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<u>**RESEARCH ARTICLES**</u>

REVIEW ARTICLE

Nepalese Journal of Agricultural Sciences, January, 2023, Volume 24
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EFFECTS OF FINGER-MILLET INTENSIFICATION ON YIELD AND DISEASE-RESISTANCE IN CENTRAL HILLS OF NEPAL

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ABSTRACT

Finger-millet is one of the well-known health benign crops widely cultivated from Terai to Himalayan region of Nepal. The low yield due to poor agronomic practices insists the scientists and farmers to pursuit the new technologies for enhancing productivity. The introduction of the principles of System of Rice Intensification (SRI) in finger-millet cultivation has shown promising results for yield increment in some parts of the world. A study was carried out in the central hill region of Nepal in two consecutive years of 2018 and 2019, utilizing split-plot design with three replications where main plot factor was finger-millet varieties (Kabre Kodo-1, Kabre Kodo-2, Okhle Kodo-1 and Dalle Kodo-1) and subplot factor was methods of cultivation (standard recommended practices (conventional transplanting), System of Fingermillet Intensification (SFMI) and directed-seeded). Conventional transplanting was done by utilizing 30-day old seedlings at 10×10 cm^2 spacing, SFMI was carried out by utilizing 15-day old seedlings at 25×25cm^2 spacing and direct seeding was done by broadcasting the seeds in finally prepared plots, other managements practices remained similar. The result indicated that the SMFI management reduced the seed rates, days to maturity, increased the number of fingers per head, numbers of tiller per hill, head weight and reduced the leaf blast disease compared to direct-seeded and conventional transplanting methods across all the tested varieties. The grain yield and straw yield were higher in SFMI compared to direct-seeded but not different from conventional transplanting across the varieties. The highest grain and straw yield was only reported in Kabre Kodo-2. There was no yield advantage in other varieties when cultivated in SFMI compared to conventional and direct-seeded conditions. The tillering and early maturity synchronization traits of the finger-millet varieties were noticed as critical varietal traits to be considered for SFMI management. Finger-millet productivity can be enhanced by introducing SRI components in finger-millet cultivation; however, the selection of the appropriate variety is crucial.

Key words: SFMI, Fingermillet, intensification, disease, yield, tillering

INTRODUCTION

Finger-millet *(Eleusine coracana* L.) is one of the vital crops in remote area of Nepal. It is cultivated in 26,3497 ha and with average productivity of 1.19 mt ha^{-1} and production of 31,3987 mt in Nepal (ABPSD, 2018) . Finger-millet is a very hardy crop, so it can be cultivated in the marginal land where the cultivation of other crops is not possible. The utilization of finger-millet was also restricted in marginal people fora long time, therefore more popularly, it is known as the poor man's food. However, the increasing awareness of the multiplier benefit of finger-millet in human health, its demand is increasing rapidly in urban areas. Finger-millet is considered to be the superior crop in nutritional content, for example, it has 3-5 times higher proteins, minerals, and vitamins, than rice and wheat, 17.5-time more fiber than rice, 34.4-time higher calcium, 20-time higher iron than rice (Nagaraj, et al., 2011).

Finger-millet is cultivated in all the ecological zones of Nepal, including plans (terai), mid-hill and high hill regions. Out of the total area of finger-millet cultivation, 3.78% lies in the terai region, 76.13 % in mid-hill and 20.09 % lies in the high hill region of Nepal (MOAD, 2014). Low yield, high disease pressure and least mechanized practices which demands high labor requirementsfor weeding and transplanting are the major challenges associated with the finger-millet cultivation in Nepal (Devkota et al, 2013, Khadka et al, 2012).

The new initiative known as System of Finger-millet Intensification (SFMI) initiated by some Indian and African farmers and researchers to increase the productivity, reduce the labor intensity and increase the disease resistance in finger-millet by using the principle of System of Rice Intensification (SRI; PRADHAN, 2012 and Abraham, et al. 2014). SRI is a healthy crop establishment system which includes reducing plant competition by increasing crop spacing, use of younger seedling, enhance the soil aeration by careful management of soil water relationship, promote the root growