopane (2008) in Hill-goats. The various factors affecting the gestation period of does are presented in Table 9.

Table 8. Least square means for age at first kidding (days) of does in Rolpa

Factors	LS±SE	NO	Significant Level
Overall	493.99 ±0.81	482	
Altitude			***
LA	475.42 ±0.38 <sup>b</sup>	162	
MA	524.42 ±0.34 <sup>a</sup>	160	
HA	482.11 ±0.41 <sup>b</sup>	160	
Breed			**
Khari	506.20 ±0.33 <sup>b</sup>	223	
Khapari	509.64 ±0.36 <sup>a</sup>	180	
Khabari	505.55 ±0.43 <sup>b</sup>	79	
Colour			NS
Black	490.64±0.35	192	
Brown	499.46±0.34	183	
White	512.25±0.53	41	
Mixed	471.77± 0.46	66	
Parity			NS
1	506.46±0.24	189	
2	490.94±0.19	282	
3	483.94±0.86	11	

Note: \*\*significant at 1% ( $P < 0.01$ ) \*\*\*significant at 0.1% ( $P < 0.001$ ), NS-non significant, LSD-Least significant difference, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

### Kidding Interval of does

The overall mean kidding interval was  $251.27 \pm 0.40$  days mentioned detail in Table (10). However, Pokharel and Neopane (2008) also reported lower kidding interval of central Terai goats ( $218 \pm 5$  days) which was in agreement with the findings of this study. According to Kamal and Nikhaila (2009) another factor which can lead to long open period is under nutrition which extends Kidding Interval. The high level of feeding after kidding shortens the interval from first breeding to conception and thus reduces Kidding Interval. Quality and quantity

of feed have effect on Kidding Interval which seems to be shorter (250 days) for goats under plenty feed and longer (314 days) for goats under feed shortage. Rolpa farmers might have supplied good quality feed to does during breeding to conception. A study done by Alphonsus *et al.* (2010) in Nigeria found the KI to be 6.9 months (207 days), which is close to 204 days reported by Sodiq (2014) in Indonesia on goat raised under traditional management.

Table 9. Least square means for Gestation Length (days) of does in Rolpa

Factors	LS±SE	NO	Significant Level
Overall	150.04 ±0.11	482	
Altitude			NS
LA	150.12±0.12	162	
MA	149.99±0.11	160	
HA	150.00±0.14	160	
Breed			
Khari	149.98±0.11	223	NS
Khapari	150.14±0.12	180	
Khabari	149.99±0.14	79	
Colour			NS
Black	150.12±0.12	192	
Brown	149.95±0.15	183	
White	150.09±0.18	41	
Mixed	149.95± 0.15	66	
Parity			NS
1	150.09±0.82	189	
2	150±0.06	282	
3	150±0.29	11	

Note: NS-non significant, LS mean- Least square mean, LSD-Least significant difference, SE- Standard error of mean, NO are the number of observations.

### Postpartum estrus of does

The overall mean post-partum estrus interval of the hilly goat flock was 91.22±0.94 days with the range of 88 to 96 days. The postpartum period is characterized by uterine involution and restoration of ovarian functions, since both should occur to establish a new pregnancy. The completion of uterine involution was defined as the day when the diameter of the uterus returned to the original non-pregnant size as observed during the normal estrous cycle. Postpartum period start from parturition and lasts until uterine involution is completed and female resumes ovarian activity (Garcia, *et al.* 2008). The interval between parturition and the first post-partum estrus is an important trait which contributes to the productive efficiency of a doe. The involution of the post-partum uterus was one of the economic important limitations in achieving the goal of suitable kidding interval. Postpartum estrus period was 77.00±4.04 and 95.33±2.60 days as reported by Sadat (2014) under semi-intensive

production are in close with little difference to the present study in Kamohri goats (Greyling, 2004).

Table 10. Least square means for kidding interval (days) of does in Rolpa

Factors	LS±SE	NO	Significant Level
Overall	251.27 ±0.40	394	
Altitude			*
LA	247.01 ±0.19 <sup>b</sup>	113	
MA	259.49 ±0.17 <sup>a</sup>	140	
HA	247.62 ±0.20 <sup>b</sup>	141	
Breed			NS
Khari	244.23±0.17	178	
Khapari	260.31±0.13	151	
Khabari	254.57±0.21	65	
Colour			NS
Black	248.23±0.17	159	
Brown	223.71±0.12	142	
White	226.45±0.26	37	
Mixed	217.01±0.23	56	
Parity			NS
1	230.40±0.13	106	
2	224.62±0.09	279	
3	209.10±0.42	9	

Note: \* significant at 5% ( $P<0.05$ ), NS-non significant, LS mean- Least square mean, LSD-Least significant difference, SE-Standard error of mean. NO is the number of observations.

### **Kidding rate of does**

The average kidding rates is  $1.54\pm 0.16$  in this study. Average kidding rate of Rolpa goat was  $1.54\pm 0.16$ . HMG/N, (1993) had also reported similar value of kidding rate (i.e. 1.47) of local hill goats. The kidding rate of Khari, Khapari, Khabari breed were  $1.41\pm 0.15$ ,  $1.58\pm 0.17$  and  $1.59\pm 0.20$  respectively. Pandey (2009) reported that the kidding rate of Khari, Khapari, Khabari goats were 1.70, 1.31, 1.44 respectively. However, Neopane (2000) reported the higher kidding rate of central Terai goat (1.60) and Tamrakar and Chapagain (2000) also reported similar value of kidding rate of Terai (1.60) and Barbari Goats (1.63) reared at RARS, Nepalgunj. The detail of kidding rates is presented in below Table (12).

Table 11. Least square means for postpartum estrus (days) of does in Rolpa

Factors	LS±SE	NO	Significant Level
Overall	91.22 ±0.94	482	
Altitude			NS
LA	89.20±0.44	162	

MA	96.44±0.40	160	
HA	88.01±0.48	160	
Breed			NS
Khari	92.83±0.39	223	
Khapari	88.62±0.42	180	
Khabari	92.19±0.51	79	
Colour			NS
Black	90.54±0.41	192	
Brown	91.35±0.40	183	
White	91.27±0.62	41	
Mixed	91.70± 0.54	66	
Parity			NS
1	89.71±0.28	189	
2	95.12±0.23	282	
3	88.82±0.10	11	

Note: NS-non significant, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

Table 12. Least square means for kidding rate of does at Rolpa district

Factors	LS±SE	NO	Significant Level
Overall	1.54 ±0.16	482	
Altitude			NS
LA	1.55±0.18	162	
MA	1.52±0.16	160	
HA	1.51±0.17	160	
Breed			NS
Khari	1.41±0.15	223	
Khapari	1.58±0.17	180	
Khabari	1.59±0.20	79	
Colour			*
Black	1.40 ±0.17 <sup>bc</sup>	192	
Brown	1.55 ±0.16 <sup>ab</sup>	183	
White	1.86 ±0.23 <sup>a</sup>	41	
Mixed	1.29 ±0.19 <sup>bc</sup>	66	
Parity			NS
1 Year	1.52±0.15	56	
2 Year	1.55±0.18	88	
3 Year	1.59±0.25	6	

Note: \* significant at 5% (P<0.05), NS-non significant, LSD-Least significant difference, LS mean- Least square mean, SE- Standard error of mean. NO is the number of observations.

### Discussion

This study was designed to characterize and evaluate the productive and reproductive performance of hill goat reared under farmers' condition in Rolpa district of Nepal during December, 2015 to July 2016. The other objectives were to study the effect of non-genetic factors like altitude, colour, age, sex, parity etc

in relation to the existing goat production system. Periodic observations on morphological traits, productive and reproductive performance were measured and recorded. The high altitudes locations were (Jhamsala and Pakhapani) followed by mid altitude locations (Gairigaun and Libang) and finally to low altitude locations (Masina and Jhenam). The elevation of selected high, mid and low altitude from the sea level in this research is at the range of 3639, 1375, 701 m respectively. The elevation of selected goat pocket areas for this research at low, mid, high altitudes were 800-1000, 1200-1400, 1500-1800 m respectively from the sea level. The two wards were selected from each location. There were three recognized breeds Khari, Khapari (Khari\*Jamunapari) and Khabari (Khari\*Barbari). However, Chyangra, Boers and Terai crosses were also observed in a few numbers. The data of 482 does were collected from different altitudes of Rolpa districts. Farmers and technicians claimed the selected goats of being pure Khari, (Khari and Jamunapari) 50% cross breed and (Khari and Barbari) 50% cross breed. However, characterization of such breeds at molecular level was not carried at Rolpa district. So, it could not be understood so far their DNA level.

Morphological attributes, productive, and reproductive performance were collected based on field monitoring and measurements. Least square analysis was performed using Harvey (1990) computer software package. Information on goat production systems were collected by employing a semi-structured questionnaire and analyzed using SPSS.

The non-genetic factors like altitude, color, sex, season and parity were considered for morphological and reproductive parameters of does. The overall mean for body weight of does were  $38.26 \pm 0.61$  kg. Low altitude body weight of does  $39.40 \pm 0.72$  kg were significantly heavier ( $P < 0.001$ ) than that of mid altitude doe ( $37.55 \pm 0.65$  kg) and high altitude doe ( $36.81 \pm 0.77$  kg). Khapari does body weight ( $39.23 \pm 0.67$  kg) were significantly heavier ( $P < 0.01$ ) than that of Khari ( $34.73 \pm 0.63$  kg) and Khabari ( $37.80 \pm 0.82$  kg). Parity of does also differed significantly ( $P < 0.001$ ) to the body weight of does. The non-genetic factors like altitude, colour, age, were considered for morphological traits of goats. The non-genetic factors like altitude, color and parity were considered for reproductive performance of does.

The overall mean of age at first heat was  $299.19 \pm 0.83$  days. The age of first heat in mid altitude ( $331.76 \pm 0.35$ ) days was significantly higher ( $P < 0.001$ ) than that of high altitude ( $289.15 \pm 0.42$ ) days and low altitude ( $288.62 \pm 0.39$ ) days. The age of first heat in Khari ( $298.54 \pm 0.34$ ) days was significantly higher

( $P < 0.001$ ) than that of Khapari ( $323.71 \pm 0.37$ ) days and Khabari ( $300.01 \pm 0.45$ ) days.

The overall mean for age at first kidding of does was  $493.99 \pm 0.81$  days. The age at first kidding at mid altitude ( $524.42 \pm 0.34$ ) was significantly higher ( $P < 0.001$ ) than that of low altitude ( $475.42 \pm 0.38$ ) and high altitude ( $482.11 \pm 0.41$ ) days respectively. The age at first kidding for Khari, Khapari and Khabari breeds was  $506.20 \pm 0.33$ ;  $509.64 \pm 0.36$ ; and  $505.55 \pm 0.43$  days, respectively. Age at first kidding differed significantly ( $P < 0.001$ ) with respect to breed.

The overall mean for gestation length was  $150 \pm 0.11$  days. The kidding interval of mid altitude ( $251.49 \pm 0.17$ ) days was significantly ( $P < 0.05$ ) higher than that of low altitude ( $247.01 \pm 0.19$ ) days and high altitude ( $247.62 \pm 0.20$ ) days. The mean for post-partum estrus was  $91.22 \pm 0.94$  days. The overall mean for Kidding rate of does was  $1.54 \pm 0.16$ . The kidding rates of Khapari, Khari and Khabari does were  $1.58 \pm 0.17$ ,  $1.41 \pm 0.15$  and  $1.59 \pm 0.20$ , respectively. Kidding rates differed significantly ( $P < 0.5$ ) with respect to coat colour of does. The overall mean kidding interval was  $251.27 \pm 0.40$  days. The overall mean for body length of does was  $74.29 \pm 0.99$  cm. The overall mean for teat length of does were  $6.19 \pm 1.39$  cm. Teat length differed significantly ( $P < 0.05$ ) with respect to altitude and ( $P < 0.01$ ) within Colour. The overall mean for udder circumference of does was  $29.46 \pm 1.43$  cm. These p-arameters differed significantly ( $P < 0.001$ ) within altitude and colour. Goat farming was practiced as a subsistence occupation with three distinct systems of feeding i.e. extensive grazing, stall feeding, and grazing plus stall feeding supplementing little maize grains and flour as per availability. Majority of the farmers depended on the community forest as well as on their own farmland for collecting fodder and forages. Major problems of goat farming in Rolpa district were occurrence of epidemic disease, lack of veterinary and technical advice, and attack of wild animal. Thus the results of this study suggest that the performance of low altitude goat flocks was better than mid and high altitude goat flocks in Rolpa district in terms of production and reproduction traits. This result could be attributed to superior genotype along with better management practices followed by the farmers in Rolpa district.

## **CONCLUSION**

Results revealed that the mean age of first heat in does (299 days), age at first kidding (493 days), gestation length (150 days), kidding interval (251 days), postpartum estrus (91 days), and kidding rates were (1.54 per doe), respectively. Altitude significantly influenced ( $P < 0.001$ ) along with parity ( $P < 0.05$ ) with respect to age of first heat in does. Significance difference of of kidding interval

( $P < 0.05$ ) was significantly influenced within different altitude of goat farming. Similarly, colour and altitude also significantly differed ( $P < 0.05$ ) with respect to kidding rates of does. Thus the results of this study suggest that the performance of low altitude goat flocks was better than mid and high altitude goat flocks in Rolpa district in terms of production and reproduction traits. This result could be attributed to superior genotype along with better management practices followed by the farmers in Rolpa district.

## REFERENCES

- Abul A. H., L. I. Mhomga and Akogwu E. I. 2013. Assessment of udder characteristics of West African Dwarf (WAD) goats reared under different management systems in Makurdi, Benue State, Nigeria. *African Journal of Agricultural Research* 8(25): 3255-3258pp.
- Akapa, G.N., C. Alphonsus, S.Y. Dalha and Y. Garba. 2013. Goat breeding structure and repeatability of litter size in smallholder goat herds in Kano, Nigeria. *Animal Research International* 7(3): 1279p.
- Alphonsus C., H. Finangwa, S.M. Yashim, O.C.P Agubosi and Sam I.M. 2010. Effect of dam parity on measures of growth in red sokoto goats 1, 3, 6 and month of age. *Journal Animal Veterinary Resources* (2): 9-13pp.
- Amin, M.R., S.S. Husain and A.B. Islam. 2000. Reproductive peculiarities and litter weight in different genetic groups of Black Bengal does. *Asian-Australasian Journal of Animal Science* 14(3): 297-301pp.
- Central Bureau of Statistics (CBS). 2016. National Population and Housing Census 2011 Volume 03. Kathmandu: Government of Nepal, National Planning Secretariat. 28pp.
- Duncan, D.B. (1955) Multiple Range and Multiple F-Test. *Biometrics*, 11, 1-5
- Faruque, S., A. Chowdhury, N. U. Siddiquee and M. A. Afroz. 2010. Performance and genetic parameters of economically important traits of Black Bengal goat. *Journal of Bangladesh Agriculture* 8(1): 67-78pp.
- Fasukovi, R., P.I. Georgiev, A.L. Antonov and A.S. Atanasova. 2014. B-mode ultrasonography of mammary glands in goats during the lactation period. *Bulgarian Journal of Veterinary Medicine* (13): 245-251pp.
- Garcia J.E., R Lopez and A. Rodriguez. 2008. Factors affecting the reproductive performance of goats under intensive conditions in a hot arid environment. *Small Ruminant Research* (63): 110-118pp.
- Greyling, J. P. C. 2004. The Induction of puberty in female Boar goat kids. *South African Journal of Animal Science* (20): 193-200pp.
- Harvey W.R. 1990. Least-square analysis of data with unequal subclass numbers. United States Department of Agriculture, Agricultural Research Service, ARS 20, USA.
- Hassan, M.R., M. A. I. Talukder and S. Sultana. 2010. Evaluation of the production characteristics of the Jamunapari goat and its adaptability to farm conditions in Bangladesh. *The Bangladesh Veterinarian* 27(1): 26 – 35pp.
- HMG/N.1993. Livestock Master plan. His Majesty's Government of Nepal Livestock development. Asian development bank. ANZDEC Limited, Agricultural Project Service Center.
- Joshi, B. R and B.S Shrestha. 2003. The Goats. Their Production and Health Management. 11-18pp.
- Milerski M., M. Margetin, A. Capistrak, D. Apolen, J. Spanik and M. Oravcova. 2006. Relationships between external and internal udder measurements and the linear scores for udder morphology traits in dairy sheep. *Czech Journal of Animal Science* (51): 383-390pp.

- MOAD. 2018. Selected indicators of Nepalese agriculture and population. Government of Nepal. Ministry of Agriculture and Cooperatives. Agribusiness promotion and statistical division. Singha Darbar, Kathmandu, Nepal
- Nikhalia, A.M.A., K. El- Hassan, El- Abid. 2009. A study on some non-genetic factors and their impact on some reproductive traits of Sudanese Nubian goats. *International Journal of Dairy Science* (4):152-158pp.
- Pandey SR, M.R. Kolacchupati,N.R. Devkota and S.P. Neopane.2009.Effect of genetic groups on litter and dam traits of goat under the western hill condition of Nepal. *Journal of institute of Agriculture and Animal Sciences(IAAS),Rampur,Chitwan* (30): 87-96pp.
- Pokharel PK and SP Neopane.2008.Indigenous Goats of Nepal. National Animal Science Research Institute.Nepal Agricultural Research Council.Khumaltar,Lalitpur. 3-8pp.
- Pokharel PK and SP Neopane.2008.Indigenous Goats of Nepal. National Animal Science Research Institute.Nepal Agricultural Research Council.Khumaltar,Lalitpur. 3-8pp.
- Sodiq, A. 2014. Doe production of Kacang and Peranakan Etawah goat and factors affecting them in the tropics and sub tropics in Indonesia. *Journal of Agricultural and Rural Development* (78): 1 – 11pp.
- Statoids. 2014. Districts of Nepal.Gwillim Law. Land administration and management mapping, surveying and aerial photogrammetry, Major references projects. Finn map.
- Tamarakar N.L. and P.B. Chapagain. 2000. Performance of Native Terai and Barbari Goats at RARS, Nepalgunj. *In: Proceedings of the fourth National Workshop on Livestock and Fisheries Research*, Kathmandu, Nepal. 193-196pp.
- Zarkawi M and MB Al-Saker (2013). Determination of certain reproductive and productive parameters in female Mountain (Jabali) and crossbred goats during different age stages. *Archivs Zootechnica* 16:15
- Zarkawi, H., K.KUTHU, K. Javed, M.E. Babar, A. Sattar and M Abdullaha. 2013. Environmental effects on growth traits of teddy goats. *The Journal of Animal and Plant Sciences* 23(3): 692p.

# Factors Affecting Adoption of Improved Shed as Climate Change Adaptation Strategy by Dairy Farmers in Terai Region of Nepal

**Shiva Chandra Dhakal**

Agriculture and Forestry University, Chitwan, Nepal

**Corresponding Author:** scdhakal@afu.edu.np

## ABSTRACT

*Impact of climate change in the relatively more vulnerable agriculture and livestock system of Nepal could increase in coming days in absence of adopting effective management strategies. There is growing evidence that improved livestock shed construction can be a potential adaptation strategy, but adopted in a limited scale by dairy farmers. In this context, a study was conducted to identify factors affecting the adoption of improved shed by dairy farmers in the terai region of Nepal. Primary data collected through household survey of 600 households, 100 from each district viz. Morang, Sarlahi, Bara, Chitwan, Rupandehi and Banke were analyzed using logistic regression technique. The results showed that central dummy has significant positive effect on adoption of improved shed and increase 6.739 times more chance to adopt improved shed as compared to eastern region. Similarly, involvement in group and co-operatives and involvement of household members in remittance earning increase the probability of adoption by 1.627 and 1.464 times, respectively as compared to households not involved in group and co-operatives, and non-remittance earning households, respectively. Findings of the study have suggested to empower farming households for diverse source of income, increase membership in group and co-operatives, and focus more priority of program interventions in eastern and western terai region of the country to increase adoption of improved shed.*

**Key words:** Adoption, climate change, improved shed, logistic regression, terai region

## INTRODUCTION

Livestock sector is the integral part of Nepalese economy which contributes 11.5% of Gross Domestic Product (MoF, 2020). Dairy sub-sector composes bulk share in the livestock sector and is contributing by 7.6 million cattle and 5.3 million buffalo (MOALD, 2020). In spite of this large population, their contribution towards food and nutritional security, income and livelihood have not been fully realized due to low productivity and high cost of production of dairy sub-sector (FNCCI, 2017). The Nepalese dairy sector faces higher cost of production (10-20%) than several other Asian countries including India (NDDDB, 2014). Agriculture Development Strategy (ADS) of Nepal has also prioritized

dairy as the second most important commodity after maize for trade and value chain promotion (MOAD, 2015). Key problems of dairy sub-sector in Nepal are growing remittance-based economy, fragmentation of land, high cost of production, poor motivation towards dairy business, low yielding dairy animals, climatic hazards and poor technological advancement in dairy sector (MOAD, 2016).

Change in the climate over a long period of time either due to natural processes or anthropogenic activities is termed as climate change (IPCC, 2007). Nepal has been experiencing abrupt climate changes in the recent decades. Climate change has multidimensional impacts on the environmental, socio-economic and development related sectors including agriculture, food security, biodiversity, water resources, energy, human health and ecosystems (Dahal, 2005; WFP, 2009). Especially in the context of Nepal, the resource poor small farmers involved in subsistence agriculture and livestock activities are more vulnerable to the impacts of climate change. For them agriculture is not just an occupation but a way of life. Livestock shed improvement is one of the important climate change adaptation strategies from the view point of dairy farming (MfFI, 2014). Heat and cold stress in dairy animals can be minimized by adoption of improved shed structure in dairy farming system (Sebastien et. al., 2017). A combination of fans, wetting, shade and well-designed housing (bed, manger, height, ventilation, drainage) can help to alleviate the negative effect of thermal stress and associated complications on animals. In spite of these benefits from improved shed for dairy animals, large proportion of dairy farmers have not adopted this in Nepal. In this context, this study was conducted to assess the determinants of different factors which are responsible for adoption of improved dairy shed in terai region of Nepal.

## **MATERIALS AND METHODS**

### **Study area and sampling**

The study was conducted in six districts namely Morang, Sarlahi, Bara, Chitwan, Rupendehi and Banke from Terai region of Nepal. These districts were purposively selected based on the availability of sufficient livestock farmers required for the study and having ample opportunities on expanding dairy farming. Two dairy farming pockets from each of the district were selected purposively in consultation with district level stakeholders working in the promotion of livestock. Fifty dairy farming households from each selected pocket in each districts were selected using simple random sampling technique to make a total of 600 sample households.

### **Date collection**

Literature review and preliminary field visit were done to develop coordination schema. This was used to develop the questionnaire. Questionnaire prepared in this manner was finalized after having pretested it in two districts one from each eastern (Morang) and western Terai (Banke) of Nepal. Data collected from interview schedule by well oriented enumerators were then verified by organizing a focal group discussion in each district under study. Collected data were entered in the SPSS spread sheet and managed for units, missing value, outliers etc. Data analysis was done using Stata and SPSS software wherever applicable.

### **Analytical techniques**

Socio-economic and demographic characteristics of the respondents like family size, age, occupational pattern, education, ethnicity, land size and livestock holdings were analyzed by using simple descriptive statistics including frequency count, percentage, mean, standard deviation etc. Similarly, descriptive statistics of different variables which were used in logistic regression model were studied using arithmetic mean and standard error. Similarly, the level of adoption of different adaptation strategies and their relative importance were studied using Adoption Strategy Index (ASI) following Mohammed (2014). ASI was used to assess relative importance of an adaptation strategy over others. Farmers were asked to rank different adaptation strategies by using the four-point rating scale (high importance, moderate importance, low importance and no importance) to rate the importance of each strategy on their dairy enterprises. The relative importance of adaptation strategies to climate change was calculated based on the following index formula:

$$ASI = AS_n \times 0 + AS_l \times 1 + AS_m \times 2 + AS_h \times 3$$

Where, ASI = Adaptation Strategy Index, AS<sub>n</sub> = Frequency of farmers rating adaptation strategy as having no importance, AS<sub>l</sub> = Frequency of farmers rating adaptation strategy as having low importance, AS<sub>m</sub> = frequency of farmers rating adaptation strategy as having moderate importance, and AS<sub>h</sub> = Frequency of farmers rating adaptation strategy as having high importance.

For making rank order of different impacts of climate change, Problem Confrontation Index (PCI) was computed as used by Hossain and Miah (2011). The PCI was computed by using the following formula:

$$PCI = Ph \times 3 + Pm \times 2 + Pl \times 1 + Pn \times 0$$

Where, PCI = Problem Confrontation Index, Ph = No. of the respondents expressed impact as “high”, Pm = No. of the respondents expressed impact as

“medium”,  $P_1 =$  No. of the respondents expressed impact as “low” , and  $P_n =$  No. of the respondents expressed impact as “not at all”.

Logistic regression is a popular statistical technique in which the probability of a dichotomous outcome like adoption or non-adoption is associated with the group of independent variables assumed in the relationship. To accomplish the objective of factors affecting adoption of improved livestock shed, logistic regression technique was used considering adoption as the function of different personal, social, economic and institutional factors. Maddison (2006), Seo and Mendelsohn (2008), and Nhemachena and Hassan (2007) studied the impact of climate change and factors affecting the adaptation measures in livestock and mixed crop livestock production in different parts of the world using this technique. Decision of farmers to adopt improved shed was estimated through logistic regression to derive the several factors that govern the probability to practice more of the adaptation strategy ( $Y_i = 1$ ).

It was hypothesized that there could be several factors that affect for practicing adaptation strategies at farm level. Decision to adopt improved shed at farm might be influenced by several socioeconomic, demographic, institutional, and financial conditions (Deressa *et al.*, 2009). The logistic model was used to analyze the binary or dichotomous response and allows examining how a change in any independent variable changes all the outcome probabilities following Regmi (2010).

$$\begin{aligned} \text{If } Y_i = 1; P(Y_i = 1) &= P_i \\ Y_i = 0; P(Y_i = 0) &= 1 - P_i \end{aligned}$$

Where,  $P_i = E(Y = 1/X)$  represents the conditional mean of  $Y$  given certain values of  $X$ .

The logistic transformation of the probability of the practicing adaptation strategies by farmers were represented as follows (Gujarati, 2003).

$$L_i = \ln [ P_i / 1 - P_i ] = Z_i = \beta_0 + \sum_{i=1}^n \beta_i X_i + \varepsilon_i$$

Where  $Y_i$  is a binary dependent variable (1, if farmers adopt improved shed, and 0 otherwise),  $X_i$  includes the vector of explanatory variables used in the model,  $\beta_i$  = parameters to be estimated,  $\beta_0$  = a constant term,  $\varepsilon_i$  = error term of the model,  $\exp(e)$  = base of the natural logarithms,  $L_i = \text{Logit}$  and  $[ P_i / 1 - P_i ] = \text{odds ratios}$  for  $i = 1, 2, 3, 4, \dots, n$  farm households. Thus, the binary logistic regression model used in the study was expressed as:

$Y_i = f(\beta_i X_i) = f(\text{central region dummy, western region dummy, age of household head, Sex of household head, ethnicity of respondent household, education of household head, family size, household with engage in abroad job, total land owned by household, livestock holding by household, access to credit,$

training taken, membership in group). Details of these variables used in the model are shown in Table 1.

Table 1. Description of explanatory variables used in improved shed adoption model

Variable name	Description
Central region (dummy)	Central region dummy (value 1 if the household is from central region, 0 otherwise) <sup>a</sup>
Western region (dummy)	Western region dummy (value 1 if the household is from western region, 0 otherwise) <sup>a</sup>
Age (yrs.)	Age of household head (yrs.)
Sex (dummy)	Sex of household head (value 1 if the household head is male, 0 otherwise)
Brahmin-Chhetri (dummy)	Ethnicity dummy (value 1 if the household is brahmin or chhetri, 0 otherwise)
Education of household head (dummy)	Years of schooling of household head (yrs.)
Family size (number)	Family size (numbers)
Abroad job (dummy)	Abroad job dummy (value 1 if the family member is in abroad job, 0 otherwise)
Total land (kattha <sup>2</sup> )	Total land owned by household (kattha)
Livestock holding (LSU)	Size of livestock holding (LSU)
Access to credit (dummy)	Access to credit dummy (value 1 if the household has access to agricultural credit, 0 otherwise)
Training (dummy)	Training dummy (value 1 if the member from household has taken training on livestock related areas, 0 otherwise)
Attachment in group (dummy)	Involvement in farmers' group and co-operatives dummy (value 1 if the member from household has membership in farmers' group and cooperatives, 0 otherwise)

<sup>a</sup> Eastern region is treated as the reference region.

## RESULTS AND DISCUSSION

### **Socio-demographic and economic characteristics**

Major socio-economic and demographic characteristics of respondents' and their households like age, sex, size of family, land and livestock holding, occupation, income structure were studied as some of these are the possible determinants of adoption as well. The average age of respondent was found 45.71 yrs. with average years of formal education 5.36 yrs., which is lower than the national overall average (8.1 yrs.) of adults above 15 years (CBS, 2011). Similarly, male

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<sup>2</sup> 1 kattha= 0.033 ha

and female per household were 3.3 and 3.1, respectively in study area which was more than male and female numbers in household of country, 2.3 and 2.5, respectively (CBS, 2011). The study on age distribution of family members in surveyed districts depicted economically active population was 64.5 % which was higher than national economically active population level of 57% (CBS, 2011). Average number of family members with primary, secondary, school level education, higher secondary and university was found 0.84 (14%), 1.49 (24.83%), 0.67 (11.12%) and 0.54 (9%), respectively in the study area. The dominant inhabitation of the Brahmin-chhetri community (46.50%) was found in study area. Being the districts of terai, on an average about two third of land holding was lowland. Area under year-round irrigation was found highest (14.98 kattha) in Rupandehi, while the lowest (0.01 kattha) in Banke which is quite below the national average of 18% (ADS, 2015). It was found that, Chitwan, Banke and Bara district have greater number of dairy animals holding than overall average (2.93).

### Prioritization of impact of climate change on livestock and livestock production system

Using PCI, the impacts of climate change on livestock production were prioritized and ranked. The findings (Figure 1) revealed that decrease in milk production was prioritized as the most important and major impact of climate change, followed by heat stress on dairy production system of terai region of Nepal. The findings of Collier *et al.* (1982) supported heat stress in dairy cattle results in dramatic reduction in forage intake and reduce milk production. Similarly, cold injury and unavailability of feed/grass were prioritized as the third and the fourth major impact of climate change, respectively. The scarcity of fodder and forages due to low and variations in rainfall pattern was major impact of climate change on livestock production system (Nkondze, 2014). The ultimate death of animal was prioritized as the least important impact of climate change in the terai parts of the country.



Figure 1. Prioritization of impacts of climate change on dairy production system

### **Adaption of different adaptation strategies by farmers in study area**

The different adaptation strategies which were under planning of farmers were ranked using Adaptation Strategy Index (ASI). It was found that key adaptation strategies which were planning to adopt by farmers for adoption were increase in approach to extension services (1675), mixed farming of crops and livestock (1623), plantation of fodder trees (1595), and construction of improved shed (1589) in the first to fourth rank (Figure 2). The other remaining strategies were diversification of farm activities, forage cultivation, feeding feed supplement to livestock, adoption of improved breeds, irrigation of grass and private pastureland, improvement of grazing land and diversification of livestock species. These showed that farmers are well aware about the adaptation strategies required to adopt the impact of climate change on livestock production system but are limiting to adopt due to different personal, institutional and social factors.

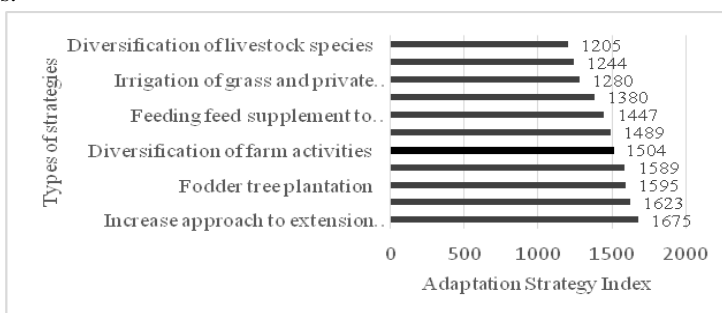


Figure 2. ASI of different strategies in study areas

Different adaptation strategies adopted by dairy farmers in study area to cope climate change impacts are shown in Figure 3. Diversification of livestock species in their farms was adopted by the largest number of respondents (77.33%) and water harvest scheme is the least adopted climate change adaptation strategy being adopted by just only 8% of the respondents. Popular adaptation strategies adopted by more than half of the total number of respondents were found to be feeding feed supplements to dairy animals (75.83%), adoption of improved shed (59.06%), and forage and fodder cultivation (54.67%). The other least adopted adaptation strategies included adoption of improved dairy breeds (38.50%), irrigation of grass and private pasture land (25.50%), maintaining of private grazing land (23.00%), livestock insurance (17.67%) and water harvest scheme (8.17%). Adoption of water harvest scheme was least adopted because of sufficient availability of underground water in terai part of the country.

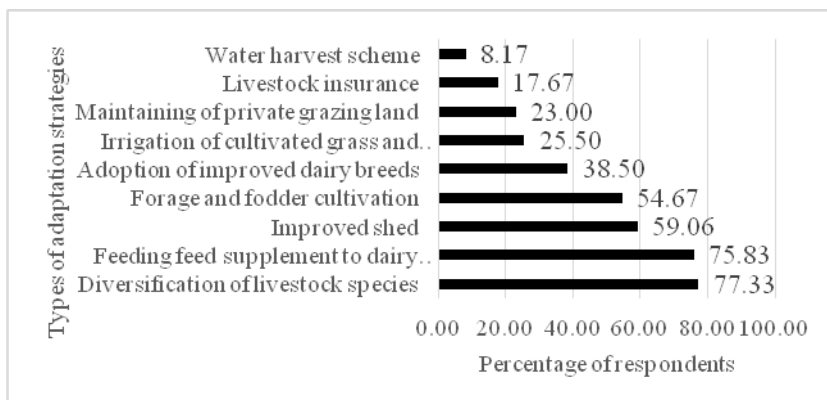


Figure 3. Distribution of respondents adopting different adaptation strategies

### Factors affecting adoption of improved shed

A Total of thirteen variables were included in binary logistic regression as explanatory variables to study factors affecting adoption of improved shed on dairy farming system in the study areas. The mean level of these variables is depicted in Table 2. It was found that the mean level of age of household head, education of household head, family size, total land holdings, and livestock holdings were at the level of 50.34 yrs., 2.42 yrs., 6.40, 18.82 kattha and 6.35 LSU, respectively. Whereas, the mean of other dummy variables viz central region, western region, Brahmin-Chhetri, abroad job, access to credit, training and attachment in groups were 0.33, 0.33, 0.76, 0.31, 0.81, 0.28 and 0.54, respectively.

Table 2. Descriptive statistics of the explanatory variables used in adoption model

Variables	Descriptive statistics (n=600)	
	Mean	S.E.
Central region (dummy)	0.33	0.01
Western region (dummy)	0.33	0.01
Age (yrs.)	50.34	0.55
Sex (dummy)	0.76	0.01
Brahmin-Chhetri (dummy)	0.77	0.01
Education of household head (yrs.)	2.42	0.17
Family size (number)	6.40	0.11
Abroad job (dummy)	0.31	0.01
Total land (kattha)	18.82	0.98
Livestock holding (LSU)	6.35	0.38
Access to credit (dummy)	0.81	0.01
Training (dummy)	0.28	0.01
Attachment in group (dummy)	0.54	0.02

The binary logistic model regressed whether the farmer had adopted livestock shed improvement as the dependent variable against the explanatory variables of region, age, sex, ethnicity, education, family size, farm size, abroad job, size of livestock holding, access to credit, training received, involvement of the farmer in groups and cooperatives and the results are depicted in Table 3. Out of the 13 variables included in logistic regression model, 3 variables were found statistically significant on adoption of livestock improve shed for mitigation impact of climate change. Central region and abroad job were significantly and positively contributing the adoption at less than 1% level of significance. Similarly, involvement of farmers in group and cooperatives was positively contributing in adoption and was statistically significant at 5% level of significance ( $p < 0.05$ ). The other variables had no significant impact on adoption of livestock shed improvement for coping impact of climate change.

When we move from eastern (bench mark regional category) to central region, the chance of adoption of livestock shed improvement for coping the impact of climate change was found about 6.74 times higher than in eastern. But when the study region is western, the chance of adoption was not significant as compare to eastern but was 1.417 times higher (Table 3). Many studies reported that adoption strategies for coping impact of climate change was found to be location specific due to variation in socio-economic condition of the farmer in different region (Tiwari et al., 2014). Wider coverage of extension system in Nepal is hindered due to poor implementation mechanism of extension program, geographic constraints, lack of incentives to extension workers and centralized developmental activities. One or more among these facts cause hesitation to extension worker to go away from capital city in general and distant regions in particular. Similar findings were found by Vincent (2007), Hinkel (2011) and Below *et. al.* (2012) and concluded that adoption of adaptation measures to climate change is location specific.

For an additional year in age, the odd of adoption of livestock shed improvement had increased by the factor of 1.004. The chance of adoption of livestock shed improvement program decreases by 0.897 times when the household head is female. Those farmers with their family members in the abroad job had 1.464 times more probability of adoption of livestock shed improvement program to cope with climate change hazards (Table 3). This may be due to increase in income level of the farmers which allow them to adopt mitigation strategies for reducing the impact of climate change. The major adoption constraint of climate change is lack of money (Deressa *et. al.* 2008). The abroad job helps to earn money in the form of remittance and part of which also goes to on-farm

investment and consequently support the adoption of improved shed. Financially well-off farmer has better forward and backward linkage to make his/her production less risky to changing context. This result resembles with the finding of Kim *et. al.* (2012). Similar result was obtained from Nhemachena and Hassan (2007) where they concluded that per capita income has a positive influence in adoption of adaptation measures.

The odd of adoption of livestock shed improvement in Brahmin-Chhetri community was found about 1.26 times more than that of other ethnic groups. Educated people were found to have more adoptive capacity than that of uneducated people because education brings the positive changes in the behavior, knowledge, attitude and perception of people. The adoptive capacity of the educated household head was found 1.036 showing the chance of increase in adoption of improved shed by this factor when the year of formal education is increased by one year. The result also showed that for every additional kattha of own farm land, the adoption of improved livestock shed increases by 1.004 times.

Farmers involved in groups and cooperatives had 1.627 times more chance of adoption of livestock shed improvement programs than those who are not enrolled in farmers' groups and cooperatives. Being the member of group encourage farmers to take decision and other farmer involve in group share their opinion about the mitigation strategies which help farmers to take the right decision. The similar result was obtained on the study conducted in Bangladesh. The output of that study was the farmers who involve in cooperative has higher chance of adoption of mitigation strategies (Uddin, *et. al.*, 2014). Though group decision towards adoption of any measure is slower at initial stage, it is considered effective over long period of time (Dangol, 2004). This result is concordant with the findings of Below *et. al.*, (2012); and Uddin *et. al.*, (2014) where they found membership of household member in any kinds of agricultural group can influence adoption of adaptation measures. Tiwari *et. al.*, (2008) found member in Community Based Organizations (CBOs) and adoption of improved technology are positively related. Similar result put forwarded by Adesina *et. al.*, (2000) that, farmers association in Cameroon has significant positive influence on adoption of agroforestry technology.

For an additional increase in the livestock holding size, the probability of adoption of the improved livestock shed shown to increase by the factor of 1.020. Access to credit is negatively correlated with the adoption of this adaptation strategy. The adoption of livestock shed improvement strategy

decreased by 0.949 times for those farmers who have access to credit than those farmers who do not have it. Farmer who had participated in the training programs had 1.225 times more chance of adoption of livestock shed improvement program than farmers who had not received the livestock shed improvement program. Several researches were conducted by number of researchers for development of adaptation strategies to cope climate change hazards in the field of dairy farming. The increased in temperature due to climate change can be reduced through providing shade to the livestock's shed (Adin, 2010). The economic loss from climate change can be reduced by improving the shed of livestock through installation of shades or sprinklers in feedlots or evaporative cooling of barns (Frank *et al.*, 2005). Most of the farmers use bedding material to protect their animals to prevent animals from extreme cold and provides cold water and shade for their animals to prevent from the extreme hot (Singh *et al.*, 2012).

Findings from the several researches had shown that livestock enterprises are highly vulnerable to climate change. Hence, it is the major demand of today to adopt the climate change adaptation strategy for the promotion of dairy farming. Estimates of the stochastic production function model indicate that an increase in THI (Temperature Humidity Index) load of 1,000 degree hours implies about a 0.38 percent decrease in milk production (Nigel *et al.*, 2014).

Table 3. Regression coefficients of logistic regression model for livestock shed improvement

Variables	Odds Ratio	SE	Z	P> z
central	6.739**	1.824	7.05	0.001
Western	1.417	0.326	1.51	0.130
Age	1.004	0.007	0.71	0.478
Sex	0.897	0.200	-0.48	0.628
Brahmin	1.259	0.279	1.04	0.297
Eduhhh	1.036	0.025	1.45	0.148
Famsize	0.965	0.030	-1.11	0.269
Abrijob	1.464**	0.297	2.08	0.006
Totland	1.004	0.003	1.20	0.230
Livestock	1.020	0.020	1.00	0.316
Acccr	0.949	0.240	-0.21	0.837
Training	1.225	0.278	0.90	0.370
Group	1.627**	0.355	2.23	0.026
Constant	0.385	0.214	-1.71	0.087
Pseudo R <sup>2</sup>	0.145			
Log likelihood	-344.32			
Observation	600			

Note: Prob (Y = 1): adopted improved livestock shed and \*\*Significance level at P ≤ 0.05

## CONCLUSION

Farmers have adopted the improved shed as artificial structure to protect their farm animals from extreme cold and hot weather. This study showed that central region dummy, abroad job and association of farmers in group and cooperatives were significantly and positively contributing to the adoption of improved shed. Major three determinants for adoption of improved shed were central region dummy, engagement of family members in abroad job and association of households in groups and cooperatives. Farmers who joined the farmer groups and cooperatives had significantly influenced the adoption.

## RECOMMENDATION

It is highly recommended that the farmers should join farmer groups and strengthen those groups so that they can have easy access to information and credit. Part of the earning from remittance is suggested to use for improved shed construction. Central part of terai region has relatively better adoption of improved shed. So, priority in terms of technical and financial support related to shed improvement should be in eastern and western terai regions of the country.

## ACKNOWLEDGEMENTS

Author is grateful to Asian Development Bank (ADB) for granting financial support to accomplish this study. Author is thankful to all farmers, key informants, enumerators and other helping hands for their support in this study.

## REFERENCES

- Adesina, A. A., Mbila, D., Nkamleu, G. B., and Endamana, D. (2000) Economic analysis of the determinants of adoption of alley farming by farmers in the forest zone of southwest Cameroon. *Agricultural Ecosystems and Environment* 80: pp 255-265.
- Below, T. B., Mutabazi, K. D., Kirschke, D., Franke, C., Sieber, S., Siebert, R., and Tschering, K. (2012) Can farmers' adaptation to climate change be explained by socioeconomic household-level variables? *Global Environmental Change* 22(1): pp 223-235.
- CBS, (2011) Population census report. Central Bureau of Statistics, Singha Durbar, Kathmandu, Nepal.
- Dahal, N. (2005) *Perceptions of climate change in Himalayas*. Tiempo Bulletin. Issue number 26. pp. 19-24. Available at: [www.tiempocyberclimate.org/newswatch/feature050910.htm](http://www.tiempocyberclimate.org/newswatch/feature050910.htm).
- Dangol, B. B. S. (2004) *Extension education*. Dangol Printers, Kathmandu, Nepal.
- Deressa, T., Hassan, R. M., Alemu, T., Yesuf, M., and Ringler, C. (2008) *Analyzing the determinants of farmers' choice of adaptation methods and perceptions of climate change in the Nile Basin of Ethiopia*. International Food Policy Research Institute.
- Deressa, T., Ringler C., and Hassan, R. M. (2009) Factors affecting the choices of coping strategies for climate extremes: The Case of Farmers in the Nile Basin of Ethiopia. IFPRI Discussion Paper No. 01032. International Food Policy Research Institute, Washington, D.C.: pp 25.
- FNCCL (2017) Annual report of agriculture and livestock sub-sector in Nepal, Kathmandu, Nepal.
- Frank, K. L., Mader, T. L., Harrington, J. A., and Hahn, G. L. (2005) Potential climate change effects on warm-season livestock productions in the Great Plains. *Journal series no. 14462, Agriculture Research Division*.
- Gujarati, D. N. (2003) *Basic econometrics*. 4<sup>th</sup> ed. United States Military Academy.

- Hassan, R., and C. Nhemachen. (2008) Determinants of African farmers strategies for adapting to climate change: Multinomial Choice Analysis. *AfJARE* 2: pp 83-104.
- Hinkel, J. (2011) Indicators of vulnerability and adaptive capacity: towards a clarification of the science-policy interface. *Global Environmental Change* 21: pp 198–208.
- Hossain, M. S. and Miah, M. A. M. (2011) Poor farmers' problem confrontation in using manure towards integrated plant nutrition system. *Bangladesh Journal of Extension Education*, 23(1&2): 139-147.
- IPCC, (2007) Climate change (2007), Cambridge University Press, Cambridge, United Kingdom.
- Kim, C., Jung, H., Lee, S., Park, S., and Takei, A. (2012) An analysis on determinants of farmers' adaptation to climate change in Korea. *J. Rural Dev.* 35: pp 53–72.
- Maddison, D. (2006) The perception of and adaptation to climate change in Africa: CEEPA. Discussion paper no. 10. Centre for Environmental Economics and Policy in Africa. University of Pretoria, Pretoria, South Africa.
- MfFI, (2014) Climate change impacts on dairy farming and adaptation options. Ministry for Foreign Industry, New Zealand.
- MoAD, (2015) Agriculture Development Strategy (ADS) 2015 to 2035, Ministry of Agriculture Development, Government of Nepal. Retrieved on 26th August, 2021. <https://nepalindata.com/resource/agriculture-development-strategy-ads-2015-2035/>.
- MoAD, (2016) Statistical information on Nepalese agriculture. Agribusiness Promotion and Statistics Division, Statistics Section, Government of Nepal, Singh Durbar, Kathmandu, Nepal.
- MoF, (2020) Economic Survey of Nepal 2020/21. Ministry of finance, Government of Nepal, Kathmandu, Nepal.
- NDDB, (2014) Report on cost of milk production in Nepal. Nepal Dairy Development Board, Hariharbhawan, Lalitpur: National Dairy Development Board, Lalitpur, Nepal.
- Nhemachena, C., and Hassan, R. (2007) Micro-level analysis of farmers adaptation to climate change in southern Africa. IFPRI discussion paper 00714.
- Nigel, K., Stacy S., and David M. (2014) Climate change, Heat stress, and U.S. Dairy Production.
- Regmi, H. R. (2010) Farmers' perception and adaptation to climate change and its implication in agriculture in Riu-Rapti water basin, Chitwan, Nepal. Thesis, M. Sc. Tribhuvan University, IAAS, Chitwan, Nepal.
- Sebastien, F., Veronique, Q., and Edith, C. (2017) Practices for alleviating heat stress of dairy cows in humid continental climate: A literature review. *Animals*, 7(5):37.
- Seo, S. N. and R. Mendelsohn. (2008) Animal husbandry in Africa: Climate change impacts and adaptations. *African Journal of Agricultural and Resource Economics*, 2(1): 65-82.
- Sossidou, E. N., Tsiplakou, E., and Zervas, G. (2014) Options for Managing Livestock Production Systems to Adapt to Climate Change. *Journal of Earth Science and Engineering*, 4(7).
- Tiwari, K. R., Rayahajhi, S., Pokharel, R. K., and Balla, M. K. (2014) Determinants of the climate change adaptation in rural farming in Nepal Himalaya. *Int J Multidisciplinary Curr Res*, 2, 234-240.
- Tiwari, K. R., Sitaula, B. K., Nyborg, I. P., and Paudel, G. S. (2008) Determinants of farmers' adoption of improved soil conservation technology in a middle mountain watershed of Central Nepal. *Environmental Management* 42: pp 210-222.
- Uddin, M. N., Bokelmann, W., and Entsminger, J. S. (2014) Factors affecting farmers' adaptation strategies to environmental degradation and climate change effects: A farm level study in Bangladesh. *Climate*, 2(4), 223-241.
- Vincent, K. (2007) Uncertainty in adaptive capacity and the importance of scale. *Global Environmental Change* 17: pp 12–24.
- WFP, (2009) The cost of coping: a collision of crises and the impact of sustained food security deterioration in Nepal. Food Security Monitoring System, United Nations World Food Programme, Nepal.

# Effect of Application of Fertilizers Mixed With Biochar in Onion Productivity and Its Profitability

**\*Poonam Bhatt, Keshab Raj Pande, Prashant Raj Giri,  
Sudikshya Devkota**

<sup>1</sup>Himalayan College of Agricultural Sciences and Technology  
Kritipur, Nepal

**\*Corresponding Author:** bpoonam53@gmail.com

## ABSTRACT

*To know the effects of application of fertilizer mixed with biochar in productivity and profitability of onion, four times replicated field experiment was conducted from 5<sup>th</sup> December to 30<sup>th</sup> April 2021 in Lalitpur, Nepal in Randomized Complete Block Design (RCBD) with six treatments prepared by combining 30 t ha<sup>-1</sup> biochar with chemical and organic fertilizer. Treatments were: Control (T1), recommended dose of fertilizer (RDF) (T2), ½ RDF+ Biochar (T3), RDF+ Biochar (T4), Vermicompost+ Biochar (T5) and cattle urine + Biochar (T6). The results showed significant increase in the onion yield up to 18.62 t ha<sup>-1</sup> in T3. The B: C ratio was a maximum (3.25) in T5. The study suggested that biochar can be best used as an amendment rather than just fertilizer in combination with RDF to get the optimum onion yield and economic profit. The addition of biochar also helped to retain soil moisture for a longer period of time.*

**Key words:** Biochar, compost, bulb yield, bulb diameter, biomass

## INTRODUCTION

Biochar is the porous carbonaceous solid produced by thermo-chemical conversion of organic materials in an oxygen-limited atmosphere that has physicochemical properties suitable for the safe and long-term storage of carbon in the environment and soil amendment (Hammond et al., 2011). The agricultural use of biochar has been growing and attracting more research interest globally due to its potential benefits to crop production, soil fertility, and carbon sequestration. The use of biochar enhanced crop yields; decreased soil acidity, increased water and nutrient holding capacity, stimulates nutrient uptake, and reduce greenhouse gas emissions from the soil (Sohi et al., 2009 and Quayle, 2010). Biochar produced through pyrolysis of biomass has a high content of carbon and may help to improve environmental quality by reducing soil nutrient leaching losses, reducing the bioavailability of environmental contaminants, sequestering carbon, reducing greenhouse gas emissions, and enhancing crop productivity in degraded soils (Ippolito et al., 2012). Biochar

prepared from locally available biomass can help to reduce the weed population in the agricultural fields which is a serious problem in organic agriculture (DAT and Avasthe 2015). Every biochar has its own characteristic which influences ultimately soil after field application. For example, biochar produced from animal manures usually has a smaller specific surface area compared to biochar derived from wood and plant biomass (Wiedner et al., 2015).

Onion (*Allium cepa*) is a major bulbous crop. According to the Statistical Information on Nepalese Agriculture 2075/76, published by MOALD, The production of onion in the fiscal year 2075/76 is 2,91,538 mt in 20,908 ha area. This shows the productivity of Nepal 13.94 mt/ha which is much less than the global average productivity of onion which is about 19.89 mt/ha (VDD, 2012). This scenario of onion productivity in the country urged the government to take programs to upgrade domestic production and productivity

## MATERIALS AND METHODS

The study was carried out in the field of Lele, Lalitpur. The experiment was laid out in a randomized complete block design with six treatments and four replications. Red Creole variety of onion, which is mainly grown for bigger bulbs, was used for the study. One and a half month-old seedling was used in 1\*1 m<sup>2</sup> plot. There were 24 plots in the experiment. Planting of seedlings was done at the spacing of 20 cm between the rows and 10 cm between the plants. The crop was raised with the best possible management practices. The FYM @ 30t/ha and Zinc Sulphate @ 10 kg/ha were pre-applied in the field.

Table 1. Different treatments and their combinations

Treatments	Combinations
T1	Control (no fertilizers and biochar)
T2	Recommended dose of fertilizer (RDF)
T3	RDF + Biochar @30 t/ha
T4	1/2RDF + Biochar @30 t/ha
T5	Compost + biochar @30 t/ha
T6	Cattle urine + Biochar @30 t/ha

### Biochar and Field Preparation

*Lantana camara*, was collected and left to dry from the periphery of Lele, Lalitpur. The pit method was used for the preparation of 50 kg of biochar. The slurry was sprayed all over the plot at the time of final field preparation just before onion transplanting. The biochar substrate was mixed with soil and onion was planted over it. Likewise, chemical fertilizers were mixed with crushed biochar and incorporated in the soil in lines. Land preparation, fertilizer

application, UCB application, transplanting, weeding, hoeing, and harvesting were carried out as per the recommended methods.

Bio-morphological characteristics of six reference plants were recorded at 30 days after transplantation (DAT) and 60 DAT. Measurements of bulb diameter, biomass, bulb weight, and yield per hectare were recorded in the field.

### **Economic analysis**

*BCR* analysis was calculated by using the following formula:

Benefit-Cost Ratio = Present value of benefit/Present value of cost

Data were statistically analyzed using MS Excel and GenStat. Duncan's multiple range test (DMRT) at a 5% level of significance was used for comparing the mean values.

## **RESULTS AND DISCUSSION**

### **Effect of fertilizer enriched biochar in bulb yield of onion**

Treatment effects on bulb weight of onion were significant. The highest bulb yield (18.62t/ha) was observed in RDF enriched biochar, which could be due to the synchronization of nutrient availability and plant requirement that increases the N use efficiency of the crop. The minimum bulb yield (8.4 5t/ha) was observed with T1 (Control). Timilsina et al., (2017) also had reported that biochar application increased radish yield in loamy sand soil at Nawalparasi Nepal. Results of this experiment overall support the fact that biochar application was effective to increase the yield of crops. The results demonstrated that the addition of nutrients is essential for higher production and productivity.

### **Bulb diameter**

The maximum bulb diameter (26.32mm) was recorded in T3 and the minimum diameter (21.33 mm) was found in T1 (Table 2). The treatment T3 gave the highest bulb diameter as compared to other treatments. The results confirmed that the dose of biochar recommended by Vista and Khadka (2017) did perform well in our case too.

### **Total biomass/plot/hectare**

The total biomass is the sum of the onion canopy, which is presented as kg/plot. The maximum biomass per plot (2.157 kg/ m<sup>2</sup>) was observed in T3, which was followed by T5 (Table 2). The minimum biomass (1.132 kg/ m<sup>2</sup>) was observed in T1. .

Similar findings were reported by Carter et al. (2013), where the highest above ground biomass was in the treatment with fertilizer+ the highest level of biochar. The highest grain yield and straw yield of rice were reported in the application of biochar along with the soil test value-based fertilizer (Meena and Prakasha, 2020).

Table 2. Effect of treatments on onion bulb diameter, biomass and bulb yield

Treatment	Bulb diameter (mm)	Biomass (kg/m <sup>2</sup> )	Bulb yield (ton/ha)
T1	21.33a	1.132a	8.45a
T2	23.82ab	1.295b	10.38bc
T3	26.32b	2.157f	18.62e
T4	25.09b	1.505c	12.32b
T5	25.68b	1.827e	15.25a
T6	23.98ab	1.702d	14.15cd
<b>Grand mean</b>	24.37	1.603	13.2
<b>Sem</b>	1.044	0.0359	0.364
<b>CV (%)</b>	8.6	4.5	5.5
<b>LSD</b>	3.147	0.1082	1.097
<b>F value</b>	2.89	107.58	99.46
<b>P-value</b>	0.051	<.001	<.001

Table 3. Analysis of B: C ratio for each treatment

S.N	Treatments	Bulb yield (t/ha)	Cost of cultivation per ha (Rs.)	Cost of onion per kg (Rs.)	Gross return Rs/ha	Net return Rs/ ha	B:C ratio
1	T1 (Control)	8.45	271100	60	507000	235900	1.87
2	T2 (RDF)	10.38	313350	60	622800	309450	1.98
3	T3 (RDF+Biochar)	18.62	343350	60	1117200	773850	3.25
4	T4 (1/2 RDF+Biochar)	11.32	323225	60	679200	355975	2.10
5	T5 (Compost+Biochar)	15.25	653100	60	913000	261900	1.401
6	T6 (Urine-soaked biochar)	14.15	383100	60	849000	465900	2.21

### **Benefit-Cost Ratio (BCR)**

The use of biochar with RDF showed the highest BCR (3.25) amongst all the treatments. The yield per hectare of T3 was significantly higher than other treatments (Table 3). Treatment 6 (Cattle urine-soaked biochar) showed BCR 2.21, which was higher than that of T5 (compost treated biochar) even though the yield in T6 was lower compared to T5. This is due to the huge quantity (cost) of compost that was solely used to fulfill the required dose of nitrogen.

### **CONCLUSION**

From this research, it can be concluded that biochar mixed with a recommended dose of fertilizer was beneficial for increasing onion yield. Application of recommended dose of fertilizer enriched with biochar increased plant biomass, bulb diameter, and bulb weight.

### **REFERENCES**

- Carter, S., Shackley, S., Sohi, S., Suy, T.B., Haefele, S. (2013) The Impact of Biochar Application on Soil Properties and Plant Growth of Pot Grown Lettuce (*Lactuca sativa*) and Cabbage (*Brassica chinensis*). *Agronomy*, 411
- Hamdani, S. (2017) Application of biochar enhanced wheat growth, yield and nutrient recovery under reduced fertilizer doses in calcareous soil?. *Pakistan Journal of Agricultural Sciences* 54.1 (2017): 107-115.
- Hammond, J., Shackley, S., Sohi, S., & Brownsort, P. (2011) Prospective life cycle carbon abatement for pyrolysis biochar systems in the UK. *Energy Policy*, 39(5): 2646-2655.
- Ippolito, J. A., Laird, D. A., & Busscher, W. J., (2012) Environmental benefits of biochar. *Journal of environmental quality*, 41(4): 967-972.
- Meena, H., Prakasha, H. (2020) Effect of biochar, lime, and soil test value-based fertilizer application on soil fertility, nutrient uptake and yield of rice-cowpea cropping system in an acid soil of Karnataka. *Journal of Plant Nutrition*. pp 1-16.
- Sohi, S. P., E. Krull, E. Lopez-Capel, and R. Bol. (2010) A review of biochar and its use and function in soil. *Advance of Agronomy* 105:47-82
- Timilsina, S., B. R. Khanal, S.C. Shah, C. P. Shrivastav and A. Khanal. (2017) Effects Of Biochar Application On Soil Properties And Production Of Radish (*Raphanus Sativus L.*) On Loamy Sand Soil. *Journal of Agriculture and Forestry University*. Volume 1 (2017). Pp.103-111.
- Van Zwieten, L., B. Singh, S. Joseph, S. Kimber, A. Cowie, and Y. Chan. (2009). Biochar and emissions of non-CO2 greenhouse gas from soil. In: *Biochar for environmental management: Science and technology*, London: Earthscan; 227-49.
- Vista, S.P. and Khadka, A. (2017) *Journal of Pharmacognosy and Phytochemistry* 2017; SP1: 673-677

## Economic Analysis of Staple Food Crops in Tanahun District, Nepal

\*<sup>1</sup>Prabhat Pandit, <sup>1</sup>Sachita Bhandari and <sup>2</sup>Hari Krishna Panta

<sup>1</sup>HICAST, Kathmandu

<sup>2</sup>Directorate of Research and Publication, IAAS, Kathmandu

\*Corresponding Author: prabhatpandit33@gmail.com

### ABSTRACT

*This study was conducted in Ward-6 of Vyas municipality of Tanahun district, Nepal to compare the profitability of four major staple food crops viz. rice, maize, millet and wheat. Field study was conducted during August and September (2021) employing household survey. A total of 112 households were selected by using simple random sampling technique. Rice, Maize, Millet and Wheat were the major staple food crops grown in the study area. Average annual household income of the respondents was 429430.75 rupees. On an average 80.62% share of total expenditure was covered by labour, 2.13% was covered by seeds and about 14% by fertilizers. Only about 3% of the total cost was covered by fixed inputs. Among the staple crops rice was the most profitable one with total income of Rs. 7858.45/ ropani for which total cost of production was estimated to be Rs. 4532.33/ ropani. Among the four staple food crops wheat was found to be the least profitable with the gross and net profits of Rs. 775.8 and Rs. 649.32 per ropani, respectively. B/C ratio of the staple food crops rice, maize millet and wheat were 1.74, 1.7, 1.38 and 1.24 respectively. Thus it is concluded that rice is the most profitable staple food crop among all four crops in Tanahun.*

**Key words:** Rice, Maize, Wheat, Millet, Profitability, B/C ratio,

### INTRODUCTION

In Nepal, the economy is dominated by agriculture. In the late 1980s, it was the livelihood for more than 90% of the population, although only approximately 20% of the total land area was found cultivable, it accounted for, on average, about 60% of the Gross Domestic Product and approximately 75% of exports. Since the Fifth Five-Year Plan (1975–80), agriculture has been the highest priority sector because economic growth was dependent on both increasing the productivity of existing crops and diversifying the agricultural base for use as industrial inputs (Matles, 1991). Staple food crops are the vital part of the agriculture production of Nepal (Ibid).

A staple food of a specific society may be eaten as often as every day or every meal, and most people live on a diet based on just a small number of food

staples (UNO, 2010). Specific staples vary from place to place, but typically are inexpensive or readily available foods that supply one or more of the macronutrients needed for survival and health: carbohydrates, proteins, fats, minerals, and vitamins (Da-Wen, 2017). Typical examples include tubers and roots, grains, legumes, and seeds. Among them, cereals, legumes, tubers and roots account for about 90% of the world's food calories intake. Staple foods are also grown in huge areas in Tanahun district which has high potential if explored properly (UN, 2010). Pariona (2019) studied the share of global calorie intake from different staple food; and s/he found that maize, rice and wheat were among the top 3 of the list. Maize, rice and wheat covered 19.5%, 16.5% and 15% share, respectively.

## **MATERIALS AND METHODS**

### **Study area, sampling technique, and sample size**

For the study ward-6 of Vyas Municipality of Tanahun district was selected after consulting with Agriculture Knowledge Centre (AKC). The respondents were selected randomly by applying random sampling method. Altogether, 112 respondents were selected from ward-6 of Vyas Municipality.

Data were collected from both primary and secondary sources. Primary data were collected by pre-tested semi-structured questionnaire survey among the farmers. The secondary data were collected from related publications from MoALD, annual reports of Vyas Municipality, AKC, books, various published and unpublished sources like journals, newspaper articles, TV interviews, etc.

### **Data Analysis**

The data was analyzed through statistical package for social science (SPSS) version 20. Both descriptive and analytical tools were used for data analysis. Analyzed data was then presented in tables graph and pie-chart.

### **Profit accountability variables**

Cost of production, return from the product, and profit from the product and benefit cost ratio (B/C) ratio was taken as profit accountability variables. The collected data was analysed by applying following method of analysis.

### **Benefit Cost Ratio**

B/C Ratio = Gross return / Total cost (Kindness, 2020).

### **Profit analysis**

The profit is the difference between the total revenue and the total cost incurred. Total cost included fixed cost and the variable cost. Cost incurred to fixed costs includes depreciation in fixed assets like different tools used for its production and land rent.

Thus, net profit can be written as:

Net profit = TR-TC or Net Profit =TR- (TFC+TVC)

Where, (TC= Total cost, TVC=Total variable cost, TR=Total Revenue, TFC=Total fixed cost)

### **Problem Ranking**

The intensity of problem being faced by the farmers during staple food crops production was identified by using 5 scaling technique comparing most serious, moderate, a little bit and no problem at all using scores 1.00, 0.75, 0.50, 0.25 and 0.00 respectively. The formula given below was used to find the index for intensity of production problems faced by the farmers.

$$I_{\text{prob}} = \sum SiFi / N$$

Where, ( $I_{\text{prob}}$  = Index value of intensity of problem,  $S_i$  = scale of  $i^{\text{th}}$  intensity,  $F_i$  = Frequency of  $i^{\text{th}}$  response,  $N$ = Total number of respondents)

## **RESULTS AND DISCUSSION**

### **Economic analysis of staple food crops production**

#### **Variable Inputs**

#### **Labour**

Labour required for millet cultivation was higher than rest of the staple foods mainly because of its traditional method of cultivation i.e. by ploughing the field by spade. The study showed that millet received 93.14% share of total expenditure of production. Similarly, wheat cultivation received share of 90 % because of its primitive intercultural operations like hoeing. Likewise, rice and maize received 67.5 and 71.85% of its total production cost. The respondent usually don't hire human labour and animal power for wheat and millet production but use the family labour and less number of hired labour which is costly.

### **Fertilizer**

Both Chemical and organic fertilizer use was seen higher in rice and maize on comparing it with millet and wheat. As the respondents were mainly doing the subsistence farming, they mainly applied farm yard manure in large proportion. 25% of rice and 22.7% of maize production cost was shared by the Farm Yard Manure (FYM) and 1.15 and 1% share of expenditure was for the NPK and other chemical fertilizers. Likewise, out of total cost of production only 4.3% and 3.4% share was analysed for millet and wheat production respectively. Whereas the lowest share of chemical fertilizer was found on wheat production of 0.2% and respondents didn't use chemical fertilizers for millet production. The analysis shows that using chemical fertilizers during production for millet and wheat was not common in study area but that was usual in practice for rice and maize production.

### **Seeds and other inputs**

The share of seed costs to the total production cost was the highest which accounted for 3.4% of the total cost. Shares of expenditure on seeds for production of rice, millet and wheat were found to be 2.2, 1.3 and 1.6%, respectively. The share of management costs like disease pest management, telephone, transportation and other costs were 0.15%, 0.15%, 0.06% and 0.1% in Rice, Maize, wheat and Millet respectively.

### **Fixed inputs**

Instrument buying and repair cost, land rent, land and water revenue costs were included in the fixed inputs. The share of these fixed inputs in the production cost were maximum (4.7%) in wheat and minimum of 0.9% in maize. Whereas, shares of fixed inputs in total expenditure was found to be 4% and 1.2% in maize and millet respectively.

The study showed that rice is the most profitable staple food crop with total income of Rs.7858.45/ ropani and total production cost of Rs4532.33/ ropani. It has the gross profit of Rs3509.3 and net Profit of Rs. 3436.9/ ropani. Likewise the income and production cost of maize was Rs3389.6 and Rs1986.1/ ropani with gross and net profit of Rs. 1421.8 and Rs. 1403.4/ ropani, respectively. Millet production cost was calculated Rs3339.45 and income was Rs4607.02 per ropani with the gross and net profit of 1308.5 and 1268 rupees per ropani respectively. Among all four staple food crops wheat was found to be the least profitable with the gross and net profit of 775.8571 and 649.32 rupees per ropani. It had the production cost of Rs2700.67 per ropani and income of 3350 rupees per ropani.

### Cost and Benefit analysis

B: C ratio for all the staple crops were greater than 1.0 (Table 1). The B/C ratio for rice was 1.74 which was greater than the B: C ratio of rice in western development region i.e. 1.5 (Joshi, 2011). Similarly the B: C ratio of maize was 1.7, which was greater than the B/C ratio of maize production of Kavre (1.035) and of Okhaldhunga (1.51) districts (Dhital, 2017). This indicates that the investment in rice and maize production is expected to deliver a positive net return in the study area. Similarly B/C ratio of millet and wheat was 1.38 and 1.24 respectively. The B/C ratio of millet in Beganas region of Pokhara was found 1.05 (Adhikari, 2012) which was less than that of Tanahun district. According to Dhital,

Table 1. Economic analysis of staple food crops production

S.N	Description	Unit	Total amount				Total amount per Ropani			
			Rice	Maize	Wheat	Millet	Rice	Wheat	Millet	Maize
A.	Variable Cost									
A1)	Labour cost	Rs	521350	215490	59590	228245	3057.771	3057.771	1427.086	2432.245
A2)	Fertilizers	Rs								0
A2.1)	FYM Cost	Rs	193900	68310	2270	10480	1137.243	1137.243	452.3841	92.65306
A2.2)	Urea	Rs	4272	2535	69	62.5	25.05572	25.05572	16.78808	2.816327
	Potash	Rs	3460	600	0	0	20.29326	20.29326	3.97351	0
	DAP	Rs	1017.5	0	0	0	5.967742	5.967742	0	0
	Others	Rs				62.5			0	0
A3)	Seed cost	Rs	16877	10197.75	1137.5	3235	98.98534	98.98534	67.53477	46.42857
A4)	Other Costs	Rs	640	0	0	0	3.753666	3.753666	0	0
	Total Variable	Rs	741516.5	297132.8	63066.5	242085	4349.07	4349.07	1967.767	2574.143
B.	Fixed Cost									0
B1)	Malpot cost	Rs	16295	1180	600	0	95.57185	95.57185	7.81457	24.4898
B2)	Panipot cost	Rs	5800	700	0	0	34.0176	34.0176	4.635762	0
B3)	Instruments	Rs	9051	900	2500	3010	53.08504	53.08504	5.960265	102.0408
B4)	Other Costs	Rs		0	0	0			0	0
	Total Fixed Cc	Rs	31246	2780	3100	3010	183.261	183.261	18.4106	126.5306
	Total Cost of f	Rs	772762.5	29912.75	66166.5	245095	4532.331	4532.331	198.0977	2700.673
	Total Revenue	Rs	1339866	511831	82075	338040	7858.452	7858.452	3389.609	3350
	Gross Profit (f	Rs	598349.5	214698.3	19008.5	95955	3509.381	3509.381	1421.843	775.8571
	Net Profit (R-	Rs	586007	211918.3	15908.5	92945	3436.991	3436.991	1403.432	649.3265
	B/C Ratio (GR	Rs	1.74	1.7	1.24	1.37				

Source: Field survey, 2021;

Note: 1 hectare= 19.66 Ropani; 1 US= 119 NRs (Jan, 2022)

B/C ratio of wheat of Kavre district was 1.42 which was greater than that of Tanahun (Dhital, 2017). Farmers of study area used fertilizers, manures or additional inputs in the minimum amount for the cultivation. Due to this the production cost was low and the benefit was high. This is the reason for higher B/C ratio of staple food crops in the study area.

### Problems faced by the farmers

From the study it was found that unavailability of inputs on time and decreased production were the two major problems of the farmers growing staple crops in Tanahun district. Others problems as stated by the respondents were price variation of the seeds, lack of proper marketing facilities and monopoly by the prise keepers of different agricultural inputs (Table 2).

Table 2. Index value of problems faced by the farmers in the study area, 2021

SN	Problems	Index value	Rank
1	Unavailability of input	0.67	2
2	Low production	0.75	1
3	Price variation	0.66	3
4	Poor marketing	0.64	4
5	Others	0.61	5

## CONCLUSION

In Tanahun district, production of staple food crops was profitable. Rice was found the most profitable staple food crop as compared to maize and wheat. Average annual income from rice the highest followed by maize and wheat, respectively. Such problems as unavailability of inputs like fertilizers and improved seed, price variations, poor marketing system had affected their production.

## REFERENCES

- Actualitix, (2016), Asia : Wheat - Producing countries (Tons) - 2016. *En.actualitix.com*.
- Adhikari, R.K., (2012), *Economics of finger millet (Elecusine coracana G.) production and marketing in peri urban area of Pokhara valley of Nepal*. Journal of development and agriculture economics.
- Balasubramanian, M.B.a.M.S., (2000), *YIELD, PROFIT, AND KNOWLEDGE GAPS IN RICE FARMING: CAUSES AND DEVELOPMENT OF MITIGATION MEASURES*. FAO.
- Casal, P.R.J.P.M.N., (2014), *Global maize production, utilization, and consumption*. The New York Academu Of Sciences.
- Da-Wen, (2017), "Non-Destructive and rapid evaluation of staple foods quality by using spectroscopic techniques.
- Da-Wen, (2017), "Non-Destructive and rapid evaluation of staple foods quality by using spectroscopic techniques: A review".
- Dhital, B., (2017), *Economy of Production and Labor Requirement in Major Field Crops of Kavre, Nepal*.
- Dulal, P.R., (2020), *comparative economics of maize grain and seed production in okhaldjunga district, Nepal*. chitwan: Journal of agriculture and national resource.
- FAO, (1996), *The World Sorghum and Millet Economies: Facts, Trends and Outlook*.
- FAO, (1996), *The World Sorghum and Millet Economies: Facts, Trends and Outlook*. FAO.
- Formplus, (2021), *Primary vs Secondary Data: 15 Key Differences & Similarities*.

- Geographic, N., (2020), *Staple Food Crops of the World*. [Online].
- Gobind, T.K.J.B.S.B.A., (2015), Status and prospect of maize research in Nepal. *Research Gate*.
- Joshi, K.L.M.P., (2011), *Production Economics of Rice in Different Development Regions of Nepal*. [Online].
- Karki, S.S.S.G.N.U.,(2019), Trend analysis of wheat area, production and productivity in Nepal: An overview. *Researchgate*.
- Kindness, D., (2020), Benefit-Cost Ratio (BCR). *Investopedia*.
- Kommerell, V., (2012), WHEAT in the World. *CGIAR Research Program on Wheat (WHEAT)*.
- Konema, (2018), The wheat production in Asia. *Konema*.
- Konema, (2021), Wheat production by country, 2020 - knoema.com. *Konema/atlas*.
- Kumar, K.S.A.M.M.,( 2014), *Assessment of the Maize Situation, Outlook and Opportunities in Asia*. Research Gate.
- Matles, A., (1991), "Nepal: A Country Study:Agriculture".
- McCORMICK, (2020), *All the latest data on maize production around the world*.
- Mottaleb, K., (2014), *Farm size and profitability of rice farming under rising input costs*. Researchgate.
- Mottaleb, K.A..R.D.B..K.G.e.a., (2017), Wheat Production and Consumption Dynamics in an Asian Rice Economy: The Bangladesh Case. *link.springer*.
- Narasimhan, C.V., (2019), *Encyclopedia Britannica*. [Online].
- Paneru, H., (2013), *millet status in Nepal and its associated breeding program mes*. slideshare.
- Pariona, A., (2019), *The dominant part of worldwide staple food are grains*, *WorldAtlas*.
- Raghav, (2020), *Growth of Food Crops in Asia*. Geography Notes.
- Robert Gould, C.R., (2020), A guide to choose a descriptive statistics tool according to the situation. *XLSTAT*.
- Sakamma, M.G., (2018), Finger Millet (*Eleusine coracana* L. Gaertn.) Production System. *Journal of Agricultural Science; Vol. 10*.
- Shahbandeh, M., (2020), *Corn production worldwide 2019/2020, by country*.
- Shahbandeh, (2020), Global leading wheat producers 2019/2020. *Statista*.
- Stephanie, (2017), Duncan's Multiple Range Test (MRT). *statisticshowto*.
- Techtarget, (2017), Emperical analysis. *Whatlas.com*.
- UN, (2010), "Dimensions of Need - Staples: What do people eat?".
- UNO,(2010), "Dimensions of Need - Staples: What do people eat?".

## **REVIEW ARTICLES**

# **Effect of Macronutrients and Micronutrients on Crop Disease Development and Management: A Review**

**\*Prem Pandey<sup>1</sup> and Ashish Ghimire<sup>2</sup>**

<sup>1</sup>Faculty of Agriculture, Far Western University, Tikapur, Kailali, Nepal

<sup>2</sup>Department of Plant Pathology, Agriculture and Forestry University (AFU), Rampur, Chitwan, Nepal

**\*Corresponding Author:** pandeyprem73@gmail.com

### ***ABSTRACT***

*The use of chemical pesticides is the most widespread and popular measure of managing crop diseases which however comes at the costs of degradation of environment, health hazards to consumers, and the problem of pesticide resistance. The optimum use of nutrients can be explored as a viable and sustainable option of managing crop diseases since they can reduce severity and incidence of diseases on crops. Several mechanisms from creation of physical barriers against penetrating pathogens to stimulation of defense pathways are involved in the process of disease resistance through nutrient supplementation. However, some nutrients like N and Mg have been observed to increase susceptibility of plants to certain diseases when supplied at larger quantity. K offers resistance to disease up to a certain limit, beyond which resistance doesn't increase. In addition, higher K with lower proportion of other nutrients like Ca can also increase certain diseases like clubroot, gummosis of citrus, etc. The form of use and method of application of fertilizer, condition of soil and environment, and the nature of pathogen can affect the susceptibility or resistance of crops to pathogens. This study has aimed to provide information on the association of several macro/micronutrients (N, P, K, Ca, Mg, S, Mn, Zn, B, Fe, Cl, Cu, and Si) with several crop diseases and mechanisms by which they resist, escape, or tolerate diseases (if they do).*

**Keywords:** Disease resistance, fertilizer, physical barriers, tolerance

### **INTRODUCTION**

Nutrients are important for growth and development of plants and also microorganisms, and also are important factors in disease control through an effect on disease resistance or tolerance (Agrios, 2005; Graham and Webb, 1991). Adequate and balanced supply of nutrients can reduce rate of disease development substantially reducing the use of chemical pesticides that raise concerns over food safety, human and environmental health, and pesticide resistance (Gupta *et al.*, 2017; Dordas, 2008). Several factors such as the nature

and method of use of fertilizer, pH, tillage, seedbed firmness, moisture level, crop sequences, presence of mycorrhizal association affect the availability of nutrients (Dordas, 2008).

Most of the essential nutrients of plants are related with plant disease severity (Huber and Graham, 1999). Excess or deficiency of the nutrients can be predisposing factor to disease caused by pathogens (Downer, 2013). A particular nutrient enhancing resistance against certain disease on the other hand can also increase severity and incidence of some other diseases (Dordas, 2008).

Mode of nutrition of pathogens can determine the expression or suppression of diseases. For example, with obligate parasites the increase in N level in plants increases disease severity whereas for facultative parasites at high N supply the severity of infection decreases. Pathogens can immobilize nutrients in rhizosphere or in infected tissues or even hinder efficient utilization of nutrients by causing nutrient deficiency, hyperaccumulation, and nutrient toxicity (Huber and Graham, 1999). Also, some organisms can utilize significant amount of nutrients for their own growth creating shortage of nutrients for plants and thus increasing susceptibility due to nutrient deficiency (Timonin, 1965). Adequate use of nutrition mainly induces resistance in hosts through formation of mechanical barriers (like thicker cell walls) or synthesis of natural defence compounds like phytoalexins, antioxidants, and flavonoids conferring resistance against pathogens (Gupta *et al.*, 2017).

Disease development is affected by the level of nutrients in several ways. Nutrients can directly affect physiology of plant or pathogen or both. More specifically, nutrients can affect sporulation and infection rate of pathogen, integrity of cell walls, membrane leakage, and chemical composition of host, growth rate of hosts enabling seedlings to escape/avoid infection during their most susceptible stages (Graham and Webb, 1991; Dordas, 2008). With the application of foliar sprays of nutrients, it is also hypothesized that Systemic Induced Resistance (SIR) and Systemic Acquired Resistance (SAR) are induced during which immunity signal is released or initiated at induction site of inducer leaf which is translocated systemically to challenged leaves, where defense responses are generated and mediated by phytohormones like salicylic acid (SA), jasmonic acid (JA), and ethylene (ET). SAR is associated with accumulation of pathogenesis-related (PR) proteins which is believed to contribute to resistance against pathogens whereas SIR is related with recognizing and responding to a pathogen attack in future (Dordas, 2008; Durrant and Dong, 2004; Verhage *et al.*, 2010).

Therefore, this review paper focuses on response of different macro and micro nutrients to the disease development and management in crops through different mechanisms.

## **MATERIALS AND METHODS**

This paper was drafted after collecting essential information from the various literatures available on internet regarding the effect of nutrients (macro and micro both) on crop disease development and management.

### **Macronutrients**

#### **Nitrogen (N)**

Nitrogen is a key component in many processes needed for growth. In particular, nitrogen is vital to chlorophyll, which allows plants to carry out photosynthesis. Nitrogen in the form of ammonia is the biggest nutrient supplied globally.

Nitrogen can produce succulent growth that will lead to exacerbation of diseases such as powdery mildew (Powel and Lindquist, 1997). Because nitrogen (N) is a crucial component of amino acids, an excess of N in plant tissues can result in increased levels of amino acids and other N-containing substances. By producing a more favourable environment for infections, these mineral imbalances reduce the host's resistance to Pathogen (Spann & Schumann, 2010). Plants with adequate nitrogen levels are more resistant to most bacterial infections; however, too much nitrogen might have the reverse effect. In general, parasites that feed on senescing (dying) tissue or that release toxins to harm or kill their hosts thrive in low-nitrogen environments. Some bacteria, on the other hand, thrive in high-nitrogen environments. These bacteria are mainly reliant on live things for nourishment (Spann & Schumann, 2010). Plants are more susceptible to bacterial infections when their K, Ca, and, in many cases, N levels are inadequate.

The responsiveness of maize to inorganic nitrogen fertilizer has been well established (Nnoham and Odurukwe, 1987). Nitrogen applied to maize increased the severity of gray leaf spot but potassium and phosphorous had little or no significant effect on the disease (Perkins *et al.*, 1995). In foliar diseases of cereals (such as rust and powdery mildew), disease incidence increased with increased application of N (Dordas, 2008). Caldwell *et al.* (2002) reported that higher levels of nitrogen and potassium application in maize increased the percentage of leaf blighting by *Cercospora zea maydis*. Several other obligate pathogens like *Pseudomonas syringae pv. Tomato*, *Ustilago maydis*, *Oidium lycopersicum*, *Puccinia graminis*, and *Erysiphe graminis* were found to attack plants more under high N supply (Hoffland *et al.*, 2000; Gupta *et al.*, 2017).

Furthermore, some other pathogens like *Didymella bryoniae* in watermelon, *Puccinia striiformis* f.sp. *tritici* in wheat were also observed to have higher infection with increased N which could be due to higher proportion of susceptible young tissues compared to mature tissues with higher level of N (Gupta *et al.*, 2017). In contrast, MacKenzie (1981) reported that on increasing N over the range of 0 to 200 kg/ha, the apparent early blight of potato caused by *Alternaria solani* reduced linearly by eight folds. Huber and McCay-Buis (1993) also reported that on applying N to cereal crops (especially  $\text{NH}_4^+$  form), take-all disease (*Gaeumannomyces graminis*) reduced since fertilization lowers disease severity under nutrient-deficient condition. Hofer *et al.*, (2016) reported that N fertilization restricts grain infection of Barley by *Fusarium*. Potato plants receiving insufficient N showed increased symptoms of wilt due to *Verticillium* sp. However excess N also doesn't improve control (Lambert *et al.*, 2005). Graham and Harper (1966) suggested that incidence of blackleg disease of potato was lower in plots under higher levels of N fertilizers. However, the lesion size due to late blight pathogen (*P. infestans*) increased moderately due to higher rates of N whereas P reduced tuber infection mainly due to increase in tuber skin thickness. N availability also affects severity of viral diseases through effect on vector attraction and development such as nitrogen-deficient foliages attract aphids that act as vectors to several viral diseases including PVY of potato (Lambert *et al.*, 2005).

There is a significant variation of nutrients including  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  that possibly could have direct or indirect effects on the development of the pathogen in maize leaf tissues (Lyimo, 2012). The source of N also plays important role in disease development such as ammonium form reduces severity of *Verticillium* wilt of potato, take-all of cereals, *Streptomyces* scab of potato and rice blast higher compared to the nitrate form due to effects like acidification of soil, reduction of root carbohydrates, stimulation of rhizospheric antagonistic microflora, etc. (Lambert *et al.*, 2005; Huber and Haneklaus, 2007). Huber and Watson (1974) and Huber and Haneklaus (2007) also listed *Pythium*, *Diplodia*, and *Puccinia* among other pathogens whose virulence on various hosts decrease in the presence of  $\text{NH}_4\text{-N}$  and increase in the presence of  $\text{NO}_3\text{-N}$  whereas the reverse applied for *Rhizoctonia*, *Fusarium*, *Sclerotinia*, *Botrytis*, *Plasmodiophora*, and *Drechslera*. Gevers *et al.* (1990) reported that  $\text{NH}_4^+\text{-N}$  increases leaf diseases caused by *Exserohilum turcicum* Leonard & Suggs (*Helminthosporium turcicum* Pass.).

The time and form of N fertilization is also found to affect periods of nutrient availability and thus affecting disease development. *Rhizoctonia* spring blight

(*R. cerealis*) and sharp eyespot of winter wheat increases with application of N fertilizer during cool and wet period whereas wheat is not affected in the fall or late spring. Liquid form of N increases spring blight more compared to granular form due to higher contact with the pathogen and increased production of pathogenesis of macerating enzymes (Huber and Haneklaus, 2007).

### **Phosphorous (P)**

Phosphorous is an essential macro nutrient and is the second most crop-limiting nutrient in most soil. Plant growth behaviour is influenced by the application of phosphorus (Kaya *et al.*, 2001). It is needed for growth, utilization of sugar and starch, photosynthesis, nucleus formation and cell division, fat formation (Masood *et al.*, 2011).

Phosphorous is known to reduce disease severity by inducing host resistance or accelerating plant maturity and thus escaping infection of pathogens that prefer younger tissues. The response to phosphorous varies with the season, cultivar and the pathogen. Higher level of P does not decrease stalk rot severity however, it seems to offer some protection against the stalk rot (Thayer and Williams, 1960). P is believed to be most effective when applied to manage seedlings and fungal diseases such as root rots where vigorous root development permits plants to escape disease (Huber and Graham, 1999). Besides, a number of diseases attacking foliage, stem, and fruit such as bacterial leaf blight and blast of rice, downy mildew, blue mould, leaf curl viral disease of tobacco, stem blight of soybean, yellow dwarf virus disease of barley, brown stripe disease of sugarcane, and root rot in corn are also found to be reduced by P application (Dordas, 2008; Gupta *et al.*, 2017). Foliar sprays of P can contribute to local and systemic protection against some foliage pathogens like powdery mildews of cucumber, grape, mango, apple, wheat, and peppers; rust of maize, etc. Moreover, severity of a number of diseases such as *Sclerotinia* rot, *Bremia* of lettuce, flag smut of wheat, and powdery mildew of several plants, rice blast, and take-all of barley have been reported to be reduced by P application (Reuveni and Reuveni 1998; Katan, 2009; Huber, 1980; Owolade *et al.*, 2006). Also, a study by Davis *et al.*, (1976) suggested that in absence of P fertilization potato scab (*Streptomyces scabies*) developed substantially in comparison to treatments with P application ranging from 84 to 336 kg/ha. Phosphorous has little or no effect on Gray leaf spot disease development on Maize (Smith, 1989). *Fusarium oxysporum f. vasinfectum* can increase the level of P in leaves but decreases N, K, Ca, and Mg levels (Dordas, 2009).

### **Potassium (K)**

Out of all the mineral nutrients, potassium (K) plays a particularly critical role in plant growth and metabolism, and contributes greatly to the survival of plants that are under various biotic and abiotic stresses (Wang *et al.*, 2013). Potassium plays essential roles in enzyme activation, protein synthesis, photosynthesis, osmoregulation, stomatal movement, energy transfer, phloem transport, cation-anion balance and stress resistance (Marschner, 2011). Also, deficiency of K leads to symptoms such as thin cell walls, weakened stalks, smaller and shorter roots, accumulation of sugar in leaves, and accumulation of unused N which in turn are favourable for entry and infection by pathogens (Gupta *et al.*, 2017). The most commonly accepted point for mechanism of K on plant resistance to pathogens is from the mechanical resistance point of view, such as thicker outer wall in epidermal cell, or by escaping from the highly incidence period (Mengel *et al.* 2001). In addition, high levels of free glutamine and glutamic acid, exudation of arginine are also associated with diseases suppression due to higher level of K (Huber and Arny, 1985). Potassium deficient plants tend to be more susceptible to infection than those with an adequate supply of K. Dordas (2008) reported that the high susceptibility of the K-deficient plant to parasitic disease is due to the metabolic functions of K in plant physiology.

Perrenoud (1990) found that the use of K significantly decreased the incidence of fungal diseases by 70%, bacteria by 69%, viruses by 41% and nematodes by 33%. The mechanistic influences of K on plant disease resistance have been reported by several researchers. Higher K<sup>+</sup> concentrations decreased the internal competition of pathogens for nutrient resources (Holzmueller *et al.*, 2007). Incidence of diseases like bacterial leaf blight, sheath blight, stem rot of rice, black rot of wheat, sugary disease of Sorghum, anthracnose of tomato, bacterial leaf blight and *Alternaria* leaf spot of cotton, *Cercospora* leaf spot of cassava, tikka leaf spot of peanut, red rust of tea, *Cercospora* leaf spot of mungbean, and seedling rot due to *Rhizoctonia solani* have been found to be reduced due to K application. The adequate potassium could not only improve root growth (Jia *et al.* 2008), but also could increase the stalk strength and reduce the incidence of stalk rot of Maize (Li *et al.*, 2010). The resistance of wheat and flax towards rust may be lost under K-deficient conditions and wilt resistant flax consumes more K compared to susceptible varieties (Huber and Haneklaus, 2007). Increasing Potassium content on leaf of the maize plant significantly reduce the disease severity of Maize streak disease caused by Maize streak virus (D. Blankson *et al.*, 2018). Potato plants have also been reported to offer resistance to *Phytophthora* due to K-induced accumulation of fungistatic levels of arginine in leaves (Huber and Haneklaus, 2007). Similarly, deficiency of K also increased

severity of *Alternaria* in many crops (Rotem, 1994). The population of some parasitic nematodes such as *Xiphinema americanum*, *Meloidogyne javanica*, and *Pratylenchus penetrans* is reduced by higher K levels. Application of K accompanied by the use of resistant cultivars has offered practical control of many crop diseases such as *Fusarium* wilt of tomato, Stewart's wilt of maize, Downy mildew of tobacco, and cabbage yellows. (Huber and Army, 1985). However, beyond an optimal level of K, there is no further increase in resistance (Dordas, 2008; Gupta *et al.*, 2017). Severity of some diseases have also been associated with higher level of K in relation to the proportion of other nutrient such as Ca. For example, Diseases like clubroot of crucifers (*Plasmodiophora brassicae*) and brown rot gummosis of orange trees (*Phytophthora parasitica*) are more problematic with higher proportion of K and lower proportion of Ca but is not serious when Ca/K ratio is close to 1:1. Also, higher K induces susceptibility of potato to *Streptomyces scabies* scab due to alteration of periderm cells and enhanced cell division (Huber and Army, 1985). Some researchers suggest that a temporary K limitation also reduces infection due to some necrotrophic pathogens by inducing jasmonate signalling pathway and thus triggering defense responses (Amtmann *et al.*, 2008; Wasternack, 2007).

### **Calcium (Ca)**

Calcium is associated with stability and function of plant membranes and is abundantly present in middle lamella. Deficiency of Ca primarily leads to leakage of low-molecular weight compounds (like sugars, amino acids) from membranes connecting cytoplasm and apoplast, stimulating infection by pathogens (Marschner, 1995). Stronger cell wall of the crops, induced by Calcium can protect crops from enzymes secreted by pathogens that impair the cell wall. Adequate levels of calcium in plants also aid in the plant's ability to isolate an infection (Patterson, 2013).

Calcium fertilizers application reduces root and stem diseases caused by *Rhizoctonia*, *Sclerotium*, *Sclerotinia*, *Botrytis*, *Fusarium*, *Erwinia*, etc. by hardening the plant cell wall and making it resistant to pathogen penetration. Studies have shown that maintaining the rigidity and stabilizing the cell wall are ways that elements like Boron (B), Manganese (Mn), and Calcium (Ca) apply to significantly prevent pest and disease attack in plants (Jordan-Meille *et al.*, 2012). The mechanism behind the protection of plants conferred by the adequate application of Ca against *Sclerotinia sclerotiorum* is believed to be binding of oxalic acid or strengthening of cell wall (Dordas, 2008). According to Easterwood G. W (2002), many plant-pathogenic fungi and bacteria produce several enzymes such as polygalacturonases and pectate transaminase during

invasion and infection of plant tissues that dissolve the middle lamella. However, increasing Ca content in plant tissue lowers polygalacturonase and pectolytic enzyme activity from *Erwinia carotovora* in vegetables like potato, bean etc. The steady supply of Calcium reduces activities of fungal pathogens like *Fusarium oxysporum* (causing wilt and crown rot in tomatoes). Calcium fertilization also reduces *Pythium* blight and root rot of turf grass and citrus, soft rot of Chinese cabbage and bean (*Pectobacterium* spp.), blackleg and soft rot of potato (*Pectobacterium atrosepticum*), Anthracnose in dragon fruit (*Colletotrichum truncatum*), Clubroot of crucifers under neutral to alkaline soils (*Plasmodiophora brassicae*) (Easterwood, 2002; Czajkowski *et al.*, 2011; Ghani *et al.*, 2011; Campbell and Arthur, 1990). Higher Ca content in cells walls resulted due to calcium fertilization also suppresses soft rot disease of potato caused by *Erwinia carotovora* and *E. chrysanthemi* by making cell walls more resistant to enzymatic degradation by pectate lyase and polygalacturonases (McGuire and Kelman, 1984).

### **Magnesium (Mg)**

Magnesium is both a tissue component as well as a regulator of physiological processes in plants that influence the general health status and susceptibility or resistance to disease (Huber and Jones, 2013). Jones and Huber (2007) reported 22 diseases that were decreased by supplying addition of Mg, 17 that were increased, and 6 where it had a variable effect depending on the environment. Magnesium has great role in photosynthesis and subsequent sugar movement, increased respiration associated with pathogen penetration and host response requires energy from photosynthesis. A deficiency of Mg during growth reduces the structural integrity of the middle lamella and the production of energy necessary for defence functions and inactivation of pathogen metabolites (Huber and Jones, 2013).

Table 1. Some reported interactions of soil or tissue Magnesium with plant diseases

<b>Disease</b>	<b>Plant</b>	<b>Casual Agents</b>	<b>Effect of Mg</b>	<b>References</b>
Huanglongbing	Citrus	<i>Candidatus Liberibacter</i> spp	Decrease	Rouse <i>et al.</i> 2010
Stunt	Corn	Spiroplasm	Decrease	Nome <i>et al.</i> , 2009
Early Blight	Potato	<i>Alternaria solani</i>	Decrease	Elfrich, 2010
Bacterial speck	Tomato	<i>Pseudomonas syringae</i> pv. <i>Tomata</i>	Increase	Vallad <i>et al.</i> , 2003
Panicle blast	Rice	<i>Pyricularia oryzae</i>	Increase	Filippi and Prabhu, 1998
Brown spot	Rice	<i>Bipolaris oryzae</i>	Decrease	Gupta <i>et al.</i> , 2017
Southern leaf blight	Maize	<i>Helminthosporium maydis</i>	Increase	Gupta <i>et al.</i> , 2017
Tuber rot	Potato	Various fungi	Decrease	Percival <i>et al.</i> , 1999

### **Sulphur (S)**

Sulphur in Plant is vital nutrient for Protein synthesis. It encourages the advancement and exploitation of vitamins and enzymes. It promotes normal plant growth and help in materialization of chlorophyll. It is responsible to improves seed construction and root growth of the plant. Sulphur reduces the severity of potato against potato scab disease (Dordas, 2008).

### **Micronutrients**

Micronutrients have diverse but essential role in plant functioning especially in photosynthesis, photolysis, protein, carbohydrate metabolism, phenylpropanoid pathway and also in plant metabolism by affecting the phenolics and lignin content and membrane stability (Dutta *et al.*, 2017). The effect of micronutrients on reducing the severity of diseases can be attributed to the involvement in physiology and biochemistry of the plant, as many of the essential micronutrients are involved in many processes that can affect the response of plants to pathogens (Marschner, 1995). It is believed that Systemic Acquired Resistance (SAR) mechanisms could be involved in suppressing diseases by micronutrients through release of  $\text{Ca}^{2+}$  ions from cell walls further interacting with salicylic acid and activating plant defence responses (Dordas, 2008; Dala-Paula *et al.*, 2019; Gupta *et al.*, 2017). An adequate supply of some micronutrients including Mn is important in active defence mechanisms of plants mediated through the Shikimate pathway (Huber and Haneklaus, 2007). The role of micronutrients in management of diseases of several host-pathogen systems are mentioned below.

### **Manganese (Mn)**

Manganese is an important micronutrient affecting resistance in plants against root and foliar diseases (Heckman *et al.*, 2003). Mn has an important role in functions like lignin biosynthesis, phenol biosynthesis, and photosynthesis among many (Dordas, 2008). Mn activates enzymes necessary for the biosynthesis of resistant lignin and suberin, inhibits induction of aminopeptidase (an enzyme that supplies essential amino acids for fungal growth) and pectin methyl esterase (an enzyme present in fungus to degrade host cell walls) (Dordas, 2008). Mn-induced activation of plant peroxides in apoplast is also believed to be responsible for stimulation of plant resistance (Heine *et al.*, 2011). Glycoprotein associated with conferring resistance of sweet potato to *Ceratocystis fimbriata* (black rot) and potato to *Phytophthora infestans* (late blight) require Mn for activity (Huber and Haneklaus, 2007).

Table 2. Effect of Soil application of Mn based fertilizers on diseases of crops

Micronutrient	Disease and Pathogen	Effect on disease	References
Manganese (Soil application of Mn based fertilizers)	Scab of Potato	Decrease	(Keinath and Loria, 1996)
	<i>Fusarium</i> infection in cotton and Sclerotinia in squash	Decrease	(Agrios, 2005)
	Potato black scurf ( <i>Rhizoctonia</i> sp.)	Decrease	(McGregor and Wilson, 1966)
	Potato Common scab ( <i>Steptomyces scabies</i> ),	Decrease	(Simoglou and Dordas, 2006;
	Rice Blast ( <i>Pyricularia oryzae</i> ),	Decrease	Dordas, 2008)
	Rice Leaf spot ( <i>Alternaria</i> ),	Decrease	(Simoglou and Dordas, 2006)
	Wheat Mildew ( <i>Blumeria graminis</i> var. <i>tritici</i> ),	Decrease	(Simoglou and Dordas, 2006)
	Cotton Wilt ( <i>Verticillium</i> ),	Decrease	(Simoglou and Dordas, 2006)
	Avocado Root rot ( <i>Pythium</i> )	Decrease	(Simoglou and Dordas, 2006)
	Wheat take-all	Decrease	(Dordas, 2008)
Black leaf mold of tomato	Decrease	(Heine <i>et al.</i> , 2011)	

### Zinc (Zn)

Zinc is an essential plant nutrients and component of plants that aids in carbohydrate transformations as it regulates the consumption of sugars. Zinc is a key component of many proteins and enzymes. Because zinc plays a crucial role in protein and starch production, a low zinc content in plant tissue causes a accumulation of amino acids and reducing sugars in tissue (Römheld and Marschner 1991). Zinc in most of the cases reduce disease severity and in cases increase severity as well. Zn deficiency leads to increased membrane leakage of low-molecular-weight compounds which makes the cells appropriate substrate for feeding by pathogens (Huber *et al.*, 2012). The reduction in severity and incidence could also be due to direct toxicity of Zn upon pathogen and increment of phenol contents of plant (Graham and Webb, 199; Prasad *et al.*, 2010).

According to Dutta *et al.* (2017) and Huber and Haneklaus (2007), Zinc nutrition is beneficial for many the management of various plant diseases such as Orange root rot (*Phytophthora nicotiana*), Citrus mold (*Penicillium citrinum*), various leaf spot (*Alternaria*, *Cochliobolus* etc.) and wilt (*Fusarium*), various stem and sheath blight (*Rhizoctonia solani*), Bacterial Leaf spot (*Pseudomonas cichorii*), Powdery scab (*Spongospora subterranean*), foot rot (*Sclerotium rolfsii*), Powdery mildew of pea (*Erysiphe polygoni*), Spring blight (*Rhizoctonia cerealis*) etc. Incidence of club root of crucifers caused by *Plasmodiophora brassicae* and severity is also suggested to be reduced by Zinc application (Sen, 2005; Dordas, 2008).

### **Boron (B)**

Boron deficiency is the most widespread micronutrient deficiency in the world that affects the structure and stability of cell wall and cell membrane and also the metabolism of phenolics or lignin and thus in several diseases, B is associated with disease resistance and tolerance (Brown *et al.*, 2002). B is known to be toxic to pathogenic fungi and deficiency (Spann and Schuman, 2009). B has showed promising results in reducing diseases caused by *Plasmiodiophora brassicae* (Woron.) in crucifers, *Fusarium solani* (Mart.) (Sacc.) in bean, *Verticillium albo-atrum* (Reinke & Berth) in tomato and cotton, Tobacco mosaic virus in bean, Tomato yellow leaf curl virus in tomato, *Gaeumannomyces graminis* (Sacc.) and *Blumeria graminis* (D.C.) (Speer) in wheat (Graham and Webb, 1991; Marschner, 1995). Lower level of B, in addition to Ca and Mg, has been reported in HLB-infected plants due to restriction in uptake, transport, or metabolism (Spann and Schumann, 2009).

### **Iron (Fe)**

Application of Fe can have positive, negative, or neutral effect on host against pathogens. Foliar application of Fe can increase resistance of wheat to rust and smut, banana to *Colletotrichum musae*, apple and pear to *Sphaeropsis malorum*, and cabbage to *Olpidium brassicae*. (Graham, 1983; Graham and Webb, 1991). However, Fe application did not suppress take-all disease of wheat and *Colletotrichum* spp. of bean (Dordas, 2008). Jones and Woltz (1970) also suggested that reduced Fe availability can reduce severity of wilt in tomato caused by *Fusarium* sp.

### **Chlorine (Cl)**

Chlorine is important for plant photosynthesis as it is involved in the opening and closing of stomata. There are reports showing that Cl application can enhance host plant's resistance to disease in which fairly large amounts of Cl are required, which are much higher than those required to fulfil its role as a micronutrient but far less than those required to induce toxicity (Mann *et al.*, 2004). Cl is also associated with Mn since it can increase the availability of Mn, increasing tolerance of plants to biotic stress caused by pathogens (Dordas, 2008). Chlorine has been shown to control a number of diseases such as stalk rot in corn, stripe rust in wheat, take-all in wheat, northern corn leaf blight and downy mildew of millet, and *Septoria* in wheat (Graham and Webb, 1991; Mann *et al.*, 2004).

### **Copper (Cu)**

Copper acts to detoxify oxygen radicals and hydrogen peroxide, thus limiting damage to plant cells. Application of Cu based nutrient can activate systemic

acquired resistance mechanisms (Reuveni and Reuveni, 1998). The reduction of disease severity through Cu fertilization is mainly due to cell wall stability and lignification of plants (Marschner, 1995). Deficiency of Cu also alters lipid structure of cell membrane necessary for conferring resistance (Broadley *et al.*, 2012). Cu has been beneficial in the control of the following diseases like Wheat Powdery Mildew (*Blumeria graminis* var. *tritici*), Sunflower Leaf/Stem spot (*Alternaria*), Ginseng Bacterial leaf spot (*Pseudomonas cichori*), Wheat Leaf rust (*Puccinia triticina*), Rye Ergot (*Claviceps* sp.), Barley Ergot (*Claviceps* sp.), Rice Blast (*Pyricularia oryzae*), Wheat Leaf/Glume blotch (*Septoria* sp.), Sugarbeet Cyst Nematode (*Heterodera* sp.), Tomato Wilt and Cotton Wilt (*Verticillium* sp.), Potato Common scab (*Streptomyces scabies*), etc. (Dutta *et al.*, 2017).

### **Silicon (Si)**

Silicon accumulated on tissues of plants such as Sugarcane, Rice etc. increases yield and resistance against diseases. According to Dutta *et al.* (2017) Si has been shown to control a number of diseases such as rice blast (*Magnaporthe grisea*), brown spot (*Cochliobolus miyabeanus*) and Sheath blight (*Rhizoctonia solani*). Silicon (Si) can decrease the intensity of blast as effectively as some fungicides, mainly because it has the potential to increase the partial resistance of cultivars to the same level observed in cultivars with complete resistance (Datnoff *et al.*, 2001). Si application has been associated with an increase in the density of silicified bulliform cells in the rice leaf epidermis (Kim *et al.*, 2002), creation of physical barrier restricting hyphal penetration, induction of accumulation of antifungal compounds like flavonoids and diterpenoid phytoalexins that degrade microbial cell walls (Alvarez and Datnoff, 2001; Brecht *et al.*, 2004-not found) all of which help in increasing resistance of plants towards pathogens. Besides these, several other micronutrients such as Li, Cd, and Hg have sometimes been linked with the possession of certain characteristics to suppress certain pathogens (Dordas, 2008).

## **CONCLUSION**

In most of the studies mentioned in this article, the increment in nutrient supply has led to decrease in the severity and incidence of diseases caused by several pathogenic agents. A wide range of mechanisms involving nutrient supplementation such as creation of physical barriers, stimulation of rapid crop growth, optimization of crop metabolic functions, secretion of biochemical substances against pathogens, inhibition of secretion of cell degrading enzymes by pathogens, induction of direct toxicity upon pathogens, etc have been found to aid crops resist, tolerate, or escape diseases. In certain cases however,

nutrition supply can aggravate disease condition. The time of application and form of fertilizer can also affect the susceptibility or resistance of a crop towards pathogenic microbes.

## REFERENCES

- Ahamad, S. (2013) *Hill Agriculture*. Published by Astral Publishing House, New Delhi. pp 550.
- Alvarez, J., & Datnoff, L. E. (2001) The economic potential of silicon for integrated management and sustainable rice production. *Crop Protection*, 20(1), 43-48.
- Amtmann, A., Troufflard, S., & Armengaud, P. (2008) The effect of potassium nutrition on pest and disease resistance in plants. *Physiologia plantarum*, 133(4), 682-691.
- Brecht, M. O., Datnoff, L. E., Kucharek, T. A., & Nagata, R. T. (2004) Influence of silicon and chlorothalonil on the suppression of gray leaf spot and increase plant growth in St. Augustinegrass. *Plant disease*, 88(4), 338-344.
- Broadley, M., Brown, P., Cakmak, I., Rengel, Z., & Zhao, F. (2012) Function of nutrients: micronutrients. In: *Marschner's mineral nutrition of higher plants* (pp. 191-248). Academic Press.
- Brown, P. H., Bellaloui, N., Wimmer, M. A., Bassil, E. S., Ruiz, J., Hu, H., Pfeiffer, H., Dannel, F., & Römheld, V. (2002) Boron in plant biology. *Plant biology*, 4(02), 205-223.
- Caldwell, P. M., Ward, J. M. J., Miles, N., & Laing, M. D. (2002) Assessment of the effects of fertilizer applications on gray leaf spot and yield in maize. *Plant Disease*, 86(8), 859-866.
- Campbell, R. N., & Greathead, A. S. (1989) Control of clubroot of crucifers by liming.
- Czajkowski, R., Perombelon, M. C., van Veen, J. A., & van der Wolf, J. M. (2011). Control of blackleg and tuber soft rot of potato caused by *Pectobacterium* and *Dickeya* species: a review. *Plant pathology*, 60(6), 999-1013.
- Blankson, D., Asare-Bediako, E., Frimpong, K. A., Ampofo, E., Taah, K. J., & Van der Puije, G. C. (2018) Incidence and severity of maize streak disease: The influence of tillage, fertilizer application and maize variety. *African Journal of Agricultural Research*, 13(12), 3- . doi:10.5897/ajar2017.12873
- Dala-Paula, B. M., Plotto, A., Bai, J., Manthey, J. A., Baldwin, E. A., Ferrarezi, R. S., & Gloria, M. B. A. (2019) Effect of huanglongbing or greening disease on orange juice quality, a review. *Frontiers in plant science*, 9, 1976.
- Datnoff, L. E., Seebold, K. W., & Correa-V, F. J. (2001) The use of silicon for integrated disease management: reducing fungicide applications and enhancing host plant resistance. In *Studies in Plant Science* (Vol. 8, pp. 171-184). Elsevier.
- Davis, J. R., McDole, R. E., & Callihan, R. H. (1976) Fertilizer effects on common scab of potato and the relation of calcium and phosphate-phosphorus.
- Dordas, C. (2008) Role of nutrients in controlling plant diseases in sustainable agriculture: a review. *Agronomy for sustainable development*, 28(1), 33-46.
- Downer, A. J., Hodel, D. R., Mathews, D. M., & Pittenger, D. R. (2013) Effect of Fertilizer Nitrogen Source on Susceptibility of Five Species of Field-Grown Palms to *Fusarium oxysporum* f. sp. *canariensis*. *Palms*, 57(2)
- Durrant, W. E., & Dong, X. (2004) Systemic acquired resistance. *Annu. Rev. Phytopathol.*, 42, 185-209
- Dutta, S., Ghosh, P., Ghorai, A. K., De Roy, M., & Das, S. (2017) Micronutrients and plant disease suppression. *Fertilizers and Environment News*, 3(2), 2-6
- Easterwood, G. W. (2002) Calcium's role in plant nutrition. *Fluid Journal*, 10(4), 1-3
- Gevers, H. O., Lake, J. K., & McNab, N. J. (1990) An analysis of ear rot and leaf blight resistance in department maize breeding material. In *Proceedings of the SA Maize Breeding Symposium* (pp. 41-46)
- Ghani, M. A. A., Awang, Y., & Sijam, K. (2011) Disease occurrence and fruit quality of pre-harvest calcium treated red flesh dragon fruit (*Hylocereus polyrhizus*). *African Journal of Biotechnology*, 10(9), 1550-1558
- Graham, D. C., & Harper, P. C. (1966) Effect of inorganic fertilizers on the incidence of potato blackleg disease. *European Potato Journal*, 9(3), 141-145

- Graham, R. D. (1983) Effects of nutrient stress on susceptibility of plants to disease with particular reference to the trace elements. *Advances in botanical research*, 10, 221-276
- Graham, R. D., & Webb, M. J. (1991) Micronutrients and disease resistance and tolerance in plants, *Micronutrients in agriculture*, 4, 329-370
- Gupta, N., Debnath, S., Sharma, S., Sharma, P., & Purohit, J. (2017) Role of nutrients in controlling the plant diseases in sustainable agriculture. In: *Agriculturally important microbes for sustainable agriculture* (pp. 217-262). Springer, Singapore
- Keinath, A. P. (1989). Management of common scab of potato with plant nutrients. *Management of Diseases with Macro-and Microelements*, 152-166.
- Lyimo, H. J. F., Pratt, R. C., & Mnyuku, R. S. O. W. (2012). Composted cattle and poultry manures provide excellent fertility and improved management of gray leaf spot in maize. *Field Crops Research*, 126, 97-103. doi:10.1016/j.fcr.2011.09.023
- Heckman, J. R., Clarke, B. B., & Murphy, J. A. (2003). Optimizing manganese fertilization for the suppression of take- all patch disease on creeping bentgrass. *Crop Science*, 43(4), 1395- 1398.
- Heine G, Max JFJ, Fuhrs H, Moran-Puente DW, Heintz D, Horst W (2011) Effect of manganese on the resistance of tomato to *Pseudocercospora fuligena*. *J Plant Nutri Soil Sci* 174:827– 836
- Hofer, K., Barmerier, G., Schmidhalter, U., Habler, K., Rychlik, M., Hüchelhoven, R., & Hess, M. (2016). Effect of nitrogen fertilization on Fusarium head blight in spring barley. *Crop protection*, 88, 18-27.
- Hoffland, E., Jeger, M. J., & van Beusichem, M. L. (2000). Effect of nitrogen supply rate on disease resistance in tomato depends on the pathogen. *Plant and Soil*, 218(1), 239-247.
- Holzmueller, E. J., Jose, S., & Jenkins, M. A. (2007). Influence of calcium, potassium, and magnesium on *Cornus florida* L. density and resistance to dogwood anthracnose. *Plant and Soil*, 290(1), 189-199.
- Huber, D. M. (1980). The role of mineral nutrition in defense. *Plant disease: an advanced treatise: how plants defend themselves*, 381-406.
- Huber, D. M., & Arny, D. C. (1985). Interactions of potassium with plant disease. *Potassium in agriculture*, 467-488.
- Huber, D. M., & Graham, R. D. (1999). The role of nutrition in crop resistance and tolerance to diseases. *Mineral nutrition of crops: fundamental mechanisms and implications.*, 169-204.
- Huber, D. M., & Haneklaus, S. (2007). Managing nutrition to control plant disease. *Landbauforschung Volkenrode*, 57(4), 313.
- Huber, D. M., & Jones, J. B. (2013). The role of magnesium in plant disease. *Plant and soil*, 368(1), 73-85.
- Huber, D. M., & McCay-Buis, T. S. (1993). A multiple component analysis of the take-all disease of cereals. *Plant Disease*, 77(5), 437-447.
- Huber, D., Römheld, V., & Weinmann, M. (2012). Relationship between nutrition, plant diseases and pests. In *Marschner's mineral nutrition of higher plants* (pp. 283-298). Academic Press.
- Huber, D. M., & Watson, R. D. (1974). Nitrogen form and plant disease. *Annual review of phytopathology*, 12(1), 139-165.
- Huber, D. M., & Jones, J. B. (2013). The role of magnesium in plant disease. *Plant and Soil*, 368(1), 73-85.
- Jia, Y. B., Yang, X. E., Feng, Y., & Jilani, G. (2008). Differential response of root morphology to potassium deficient stress among rice genotypes varying in potassium efficiency. *Journal of Zhejiang University Science B*, 9(5), 427-434.
- Jones, J. P., & Woltz, S. S. (1969). Fusarium wilt (race 2) of tomato: Calcium, pH, and micronutrient effects on disease development. *Plant Disease Reporter*, 53(4), 276-279.
- Jones JB, Huber DM (2007) Magnesium and plant disease. In: Datnoff LE, Elmer WH, Huber DM (eds) *Mineral nutrition and plant disease*. APS Press, St. Paul, pp 95–100
- Jordan-Meille, L, Rubæk, G, Ehlert, P, Genot, V, Hofman, G, Goulding, K, Recknagel, J, Provolo, G, Barraclough, P. (2012). An overview of fertilizer-P

- recommendations in Europe: soil testing, calibration and fertilizer recommendations. *Soil Use and Management*, 28(4), 419-435.
- Katan, J. (2009). Mineral nutrient management and plant disease. *IPI K Centre-Newsletter e-ific*, 21, 6-8.
- Kaya, C., Higgs, D., & Kirnak, H. (2001). The effects of high salinity (NaCl) and supplementary phosphorus and potassium on physiology and nutrition development of spinach. *Bulg. J. plant physiol*, 27(3-4), 47-59.
- Lambert, D. H., Powelson, M. L., & Stevenson, W. R. (2005). Nutritional interactions influencing diseases of potato. *American Journal of Potato Research*, 82(4), 309-319.
- Li, W. J., Ping, H. E., & Jin, J. Y. (2010). Effect of potassium on ultrastructure of maize stalk pith and young root and their relation to stalk rot resistance. *Agricultural Sciences in China*, 9(10), 1467-1474.
- Moran, L. (1994). Investigation on Harmfulness and Prevention with Potash Fertilizer of Bacterial Wilt of Corn in Heilongjiang Province [J]. *HEILONGJIANG AGRICULTURAL SCIENCE*, 2.
- MacKenzie, D. R. (1981). Association of potato early blight, nitrogen fertilizer rate, and potato yield. *Plant Disease*, 65(7), 575-577.
- Mann, R. L., Kettlewell, P. S., & Jenkinson, P. (2004). Effect of foliar- applied potassium chloride on septoria leaf blotch of winter wheat. *Plant pathology*, 53(5), 653-659.
- Marschner H. (1995) *Mineral Nutrition of Higher Plants*, 2nd ed. Academic, London, p. 889.
- Marschner, H. (2011). *Marschner's mineral nutrition of higher plants*. Academic press.
- Masood, T., Gul, R., Munsif, F., Jalal, F., Hussain, Z., Noreen, N., Khan, H., Khan, H. & Nasiruddin, K. H. (2011). Effect of different phosphorus levels on the yield and yield components of maize. *Sarhad Journal of Agriculture*, 27(2), 167-170.
- McGregor, A. J., & Wilson, G. C. S. (1966). The influence of manganese on the development of potato scab. *Plant and Soil*, 25(1), 3-16.
- McGuire, R. G., & Kelman, A. (1984). Reduced severity of *Erwinia* soft rot in potato tubers with increased calcium content. *Phytopathology*, 74(10), 1250-1256.
- Mengel K, Kirkby E A, Kosegarten H, Appel T. 2001. Principles of Plant Nutrition. 5<sup>th</sup> ed. Kluwer Academic Publishers, Dordrecht. The Netherlands. pp.553-571.
- Nnoham, O. I., & Odurukwe, S. O. (1987). Effects of N fertilizer rate, soil water tension and soil texture on growth and N uptake by maize (*Zea mays* L.). *Fertilizer research*, 13(3), 241- 254.
- Nome, C., Magalhães, P. C., Oliveira, E., Nome, S., & Laguna, I. G. (2009). Differences in intracellular localization of corn stunt spiroplasmas in magnesium treated maize. *Embrapa Milho e Sorgo-Artigo em periódico indexado (ALICE)*.
- Owolade, O. F., Adediran, J. A., Akande, M. A., & Alabi, B. S. (2006). Effects of application of phosphorus fertilizer on brown blotch disease of cowpea. *African journal of Biotechnology*, 5(4), 343-347.
- Patterson, G. (2013). Calcium nutrition in plants. *Canadian Certified Crop Advisor Association. Accessed March, 10, 2013*.
- Perkins, J.M., Smith, D.R., Kinsey, J.G., Dowden, D.C., 1995. Prevalence and control of gray leaf spot. In: Proceeding Annual Conference 111, Maize Breeders School, University of Illinois, Urbana, pp. 177-185.
- Percival, G., Karim, M., & Dixon, G. (1999). Pathogen resistance in aerial tubers of potato cultivars. *Plant pathology*, 48(6), 768-776.
- Perrenoud, S. (1977). *Potassium and plant health* (No. 3). Bern: International Potash Institute.: Bern, Switzerland, 1990; pp. 8-10.
- Powell, C. C., & Lindquist, R. K. (1992). *Ball pest and disease manual*. Ball publishing.
- Reuveni, R., & Reuveni, M. (1998). Foliar-fertilizer therapy—a concept in integrated pest management. *Crop protection*, 17(2), 111-118.
- Römheld, V., & Marschner, H. (1991). Function of micronutrients in plants. *Micronutrients in agriculture*, 4, 297-328.
- Rotem, J. (1994). *The genus Alternaria: biology, epidemiology, and pathogenicity*. APS Press, Saint Paul.
- Rouse, B., Roberts, P., Irey, M., Boyd, M., & Willis, T. (2010, December). Monitoring trees infected with Huanglongbing in a commercial grove receiving

- nutritional/SAR foliar sprays in southwest Florida. In *Proceedings of the Florida State Horticultural Society* (Vol. 123, pp. 118-120).
- Rouse, B., Irey, M., Gast, T., Boyd, M., & Willis, T. (2012, December). Fruit production in a southwest Florida citrus grove using the Boyd nutrient/SAR foliar spray. In *Proceedings of the Florida State Horticultural Society* (Vol. 125, pp. 61-64).
- Prasad, D., Singh, R., & Singh, A. (2010). Management of sheath blight of rice with integrated nutrients. *Indian Phytopathology*, 63(1), 11.
- Sen, P. (2005). Antagonistic effect of Ca, B and Mo on club-root disease of rape-mustard. *Indian Agriculturist*, 49(1/2), 13-16.
- Smith, K. L. (1989). *Epidemiology of gray leaf spot of field corn (Zea mays L.) caused by Cercospora zea-maydis Tehon and Daniels* (Doctoral dissertation, University of Maryland, College Park).
- Spann, T. M., & Schumann, A. W. (2009). The role of plant nutrients in disease development with emphasis on citrus and Huanglongbing. In *Proc. Fla. State Hort. Soc* (Vol. 122, pp. 169-171).
- Spann, T. M., & Schumann, A. W. (2010). Mineral nutrition contributes to plant disease and pest resistance. *EDIS*, 2010(4).
- Thayer, P., and Williams L. E. (1960) Effect of nitrogen, phosphorous and potassium concentrations on the development of Gibberella stalk and root rot of corn. *Phytopathology*. 50: 212-14.
- Timonin, M. I. (1965) Interaction of higher plants and soil microorganisms, *Microbiology and Soil Fertility*. Oregon State University Press, Corvallis, OR, 135-138.
- Vallad, G. E., Cooperband, L., & Goodman, R. M. (2003). Plant foliar disease suppression mediated by composted forms of paper mill residuals exhibits molecular features of induced resistance. *Physiological and Molecular Plant Pathology*, 63(2), 65-77.
- Wang, M., Zheng, Q., Shen, Q., & Guo, S. (2013) The critical role of potassium in plant stress response. *International journal of molecular sciences*, 14(4), 7370-7390.
- Wasternack, C. (2007) Jasmonates: an update on biosynthesis, signal transduction and action in plant stress response, growth and development. *Annals of botany*, 100(4), 681-697.

## Antimicrobial Drug Residues in Chicken Meat: A Potential Human Health Concern

Shankar Pandey<sup>1\*</sup>, Sharada Thapaliya<sup>2</sup> & Doj Raj Khanal<sup>3</sup>

<sup>1</sup>Central Referral Veterinary Hospital, Kathmandu,

<sup>2</sup>Agriculture and Forestry University, Rampur, Nepal

<sup>3</sup>Nepal Agricultural Research Council, Lalitpur, Nepal

\*Corresponding Author: drspvet@gmail.com

### ABSTRACT

*Antibiotics are used in animal agriculture especially in poultry industry, not only for therapeutic and prophylactic purposes, but also as a growth promoter to enhance the health and productivity of flocks. The extensive use of antimicrobial drugs (AMD) leads to antibiotic residues in frequently consumed foods of animal origin. Many producers and consumers are unaware of antimicrobial residues in meat. A crucial step is the screening of veterinary drug residues in live animals, feeds and animal products. There are various methods of AMD residue assessment namely screening method which is qualitative and confirmatory method that is quantitative requiring more efforts. The major public health significances of antimicrobial residues include the development of antimicrobial drug resistance, hypersensitivity reaction, carcinogenicity, mutagenicity, teratogenicity, bone marrow depression, and disruption of normal intestinal flora. Indiscriminate use of AMDs in poultry industry should be discouraged through good veterinary practice, good husbandry practice, rational use of veterinary drugs and continuous residue monitoring programs. In this paper, an overview on antimicrobial drug residues in chicken meat and recommendations to minimize its level in market meat has been discussed.*

**Keywords:** AMD, residues; poultry; meat; antibiotics, monitoring

### INTRODUCTION

Antimicrobial drugs were first used in veterinary medicine for the treatment of mastitis in dairy cows shortly after they were developed (Gildow et al., 1938). The discovery of antibiotics and their use in animals and humans was indisputably one of the greatest achievements of the 20<sup>th</sup> century (Page and Gautier, 2012). However, Antimicrobial compounds, in addition to their therapeutic value, enhance growth and promote the feed efficiency of the food animals, which led to widespread use as feed supplements (Lassiter, 1955). Approximately 78-80% of all animals produced for food purposes get AMDs during their life. Many of the antimicrobials used to treat bacterial infections in humans also have veterinary applications; they are used to treat infections in sick and injured animals. As prophylactic agents and growth promoters, the

antimicrobials that are used at suboptimal concentrations are potentially dangerous since these agents can encourage the production of antimicrobial resistant strains of bacteria (Khachatourians, 1998 and Simonsen *et al* 1998).

In Nepal, the gross domestic product (GDP) contribution from agriculture and forestry sector is 27.08% (CBS, 2020). Poultry production in Nepal contributes 4% whereas livestock contributes 11% of total GDP (FAO, 2014). Antimicrobial drugs are used haphazardly in the treatment of disease (Faraj, and Ali, 1981) by the farmers without laboratory diagnosis, veterinary prescription and supervision (Boisseau, 1993). Unsafe drug residue tends to accumulate in edible parts of food animal e.g., breast muscle of chicken (Mund *et al.*, 2017). The residue level above the Maximum Residue Level (MRL) is called violative residue which causes serious public health hazards and development of antibiotic resistance (Hussein, and Khalil, 2013).

Improper maintenance of treatment records or failure to identify treated animals, haphazard use of antimicrobials without following the full treatment regimen or long-term use of antimicrobials may lead to their residues in foods of animal origin. The most likely cause of violative drug residues is the failure to observe withdrawal times. Faecal recycling, where the drug excreted in faeces of treated animals contaminates the feed of untreated animals (Paturkar *et al*, 2005). Violative drug residues can also occur as a result of improper use of a licensed product or through the illegal use of unlicensed products. Extra label dosages and use of drugs, which have not been approved for the species in question, may lead to violative residues (Kaneene and Miller, 1997). Protection of public health against possible harmful effects of veterinary drug residues is a relatively recent preoccupation. The initial intention for adequate consumer protection led to the desire to achieve complete elimination of all traces of drug residues in food commodities. Therefore, veterinary drugs were initially approved based on a “no residue” tolerance policy, but actually the “zero” tolerance represented the sensitivity of the analytical method used to monitor for drug residues. As analytical methods improved, the “no residue” tolerance was continually being lowered (Boisseau, 1993; Teske, 1993).

Residues of all veterinary drugs are higher in liver and kidney tissues as compared to muscle tissue. Analyses have shown that residue levels of some antibiotics can vary in different poultry muscle tissues (Reyes-Herrera *et al*, 2005). Following antimicrobial drugs were considered as the most likely to be detected in meat: Penicillin (including Ampicillin), Tetracycline (including

oxytetracycline and chlortetracycline), Sulfonamides, Neomycin, Gentamicin and Streptomycin.

Codex Alimentarius Commission (CAC), an international recognized body which is joint FAO/WHO body for standardization and has established Maximum Residue Limit (MRL) in animal food products for veterinary drugs for the safety of the people globally (Peters et al., 2009). The antibiotic residue level above the Maximum Residue Limit will cause serious public health hazards (Walters, 2021). In Nepal, Veterinary Standards and Drug Regulatory Laboratory (VSDRL) has set the MRL for antimicrobial drugs.

## **MATERIALS AND METHODS**

Desk review has been done from different sources to identify factors affecting antimicrobial residues and its public health concern.

### **COMMON ANTIMICROBIAL DRUGS USED FOR ANIMALS**

In the clinical practice of human and veterinary medicine throughout the world large amount of antibiotics are used. Equally, many scientists intensively work on discovery and synthesis of new drugs with broader antimicrobial spectrum, stronger action and more satisfactory safety profile. Most failures during antimicrobial therapy may occur when the pathogenic microorganism is unknown and combination of two or more drugs administered empirically. To avoid these mistakes, clinically confirmed, effective antimicrobial combinations should be used (Vitomir et al., 2011).

Poultry industry is reported to be the fastest growing meat industry showing more than 12 fold increase between 1961 and 2014 (Ritchie and Roser, 2020). The global antimicrobial use in food animals is increasing tremendously, estimated at 63,151 tons in 2010, and projected to rise by 67% in 2030. Brazil, Russia, India, and South Africa have the highest estimated global antimicrobial consumption (Van Boeckel et al., 2015). In Nepal, the total quantity of drug from import and manufactured in-country were converted into active pharmaceutical ingredients (API) and classified by classes of antimicrobials. During 2018 and 2019, the classes of antimicrobials used in Nepal include Cephalosporins, Aminoglycosides, Amphenicols, Fluoroquinolones, Macrolides, Penicillins, Sulfonamides and Trimethoprim, Tetracycline, Nitrofurans and Tiamulin are consumed in the livestock sector in Nepal. The total quantities of API consumed in animals in Nepal were 91088 kg and 47694 kg in 2018 and 2019 respectively (VSDRL, 2020).

The poultry industry uses antibiotics to improve meat production through increased feed conversion, growth rate promotion and disease prevention. Antibiotics can be used successfully at sub-therapeutic doses in poultry production to promote growth (Barcelo, 2007; Chattopadhyay, 2014) and protect the health of birds by modifying the immune status of broiler chickens (Lee et al., 2012). This is mainly due to the control of gastrointestinal infections and microbiota modification in the intestine (Singh et al., 2013).

The use of antibiotics in developing countries like Nepal is very common. The antibiotics which are used commonly for the prevention of respiratory diseases and necrotic enteritis are tetracycline, gentamicin, neomycin, tylosin, erythromycin, virginiamycin, ceftiofur and bacitracin. Similarly, quinolones compounds are used for gastrointestinal and dermal problems. Sulphonamides can be used for treatment and prevention of various diseases like fowl typhoid, coccidiosis, pullorum and many others. In poultry industry, antibiotics are mainly being used for improving the growth performance as it helps in better metabolic conversion of nutrients into tissue by changing the gut motility, providing the favorable environment (Thapa, 2021).

### **OCCURRENCE OF ANTIMICROBIAL DRUG RESIDUES**

Several workers have reported occurrence of antibiotic residues in poultry meat collected from different places. Some workers have even reported residue levels to be above the maximum residue limits (Pandey et al, 2009; Prajapati et al., 2017; Maharjan et al., 2020). Pandey et al., 2009 showed that in a study in Kathmandu and Chitwan district, out of 480 chicken meat samples tested for antibiotic residues by European four plate test method, 18.91% found positive. The antimicrobial residues in liver, kidney and breast meat were 17.12%, 26% and 13.62% respectively. The residues of tetracyclines,  $\beta$ -lactams, sulfonamides, aminoglycosides, macrolides and fluoroquinolones were found 33.95%, 26.45%, 20.41%, 7.91% and 5.83% respectively.

In a study in Dharan it is stated that through microbial inhibition technique, 57% of chicken meat samples were found to contain residues among which the highest percentages was found in kidneys (72%) followed by liver (68%), gizzard (68%) and finally breast muscle (20%). Highest number of samples were positive towards  $\beta$ -lactams and/or tetracyclines (49%) followed by aminoglycosides (29%), sulfonamides (27%) and quinolones (17%) (Thapa, 2021). In another study (Prajapati et al., 2017), 92 chicken breast samples were collected from Kathmandu, Kaski, and Chitwan and screened, using the Enzyme

Linked Immunosorbent Assay (ELISA) technique. Out of 92 samples, 57 (62%) samples were found positive for antibiotics residues, of which 38% samples were positive for streptomycin residue, 15.2% for ciprofloxacin and 8.7% for enrofloxacin). In a study by Sapkota et al., 2019 clearly showed that there was the presence of antibiotic residue in the sampled poultry tissue in Kathmandu valley. It was found that 13% of 60 samples were found to be positive of which, 5 were muscles samples and 3 were liver samples (Sapkota et al., 2019).

A cross-sectional study was conducted to estimate antibiotic residues in meat samples of chicken from three districts of Nepal. 42 chicken samples each from Kailali (Farwestern Province), Kaski (Gandaki Province), and Nuwakot (Bagmati Province) districts were tested for tetracycline, sulphonamides, penicillin, gentamicin and streptomycin residues by the application of the ELISA method. At Kaski district, approximately 57%, 50% and 83% of the samples were tested positive for gentamicin, tetracycline, and fluoroquinolones residues, respectively and in Kailali, 48% of meat samples were tested positive for sulphonamides and in Nuwakot, 50% of meat samples were tested positive for penicillin. The antibiotic residues in chicken meat were within the national maximum residue limit (MRL) (Gompo et al., 2020).

The above results showed that there are variations in the level of antimicrobial residues in meat samples in different geographical locations. These differences might be as a result of non-compliance with withdrawal periods by farmers, illegal or off label use of drugs, incorrect dosage and lack of good veterinary practices (Ivona and Mate, 2002; Paturkar et al., 2005).

### **ADVERSE EFFECTS OF DRUG RESIDUES AND PUBLIC HEALTH SIGNIFICANCE**

Rational use of veterinary drugs is one of the essential factors for the protection of animal health but their residues may persist in foods of animal origin. Antibiotic residues in foods of animal origin may be the cause of numerous health concerns in humans. Antimicrobial residues in animal tissues above the legal tolerance clearly have an impact on human health. Tolerances represent the maximal level or concentration of antimicrobial residues permitted in animal tissues at the time of slaughter. The tolerances are intended to ensure that residual drugs will have no harmful effects if ingested (Paige et al., 1997). Antibiotics which are used as animal feed for growth promotion and their haphazard use results in antibiotics resistance which cause difficulty in disease treatment of both animals and humans (Wegener et al., 1999). Animal food products containing antimicrobial residue may also pose serious allergic reaction

to those patients who are very sensitive to respective antibiotics like penicillin (Padol et al., 2015). Several pathologic effects are seen like gastrointestinal disturbances, carcinogenicity (e.g., sulphamethazine, oxytetracycline, and furazolidone), mutagenicity, nephropathy (e.g., gentamicin), hepatotoxicity, reproductive disorders, bone marrow toxicity (e.g., chloramphenicol), myelotoxicity (Nisha, 2008).

The global consumption of antibiotics in human and animal production is estimated between  $1 \times 10^5$  and  $2 \times 10^5$  t (Manzetti and Ghisi, 2014). Releasing thereby large quantities of antibiotics into the environment entertains the cycle of biotransformation and bioaccumulation of antibiotics in the environment. According to Manzetti and Ghisi (2014), the most vulnerable ecosystems to antibiotic contamination are confined aquatic ecosystems such as ponds and lakes and soils close to urban sites. Aquatic compartments, such as water and sediments, can thus play an important role in the transfer, evolution and ecology of antibiotic resistance genes (Marti et al., 2014). Furthermore, antibiogram test revealed multi-pharmacological resistance in Enterobacteriaceae isolates from eggs and broiler meat (Singh et al., 2010; Yulistiani et al., 2017).

A wide range of antibiotics has been found in the following products: milk, eggs, poultry, beef, pork, seafood, fish, and mutton. Particular attention should be paid to antibiotics that are toxic to humans even in low concentrations, such as chloramphenicol and tetracycline. Various studies have shown that antibiotic residues from food can negatively impact human health in the form of allergic reactions, mutations in cells, the development of imbalances in the intestinal microbiome, and, ultimately, multi-resistant germs (Treiber and Beranek-Knauer, 2021).

Penicillin derivatives (b-lactam antibiotics) are widely used and eliminated through urine. JECFA (2010) found that penicillin residues in kidney and liver were about 100 times higher than those in muscle. Allergic reactions were marked due to penicillin residues. Discolored teeth, allergic reactions or peripheral blood changes are the adverse effect from tetracyclines. Oxytetracycline induces antibiotic resistance in coliforms in human intestine. The primary mechanism of toxicity of sulphonamides is associated with the thyroid-hypothalamus-pituitary axis and therefore toxicity should be measured by parameters of thyroid and pituitary function. Hypersensitivity reactions to therapeutic levels of sulphonamides have been reported but there have been no cases that involved exposure to residues in foods (Paige *et al*, 1999). Aminoglycoside residue poses renal and ototoxicity. Gentamicin is depleted

rapidly from muscle and fat, but tends to persist in kidney and liver. There have been allergic reactions to streptomycin but no cases of exposure to residues in foods have been reported. Chloramphenicol residues causes aplastic anaemia (Dayan, 1993).

Products that exceed the maximum allowed residue limits pose a serious problem. Heat treatments that occur in cooking processes can reduce the risk of ingestion of sulfonamides, tetracyclines (Kühne et al., 2001; Gratacós-Cubarsí et al., 2007), and fluoroquinolones but do not guarantee their breakdown or the complete breakdown of these antibiotics' residues in animal products, such as broiler meat. The high stability of quinolones and  $\beta$ -lactams represents a significant risk to human health because the residues of these antibiotics can remain even after heat treatment (Roca et al., 2010) and, therefore, can reach the consumers. Apart from that, concentrations of antibiotic residues vary between different edible muscle tissues (Reyes-Herrera et al., 2005; Reyes-Herrera, and Donoghue, 2008).

## **DEVELOPMENT OF ANTIMICROBIAL RESISTANCE**

The antibiotic residues, and antibiotic-resistant bacteria and resistance genes are considered as environmental pollutants and responsible for a tenacious public health crisis throughout the globe (Xi et al, 2009). Antimicrobial resistance (AMR) is a natural phenomenon that occurs when microorganisms are exposed to antibiotic drugs. Under the selective pressure of antibiotics, susceptible bacteria are killed or inhibited, while bacteria that are naturally (or intrinsically) resistant or that have acquired antibiotic-resistant traits have a greater chance to survive and multiply. Not only the overuse of antibiotics but also the inappropriate use (inappropriate choices, inadequate dosing, poor adherence to treatment guidelines) contribute to the increase of antibiotic resistance (Prestinaci et al, 2015). Infection with drug resistant microbes increases the morbidity, mortality, length of hospitalization and treatment cost of patients (Prestinaci et al., 2015; Gandra et al., 2014). Such scenario will continue to affect low- and middle- income countries like Nepal as they suffer from overuse and misuse of antibiotics (Pokharel et al, 2019; Pokharel & Adhikari, 2020). A multitude of factors contribute to the development of antimicrobial resistance. Increasing demands for food from animals and environment for a growing population has further added pressure in the eco-system. Also, increasing food and environmental links has facilitated the rapid transfer of drug-resistant pathogens (Manyi-Loh et al., 2018). In response to these challenges, a holistic 'One Health' approach has been advocated in recent years that aims to include

the health of human, animal and the environment. One health approach can be utilized to enhance risk analysis on emergence, spread and control strategies of AMR at the human-animal-local environment interfaces (McEwen and Collignon, 2018).

### **METHODS USED TO ASSESS THE RESIDUES**

Residue analysis methods can be classified as qualitative, semi-quantitative and quantitative. Typically, residue analysis involves both screening and confirmatory tests. A screening method is the first-hand analysis of the sample to establish the presence or absence of residues which include microbial inhibition assay, microbial receptor assay, enzymatic colorimetric assay and receptor binding assay (Aerts et al., 1995). It should be a low-cost and high-sample throughput method, optimized to prevent false-negative results and have an acceptable number of false-positive results (Heitzman, 1994). Liquid chromatographic methods such as mass spectrometry (LC–MS) and tandem mass spectrometry (LC–MS/MS), immunogram and gas chromatography are confirmatory methods. Validation of the detection method depends on specificity, accuracy, precision, limit of detection, limit of quantification, practicability, and applicability (Rao, 2018).

Table 1. MRLs of common AMDs (VSDA, 2012)

AMDs category	Maximum Residue Limits (MRLs) @ $\mu\text{g}/\text{Kg}/\text{L}$			
	Muscle	Liver	Kidney	Eggs
Benzyle Penicillin/Procaine Penicillin	50	50	50	
Ceftiofur	1000	2000	6000	
Colistin	150	150	200	
Chloramphenicol	100	100	100	50
Erythromycin	100	100	100	50
Gentamycin	100	2000	5000	
Levamisole	10	100	10	
Spectinomycin	500	2000	5000	2000
Spiramycin	200	600	800	
Sulfadimidine	100	100	100	
Tetracycline (Oxy, Chlor)	200	600	1200	400
Tylosin	100	100	100	300

### **NATIONAL STANDARD FOR MAXIMUM RESIDUE LIMITS (MRLS)**

In order to safeguard human health, the World Health Organization (WHO) and the Food Agriculture Organization (FAO) have set standards for acceptable daily intake and maximum residue limits in foods. Regulatory limits for antibiotic residues have been imposed on the dairy and meat industry in many

countries (CAC, 2019). Veterinary Standards and Drug Regulatory Laboratory (VSDRL) previously VSDAO (Veterinary Standard and Drug Administration Office) has set the MRLs for veterinary drugs based on the available research, guidelines available in the country and neighboring countries. This is “National Microbial standard For Meat, Milk, Egg and MRL of Veterinary Drugs 2012”. VSDRL in association with Department of Livestock Services (DLS) is the responsible institution to check, verify and recommend the action to be taken in case of any deviation from the standard. MRLs of common antimicrobial drugs are shown in Table 1 (VSDAO, 2012).

## **CONCLUSION AND WAY FORWARD**

From the current review, it can be concluded that there are AMD residues in marketed meat in different location of the country. Some of the antimicrobial residues were found above the maximum residue limits that presented serious threat to consumer health. There is no doubt that neither humans nor animals can live without antibiotics as they are some of the most effective antimicrobial treatments. However, at the same time, the misuse of antibiotics may result in the aforementioned health hazards. Thus, the reduction of antibiotic use constitutes a challenge for the world. In order to achieve such a reduction, the following steps should possibly be considered:

**Ethical veterinary practice:** Prudent use of antibiotics is critical in ensuring safety of meat and poultry products. Good veterinary practice and good animal husbandry practices are to be adopted at farm level through veterinary supervision and monitoring. AMDs should be kept under prescription drugs and over-the-counter sale of AMDs should be legally discouraged. To prevent the risk of AMD residues, it is necessary to use drugs rationally, i.e., to use them only when they are really indicated, in the right way, at the right time, in the right dose and respecting withdrawal period. Also, it is necessary to respect sensitivity to antimicrobial while using antibiotics in veterinary practice.

**Residue Monitoring Program:** Nepal has own standard for MRL of Veterinary Drugs approved in 2012 but there is a need of its implementation through rigorous residue monitoring program at federal, provincial and local level. For developing country like Nepal, legal action should be strictly taken if substandard products with AMD residues are produced repeatedly even though after regular monitoring and recommendations.

**Possible alternatives for coming world:** Due to development of resistant strains of bacteria against many antibiotics, the world is worried about the

danger to human and animal health. For which, various thoughts are arisen for strategies to reduce the use of antibiotics and to introduce the alternatives in poultry industry. The natural agents with similar beneficial effects of growth promoters such as probiotics, prebiotics, enzymes, organic acids, immunostimulants, bacteriocins, bacteriophages, phyto-genic feed additives and essential oils are to be used to reduce the mortality rate, maintain a good poultry health and yield preserving environment and consumer health (Mehdi et al., 2018).

**Residue Control Program:** For prevention of unwanted drug residues entering the human food chain, both the government authorities and the industries should establish extensive control programmes. Also, the regulatory policies are required to be put in place by the authorities to address the problems of farmers at field level. Training of producers and other stakeholders is also essential to improve quality of meat and it will only improve when the people realize the fact that healthy animals are more profitable, which encourages them to pay attention to proper and rationalized usage of veterinary drugs in treatment of diseases.

**Awareness Program:** School educational program regarding antimicrobial residues in animal products and the associated development of multi-resistant germs should be conducted. Moreover, the issues should be presented in media for the public awareness. Knowledge on alternatives to antibiotics, such as various vaccinations, the use of pre-and probiotics, organic oils and phage therapy should be communicated to the citizens to ultimately reduce the use of antibiotics in poultry farming.

## REFERENCES

- Acharya, K. P., & Wilson, R. T. (2019) Antimicrobial Resistance in Nepal. *Frontiers in Medicine*, 6:105. <https://doi.org/10.3389/fmed.2019.00105>
- Aerts, M.M., Hogenboom, M., and Brinkman, U.A. (1995) Analytical strategies for the screening of veterinary drugs and their residues in edible products. *Journal of Chromatography* 667:1-20.
- Barcelo, D. (2007) Pharmaceutical residue analysis, *Trends Anal Chem* 26: 454-5.
- Boisseau, J. (1993) Basis for the evaluation of the microbiological risks due to veterinary drug residues in food. *Veterinary Microbiology* 35 (1993): 187-192.
- CAC. (2019) General Standard for contaminants and toxins in food and feed CXS 193-1995 (Amendment in 2019), Codex Alimentarius Commission. Available from <https://www.fao.org/fao-who-codexalimentarius> (accessed December 25, 2021).
- CBS. (2020) Statistical Information on Nepalese Agriculture, CBS, Kathmandu.
- Chattopadhyay, M.K. (2014) Use of antibiotics as feed additives: a burning question, *Front Microbiol* 5:334.
- Cow Milk. Retrieved from <http://www.sedindia.org>

- Dayan, A.D. (1993) Allergy to antimicrobial residues in food: assessment of the risk to man, *Vet Microbiol*, 35(3-4):213-26. doi: 10.1016/0378-1135(93)90146-x.
- FAO. (2014) Poultry Sector Nepal. Livestock Country Reviews. No. 8:4-16.
- Faraj, B., and Ali, F. (1981) Development and application of a radioimmunoassay for tetracycline. *Journal of Pharmacology and Experimental Therapeutics* 217: 10-14.
- Gandra, S., Barter, D. M. and Laxminarayan, R. (2014) Economic burden of antibiotic resistance: how much do we really know? *Clin. Microbiol. Infect.* **20**, 973–980.
- Gandra, S., Barter, D.M., and Laxminarayan, R. (2014) Economic burden of antibiotic resistance: how much do we really know? *Clin. Microbiol. Infect.* 20:973–980. doi: 10.1111/1469-0691.12798.
- Gildow, E.M., Fourt, D.L., and Shaw, A.O. (1938) Sulfanilamide in the treatment of streptococcal mastitis, *J. Dairy Sci.*, 21:759-766.
- Gompo, T.R., Sapkota, R.C., Subedi, M., Koirala, P., and Bhatta, D.D. (2020) Monitoring of Antibiotic Residues in Chicken Meat, Cow and Buffalo Milk Samples in Nepal, *Int. J. Appl. Sci. Biotechnol.* Vol 8(3): 355-362 DOI: 10.3126/ijasbt.v8i3.31314.
- Gratacós-Cubarsí, M., Fernandez-García, A., Picouet, P., Valero-Pamplona, A., García-Regueiro, J.A., and Castellari, M. (2007) Formation of Tetracycline Degradation Products in Chicken and Pig Meat under Different Thermal Processing Conditions. *J. Agric. Food Chem*, 55, 4610–4616.
- Heitzman, R. J. (1994) Residues in food producing animals and their products: reference materials and methods. *Veterinary Drug Residues*. 2nd ed. Blackwell Scientific Publications, Oxford, UK.
- Hussein, M.A., and Khalil, S. (2013) Screening of some antibiotics and anabolic steroids residues in broiler breast marketed in El-Sharkia governorate. *Life Sci.J* 10 (2013).
- Ivona, K., and Mate, D. (2002) Evaluation of the sensitivity of individual test organisms to residual concentrations of selected types of drugs. *Slovenian Veterinary Research*, 9: 78-82.
- JECFA. (2010) *Compendium of Food Additive Specifications*, FAO, Italy. Available from <https://www.fao.org/3/i1782e/i1782e.pdf> (accessed 20 Dec, 2021).
- Kamdi, B. P. (n.d.). Occurrence, Public Health Implications Kaneene, J.B., and Miller, R. (1997) Problems associated with drug residues in beef from feeds and therapy, *Rev Sci Tech*, 16(2):694-708. doi: 10.20506/rst.16.2.1055.
- Khachatourians, G. G. (1998): Agricultural use of antibiotics and the evolution and transfer of antibiotic resistant bacteria. *CMAJ*, 159: 1129-1136.
- Kühne, M., Körner, U., and Wenzel, S. (2001) Tetracycline residues in meat and bone meals. Part 2: The effect of heat treatments on bound tetracycline residues. *Food Addit. Contam*, 18, 593–600.
- Lee, K.W., Ho Hong, Y., Lee, S.H., Jang, S.I., Park, M.S., Bautista, D.A., et al. (2012) Effects of anticoccidial and antibiotic growth promoter programs on broiler performance and immune status. *Res Vet Sci*, 93:721-8.
- Maharjan, B., Neupane, R. and Bhatta, D. D. (2020). Antibiotic residue in marketed broiler meat of Kathmandu metropolitan city [Report]. Vol. 3. *Arch. Vet. Sci. Med.*
- Manyi-Loh, C., Mamphweli, S., Meyer, E., and Okoh, A. (2018) Antibiotic Use in Agriculture and Its Consequential Resistance in Environmental Sources: Potential Public Health Implications. *Molecules*;23:1. doi: 10.3390/molecules23040795.
- Manzetti, S., and Ghisi, R. (2014) The environmental release and fate of antibiotics. *Mar Pollut Bull*, 79:7-15.
- Marti, E., Variatza, E., and Balcazar, J.L. (2014) The role of aquatic ecosystems as reservoirs of antibiotic resistance. *Trends Microbiol*, 22:36-41.

- McEwen, S.A., and Collignon, P.J. (2018) Antimicrobial resistance: a one health perspective. *Microbiol. Spectr*;6:1. doi: 10.1128/microbiolspec.ARBA-0009-2017.
- Mehdi, Y., Létourneau-Montminy, M.-P., Gaucher, M.-L., Chorfi, Y., Suresh, G., Rouissi, T., Brar, S.K., Cote, C., Ramirez, A.A. and Godbout, S. (2018) Use of antibiotics in broiler production: Global impacts and alternatives. *Animal Nutrition*, 4(2), 170-178.
- Mund, M., Khan, U., Tahir, U. et al. (2017) Antimicrobial drug residues in poultry products and implications on public health: A review. *International Journal of Food Properties* 20: 1433-1446.
- Pandey, S., Thapaliya, S., Manandhar, P., & Basnet, Nisha, A. (2008). Antibiotic Residues - A Global Health Hazard. *Veterinary World*, 2(2), 375. <https://doi.org/10.5455/vetworld.375-377>
- Nisha, A. (2008). Antibiotic Residues - A Global Health Hazard. *Veterinary World*, 2(2), 375. <https://doi.org/10.5455/vetworld.2008.375-377>
- Padol, A. R., Malapure, C. D., Dimple, V. D., & Kamdi, B. P. (2015) Occurrence, Public Health Implications and Detection of Antibacterial Drug Residues in Cow Milk. Retrieved from <http://www.sedindia.org> [accessed 18 December 2021].
- Page, S., and Gautier, P. (2012) Use of antimicrobial agents in livestock. *Rev. Sci. Tech.*, 31, 145-188.
- Paige, J.C., Tollefson, L. and Miller, M.A. (1999) Health implications of residues of veterinary drugs and chemicals in animal tissues. *Vet. Clin. North Am. Food Anim. Pract.* 15: 31.
- Paige, J.C., Tollefson, L., and Miller, M. (1997) Public health impact on drug residues in animal tissues, *Vet Hum Toxicol*, 39(3):162-9.
- Pandey, S., Thapaliya, S., Manandhar, P., and Basnet, H. (2009). Detection of antimicrobial drug residues in chicken meat by modified EU four plate test. *Nepalese Veterinary Journal*, 29, 47-54.
- Paturkar, A.M., Waskar, V.S., Mokal, K.V. and Zende, R. (2005) Antimicrobial drug residues in meat and their public health significance - A review, The Indian journal of animal sciences 75(9):1103-1111**
- Peters, R. J. B., Bolck, Y. J. C., Rutgers, P., Stolker, A. A. M., & Nielen, M. W. F. (2009) Multi-residue screening of veterinary drugs in egg, fish and meat using high-resolution liquid chromatography accurate mass time-of-flight mass spectrometry. *Journal of Chromatography A*, 1216(46), 8206-8216.
- Pokharel S, and Adhikari B. (2020) Antimicrobial resistance and over the counter use of drugs in Nepal. *J. Glob. Health*, 10. doi: 10.7189/jogh.10.010360.
- Pokharel, S. and Adhikari, B. (2020) Antimicrobial resistance and over the counter use of drugs in Nepal. *J. Glob. Health* 10, 010360. <https://doi.org/10.7189/jogh.10.010360>**
- Pokharel, S., Raut, S. and Adhikari, B. (2019) Tackling antimicrobial resistance in low-income and middle-income countries. *BMJ Glob. Health* 4, <https://doi.org/10.1136/bmjgh-2019-002104>
- Pokharel, S., Raut, S., and Adhikari, B. (2019) Tackling antimicrobial resistance in low-income and middle-income countries. *BMJ Glob. Health*, 4. doi: 10.1136/bmjgh-2019-002104.
- Prajapati, M., Ranjit, E., Shrestha, R., Shrestha, S.P., Adhikari, S.K. and Khanal, D.R. (2017) Status of Antibiotic Residues in Poultry Meat of Nepal, *Nepalese Vet. J.* 35:55-62

- Prestinaci, F., Pezzotti, P. and Pantosti, A. (2015) Antimicrobial resistance: a global multifaceted phenomenon. *Pathog. Glob. Health* 109, 309–318.
- Prestinaci, F., Pezzotti, P., and Pantosti, A. (2015) Antimicrobial resistance: a global multifaceted phenomenon. *Pathog. Glob. Health*; 109(7): 309-318. doi: 10.1179/2047773215Y.0000000030.
- Rao, T.N. (2018) Validation of analytical methods, Calibration and Validation of Analytical Methods - A Sampling of Current Approaches, Mark T. Stauffer, IntechOpen, DOI: 10.5772/intechopen.72087.
- Reyes-Herrera, I., and Donoghue, D.J. (2008) Antibiotic Residues Distribute Uniformly in Broiler Chicken Breast Muscle Tissue. *J. Food Prot*, 71, 223–225.
- Reyes-Herrera, I., Schneider, M.J., Cole, K., Farnell, M.B., Blore, P.J., and Donoghue, D.J. (2005) Concentrations of Antibiotic Residues Vary between Different Edible Muscle Tissues in Poultry. *J. Food Prot.*, 68, 2217–2219.
- Ritchie, H. and Roser, M. (2020). Meat and Dairy Production, Our World In Data, Retrieved from <https://ourworldindata.org/meat-production> [accessed 17 December 2021].
- Roca, M., Castillo, M., Marti, P., Althaus, R.L., and Molina, M.P. (2010) Effect of Heating on the Stability of Quinolones in Milk. *J. Agric. Food Chem*, 58, 5427–5431.
- Sapkota, R., Raut, R., Khanal, S., Gyawali, M., and Sahi, D. (2019) Screening of antibiotic residue in poultry in Kathmandu valley of Nepal: A cross-sectional study. *Arch Pharm Pharma Sci*; 3: 079-081. DOI: 10.29328/journal.apps.1001017
- Simonsen, G. S.; Haaheim, H.; Dahl, K.H.; Kruse, H.; Lovseth, A.; Olsvik, O. and Sundsfjord, A. (1998): Transmission of Van. A-type Vancomycin resistant enterococci and Van A resistant elements between chicken and humans at avoparcin-exposed farms. *Microbiol. Drug Resist winter.*, 4: 313-318.
- Singh, P., Karimi, A., Devendra, K., Waldroup, P.W., Cho, K.K., and Kwon, Y.M. (2013) Influence of penicillin on microbial diversity of the cecal microbiota in broiler chickens. *Poult Sci*, 92:272-6.
- Singh, S., Yadav, A.S., Singh, S.M., and Bharti, P. (2010) Prevalence of salmonella in chicken eggs collected from poultry farms and marketing channels and their antimicrobial resistance. *Food Res Int*, 43:2027-30.
- Teske, R. (1993) Microbiological significance of drug residues in food welcome and introduction. *Vet. Hum. Toxicol.* 35, 1-2.
- Thapa, S. (2021) *Antibiotic residues in broiler meat sold in Dharan*, B. tech Dissertation, Department of Food Technology, Dharan.
- Treiber, F. M., and Beranek-Knauer, H. (2021) Antimicrobial Residues in Food from Animal Origin—A Review of the Literature Focusing on Products Collected in Stores and Markets Worldwide, *Antibiotics* 10(5): 534. <https://doi.org/10.3390/antibiotics10050534>
- Van Boeckel, T.P., Brower, C., Gilbert, M., Grenfell, B.T., Levin, S.A., Robinson, T.P., Teillant, A., and Laxminarayan, R. (2015) Global trends in antimicrobial use in food animals, *Proc Natl Acad Sci U S A*; 112(18):5649-54.
- Vitomin, C., Silva, D., Biljana, A., and Sanja, C. (2011) The significance of rational use of drugs in veterinary medicine for food safety. *Tehnologija mesa*, 52(1):74–79.
- VSDAO (2012) National Microbial Standard and Maximum Residue Limit of Veterinary Drugs in Meat, Milk And Eggs.
- VSDRL. (2020) Status of Antimicrobial Use in Livestock Sector in Nepal, *VSDRL Technical Bulletin* :1-8.
- Walters, B. K. (2021) *Human Food Safety of Veterinary Drugs*. Available from <https://tr-africa.oie.int/wp-content/uploads/2019/12/3-walters.pdf> (accessed December 22, 2021).

- Wegener, H.C., Aarestrup, F.M., Jensen, L.B., Hammerum, A.M., and Bager, F. (1999) Use of antimicrobial growth promoters in food animals and *Enterococcus faecium* resistance to therapeutic antimicrobial drugs in Europe, *Emerg Infect Dis* 5(3): 329-335.
- Xi, C., Zhang, Y., Marrs, C.F., Ye, W., Simon, C., Foxman, B., and Nriagu, J. (2009) Prevalence of Antibiotic Resistance in Drinking Water Treatment and Distribution Systems. *Appl. Environ. Microbiol.* 75:5714–5718. doi: 10.1128/AEM.00382-09.
- Yulistiani, R., Praseptianga, D., Raharjo, D., and Shirakawa, T. (2017) Prevalence of antibiotic resistance enterobacteriaceae strains isolated from chicken meat at traditional markets in Surabaya, Indonesia, *IOP conference series: materials science and Engineering*, vol. 193. IOP Publishing; p. 012007.

## **SUCCESS STORY**

### **Towards Climate Smart Villages (CSV)**

**Ankita Priyadarshani<sup>1</sup>, Bheem Raj Rai<sup>1</sup>, Françoise Binsfeld,<sup>2</sup>  
Jeanne Bormann<sup>3</sup> and Binayak Rajbhandari<sup>3</sup>**

<sup>1</sup> Association for Rural Development (ARD), Kavre; <sup>2</sup>AEIN, Luxembourg; <sup>3</sup>  
Mangrove Foundation, Luxembourg; <sup>4</sup>HICAST, Kathmandu

**Corresponding Author:** mishra.ankita852@gmail.com

#### ***ABSTRACT***

*This article presents glimpses of a project on adaptation and mitigation to climate change in Kavre and Bhaktapur district. It presents the information under the sub headings like introduction, about climate smart village (CSV) project, interventions and accomplishments of the project, outcomes and impacts as well as effectiveness of the project. The CSV Project has become successful in bringing about very distinctive and impressive impacts on targeted areas and beneficiaries through execution of its climate adaptation and mitigation related activities.*

**Key words:** Climate change, adaptation, mitigation, sustainable livelihoods, rain water harvesting,

#### **INTRODUCTION**

Climate change is the long-term shifts in temperatures and weather patterns. These shifts could be both natural i.e. through variations in the solar cycle as well as artificial i.e., through the vehicles and industries. Since the 1800s, human activities have been found the main driver of climate change, primarily due to burning fossil fuels like coal, oil and gas. Climate change has caused severe impact on agriculture and crop production. With the rapid increase of the global population, their requirements for living a quality life i.e., fuel, food, and fiber, is also increasing. Farmer should adopt sustainable agriculture practices which provides resilience to climate change and uplifts the farmers' livelihood. Experts have proposed several technological, institutional, and policy interventions to help farmers adapt to current and future weather variability and to mitigate greenhouse gas (GHG) emissions. Among them, Climate-smart agriculture practices have been taken as eco-friendly practices that help to enhance production sustainably with minimum effect on resources and micro-climate. Some of these practices include farming inside tunnel, reduced tillage, improved

animal sheds, bio-gas, intercropping, integrated pest management, rainwater harvesting, use of information and communication technology, etc.

Among the different sectors, agriculture is one the main developmental areas to face the adverse effect of climate change. As agriculture is extremely vulnerable to changes in weather condition, the impact can be seen easily on the production of crops. Higher temperatures eventually reduce the yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns increase the livelihood of short-run crop failures and long run production declines. Although there will be gains in some crops in some regions of the world, the overall impacts of climate change on agriculture are expected to be negative, threatening global food security. Food, fiber, or fuel demands continue to increase globally due to population growth but limited additional land is available for agricultural expansion. The livelihood of farmers should be upgraded at the farm level by implementing different strategies to manage climate risk (McCarthy et al., 2016).

As the rest of the world, Nepal is also vulnerable to climate change impacts. So, it's our duty to cope with the major as well as minor changes of climate following adaptation and mitigation and involving more women in agriculture as they are more vulnerable to Climate change. In order to contribute for the welfare of environment and earth, also to cope with the changes brought by the global climate changing pattern, Association for Rural Development (ARD), a non-profit non- government organization has stepped ahead with its project ***“Towards Climate Smart Villages (CSV): promotion of affordable and replicable adaptation and mitigation practices to enhance livelihoods of vulnerable communities in the Kavrepalanchowk and Bhaktapur Districts, Nepal”*** under the financial assistance of **AEIN, Luxembourg**. A 3-year project was started in March 2019 with an aim to assist the vulnerable communities' farmers within the Bhaktapur and Kavrepalanchowk districts by providing the necessary tools, techniques, materials and knowledge in order to stay firm against climate change and enhance their livelihood by increasing crop production in spite of all what we have been facing right now due to global climate change.

## **ABOUT CSV PROJECT**

CSV project has been financed by the Luxembourg Ministry of Environment, Climate and Sustainable Development under the International Climate fund (90%) and AEIN Luxembourg (10%) through contributions provided by The

Mangrove Foundation. The three-year project period started on 1 March 2019 and will end on 28 February 2022. The overall objective of the project is to build resilience of local communities to climate change by adopting climate smart activities. CSV intends to achieve its target by identifying, verifying, and scaling up Climate-Smart Practices in the selected wards of two districts of Nepal i.e., Kavrepalanchowk and Bhaktapur districts. The “Climate Smart Village Program” defines a selection of activities aimed at reducing negative climate change effects based on government defined priorities in five major areas as laid down in the “Climate Smart Village procedure – 2073 B.S. (2016 A.D)” of the Government of Nepal. CSV works through innovative science for the development of partnerships among the stakeholders like institutional actors, local authorities, intervention beneficiaries, etc.

### **Thematic axes**

The project was initiated with 5 thematic axes dedicated to improve climate change resilience of vulnerable communities within the project area:

1. Capacity building on climate change through training and workshops
2. Implementation of agriculture-smart technical infrastructures and related development activities
3. Climate change policy support programs and development of LAPAs at local level following the NAPA framework
4. Implementation of water-smart activities
5. Promotion of biodiversity conservation and carbon and energy-smart activities.

## **INTERVENTIONS AND ACCOMPLISHMENTS OF THE PROJECT**

Climate-smart Village Project Activities Completed by ARD:

1. Capacity building through training and workshops on climate change adaptation and mitigation
2. Agriculture-smart physical infrastructures and development activities
  - A. Improved agriculture farming**
    - a) Soil sample testing in arable land plots, use of species/varieties with good site adaptation, fertilization plans
    - b) Use of sustainable agricultural kits (SAKs)
    - c) Agricultural infrastructures
      - i. Small irrigation systems
      - ii. Plastic tunnels
      - iii. Drip irrigation

- d) Organic kitchen gardens and multi-cropping practices
- e) Seasonal and off-seasonal vegetable farming
- f) Integrated pest management (IPM) practice
- g) Commercial fruit farming (lemon, kiwi and grapes)
- h) Cash crop farming (organic vegetables, lemon and walnut)

**B. Improved livestock rearing**

- a) Improved grass seeds and fodder tree plantation
- b) Construction of improved cattle sheds and cattle urine collection
- c) Compost preparation and use

3. Conduction of climate change policy support programs

- a) Preparation of three LAPAs (one LAPA in each of the selected districts)
- b) Facilitation of the mainstreaming of developed LAPAs in local government plans and policies

4. Water-smart activities

- a) Plastic ponds for water collection
- b) Roof-top rain-water harvesting sets
- c) Clean drinking water supply programs
- d) Natural spring water source conservation activities

5. Biodiversity conservation and carbon and energy-smart activities

- a) Forest nursery for seedling production of tree and fodder plants
- b) Tree plantation program
- c) Cultivation of *Taxus baccata* and medicinal and aromatic plants
- d) Installation of bio-gas plants
- e) Waste management campaign & programs

*“The project activities were found to be in strong congruence with the target objectives not only of the donor agency (AEIN Luxembourg) and partner organization (ARD Nepal) but also of other national and international development and climate change related agencies and agenda such as the ICF, the SDGs, and NAPA and LAPA Strategy and CSV Procedure 2016 of Government of Nepal” (Ojha, 2021).*

**1. Congruency between CSV Project Interventions and the International Climate Fund Strategy (ICF)**

Luxembourg’s International Climate Fund Strategy, policy, technology and project initiatives that has created climate change mitigation and/or adaptation

has used the following processes under the Natural Capital, Biodiversity, and Land-Use thematic area: Conservation, restoration and enhancement of natural ecosystems, including forests, grasslands, peatlands as well as coastal wetlands, and their ecological services; utilization of renewable energy sourcing as well as energy efficiency measures for the enhancement of environment and biodiversity investments; carrying out of tasks related organic agriculture, agroforestry, sustainable forestry, long run pasture grazing, aquaculture and natural farming in order to successfully build up fertile top-soils and last but not the least building resilience with nature-based solutions for infrastructure planning, design and implementation.

The CSV Project clearly and strongly shows the potential for replication of its activities (intervention pattern and process) in other areas - communities or settlements and countries having similar socioeconomic and environmental circumstances similar to the ones that prevail in its current working areas in Nepal. Substantial attention has also been given by the CSV project to the gender equity aspect, i.e., greater importance to the involvement of rural women in the climate change adaptation and mitigation processes and distinctly reflects its strong accord with the climate change related interventions and support schemes of the International Climate Fund (ICF).

## **2. Congruency between CSV Project Interventions and the Sustainable Development Goals (SDGs)**

The sustainable development goals (SDGs) are set to reduce risks and vulnerabilities especially of fragile places and marginalized people. The major climate change related interventions include (i) building resilience and adaptive capacity, (ii) reducing emissions, (iii) strengthening data and monitoring of climate change, and (iv) climate-proofing technology for infrastructure development. A robust monitoring system with credible data set is crucial for the successful achievement of the SDGs.

SDG 2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture

SDG 5: Achieve gender equality and empower all women and girls:

SDG 6: Ensure availability and sustainable management of water and sanitation for all

SDG 7: Ensure access to affordable, reliable, sustainable and modern energy for all

SDG 9: Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation

SDG 13: Take urgent action to combat climate change and its impacts

SDG 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation halt biodiversity loss

SDG 17: Strengthen the means of implementation and revitalize the global partne CSV project objectives and intervention areas are found to be closely in line with the above views and visions of the Government of Nepal in the context of the SDGs.

### **3. Relevance and Role of the CSV Project for Women Empowerment**

Women have shaped cultures, societies and economies of mankind in many important ways throughout recorded history. However, in many cases – especially in developing countries – they have limited control over resources including institutional services and facilities. This restricts their ability to generate income and improve their socio-economic standing. Thus, it is now being increasingly realized that excluding women from taking part in the development process is to ignore half of the needs, aspirations and potential of humanity, and that any developmental intervention that excludes women implicitly or explicitly is bound to fail. With this growing realization, there have been constant emphasis laid on development mechanisms that could contribute to the advancement of those women living to a backward, tough and poverty stricken rural life (Ojha and Weber 1993). A large sum of agriculture production is grown each by women. Even in Nepal, agriculture employs 82% of the female workforce (World Bank, 2018). In view of the above-stated kinds of developmental realities and realizations as well, the Climate Smart Village Project's major focus is on women as well apart from eco-friendly activities.

### **4. CSV Project Objectives and Activities in Line With Government of Nepal's NAPA and LAPA Strategy**

The Government of Nepal formulated and released the National Adaptation Programme of Action (NAPA) in 2010 AD and as its derivative the Local Adaptation Plans for Action (LAPAs) Framework in 2011. This framework is expected to provide the effective delivery of adaptation services to the most climate vulnerable areas and population in the country. The LAPA is intended to strengthen the rural communities' understanding of climate change, local assets, and vulnerabilities and offers prospective solutions and adaptation strategies, funding mechanisms and priority action plans. The CSV project activities fit fully into the NAPA and LAPA strategy of the Government of Nepal. Thus, it is in line with the agenda of the Intended Nationally Determined Contributions

(INDC) proposed by Nepal to the United Nations Framework Convention on Climate Change (UNFCCC).

The CSV project has been chiefly implementing agriculture-related climate change adaptation and mitigation activities in its working areas with the overall objective of building resilience of local communities to climate change by adopting a select set of climate-smart activities aimed at reducing negative climate change effects based on priorities in the following five major practice areas delineated by the Government of Nepal in its Climate Smart Village Procedure 2073 BS (2016 AD): (i) water-smart practices; (ii) carbon and energy-smart practices; (iii) agriculture-smart practices; (iv) biodiversity-smart practices; and (v) knowledge-smart interventions.

So far, the CSV project has formulated, based on consultations with local people and representatives, and handed over three LAPAs, 2 for Bethanchowk Rural Municipality Ward 2 & 3 of Kavrepalanchowk District, and 1 for Suryavinayak Municipality Ward 8 of Bhaktapur District. Concerned authorities of the Wards have expressed their appreciation for the production of the LAPAs and have been supportive towards their full-fledged implementation.

## **OUTCOMES AND IMPACTS**

Overall, the CSV Project has been successful in bringing about very distinct and impressive impacts on target areas and beneficiaries through execution of its set of climate adaptation and mitigation related activities. Such activities, structures or facilities as Improved Animal Shed (IAS), biogas, renovation of traditional irrigation systems (channels), roof-top rain water harvesting jars, seeds and saplings of improved varieties of some fruits, fodders, spices and grasses, and mini-tillers have created a variety of benefits to the beneficiaries. For example, the irrigation channel renovation at Chyamrangbesi has made it possible for the villagers to bring back their land to irrigation and increased crop yield.

The beneficiaries as well as stakeholders are much appreciative of the way the project intervention has taken place and made positive impacts on the target beneficiaries in particular and the other related individuals and institutions in general. The demonstration effect of most of the project activities/practices have been very strong and has reached far and spread far-wider positive impacts in terms of people's awareness, knowledge, trust and interest in most of those activities/practices. Plastic tunnel and ponds have also gained attraction among beneficiaries; Ghattekhola irrigation system has become successful, serving at least 52 households in Chyamrangbesi. It has generated additional employment

and income as well. Bhandari et al (12021) has pointed out that “*Out of 200 respondents, 54 households (27%) had started cultivating vegetables under plastic tunnels and 28 households (14%) had constructed improved animal sheds. The improved animal shed offered space for housing at least 3 to 4 buffaloes. Cattle urine collected in plastic drums were used for organic vegetable farming. It has improved livestock health, enhanced the sanitary quality of animal products (i.e. milk) while lowering the environmental impact* ».

Due to ARD, there has been a lot of services and facilities available to farmers – plastic tunnel, container for organic pesticide/fertilizer, container to collect urine, tomato seeds, methods to plant and take care of the plants. Information and training were given about plant protection / pesticide and skill to treat blast disease. Planting of grass and tree species was done in community forest throughout the month of Shraavan (June - July 2021).

## **EFFECTIVENESS**

Given that climate change also has increased prospects for the cultivation of new and important crops in the project areas and the impacts of climate change have largely been adversed in such forms as drying off of water resources, increased infestation of insects and crop diseases, and depletion in forest resources, the adaptation and mitigation related interventions of the project have been most relevant, timely, essential, and much advantageous in many important ways. The Local Adaptation Plan of Action (LAPA) formulation, introduction and implementation support to the Local government system have created substantially high level of awareness, information and interest among the beneficiaries and local representatives and officials towards climate change adaptation and mitigation measures and mechanisms.

Lockdown enforced in the country because of the Covid-19 caused delays in the allocation of seeds, seedlings and other materials among the beneficiaries. Similarly, delayed and costly transportation of materials were done. Political instabilities and troubles cause now and then serious problems and constraints in the smooth functioning of project activities. Most notably, under the current adverse conditions where Covid-19 pandemic prevails and certain sections of the road and trail networks connecting the project sites are fragile and risky hampering easy transportation and physical contacts in the rugged high-altitude terrain. Instead of all these obstacles and hurdles, all the activities were found successfully, efficiently and effectively within the working clusters.

All the stakeholders (beneficiaries, Local Government Representatives as well as Officials, and partners) have recommended the need for further expansion and execution of interventions. Impressed and encouraged from the nature of the project activities (practices) and their remarkably great positive impacts, the beneficiaries and stakeholders are strongly anticipating and demanding the launch of a second phase to the project. Beneficiaries and other stakeholders are highly supportive to project initiatives and willing to offer continued contribution in all possible ways.

## **CONCLUSION**

The CSV Project has become successful in bringing about very distinctive and impressive impacts on targeted areas and beneficiaries through execution of its climate adaptation and mitigation related activities. Per household income has been increased by selling vegetables and cash crops. Organic fresh and green vegetables are available in all seasons in around 400 households.

Greenery has been increased simultaneously controlling soil erosion. Water availability has been assured in all seasons due to the development of plastic ponds and rainwater harvesting from the rooftops. Mass awareness on climate change mitigation has also been raised due to the organization of interaction workshops, orientation and training sessions. And most importantly carbon emission has been reduced by using compost fertilizers and increased organic production.

## **RECOMMENDATION**

Since invention and technology dissemination is a continuous process as well as need and time specific, there is a requirement of some more additional research and refinement in order to develop a chain of Climate Smart Agriculture (CSA) choices so that farmers can easily embrace it. Moreover, extensive involvement and coordination among researchers, development workers, change initiators and policy-makers are required for the continuous learning in order to make CSA scaling up more impactful.

Also, multidisciplinary approaches are required, combining the local context nature of the technologies, and synergies; these could be developed via public-private-local authorities partnerships. It is high time to systematically ingrain CSA and CSV into local development plans, the National Adaptation Plan (NAP), and institutional research, monitoring and evaluation systems for learning and continuous improvement.

## REFERENCES

- AEIN, (2021) “Terms of Reference (ToR) for the external evaluation of the project “Towards Climate Smart Villages: promotion of affordable and replicable adaptation and mitigation practices to enhance livelihoods of vulnerable communities in the Kavrepalanchowk and Bhaktapur Districts, Nepal,” funded by Aide à l’Enfance de l’Inde et du Népal (AEIN Luxembourg) and implemented by Association for Rural Development (ARD), in Kavrepalanchowk and Bhaktapur districts”, Aide à l’Enfance de l’Inde et du Népal (AEIN Luxembourg), 28 July 2021, Luxembourg.
- ARD, (2021) “Local Adaptation Plan of Action for Bethanchowk Rural Municipality - Ward 2, Kavre”, Association for Rural Development (ARD), Bhaktapur.
- ARD, (2021) “Local Adaptation Plan of Action for Bethanchowk Rural Municipality - Ward 3, Kavre”, Association for Rural Development (ARD), Bhaktapur.
- ARD, (2021) “Local Adaptation Plan of Action for Suryavinayak Municipality - Ward 8, Bhaktapur”, Association for Rural Development (ARD), Bhaktapur.
- ARD, (2020) Annual Progress Report 2019: “Towards Climate Smart Villages: promotion of affordable and replicable adaptation and mitigation practices to enhance livelihoods of vulnerable communities in Bhaktapur and Kavrepalanchowk Districts, Nepal,” Association for Rural Development (ARD), Kavrepalanchowk, April 2020.
- Bhandari, A., Rai, B., Rajbhandari, B.P., Binsfeld, F., and Bormann, J. (2021) Adaptation and mitigation of climate change through the use of improved sustainable agriculture practices, Kathmandu, *Nepalese Journal of Agricultural Sciences*, vol 20, 147-153
- FAO (2013) Climate-smart agriculture sourcebook. Rome: Food and Agriculture Organization of the United Nations ([www.fao.org/docrep/018/i3325e/i3325e.pdf](http://www.fao.org/docrep/018/i3325e/i3325e.pdf)). (p. 1).
- McCarthy, N., Lipper, L., Branca, G., (2011) Climate-smart agriculture: smallholder adoption and implications for climate change adaptation and mitigation. Mitigation of Climate Change in Agriculture Working Paper, Pp. 3.
- Ojha, E. R., (2021) “Towards Climate Smart Villages: Promotion of Affordable and Replicable Adaptation and Mitigation Practices to Enhance Livelihoods of Vulnerable communities in Bhaktapur and Kavrepalanchowk Districts of Nepal”. Impact assessment Report. September 2021.
- Poudel, B., et. al., (2017) *Climate Smart Agriculture in Nepal* (<https://www.libird.org/app/publication>)
- Rajbhandari, B.P. and Twayana, R., (2021) “Towards Climate Smart Villages: promotion of affordable and replicable adaptation and mitigation practices to enhance livelihoods of vulnerable communities in the Kavrepalanchowk and Bhaktapur (PROJECT FOLLOW-UP: 1 March 2020 – 28 February 2021)”, April 2021. 31
- Rajbhandari, B.P., (2021) “Towards climate smart villages: promotion of affordable and replicable adaptation and mitigation practices to enhance livelihoods of vulnerable communities in Kavrepalanchowk and Bhaktapur Districts, Nepal (BRIEF REPORT OF PROJECT MONITORING)”, 11 May 2021.
- World Bank, (2018) DataBank. Available online at: <https://databank.worldbank.org/data/home.aspx> (accessed July 01, 2019).

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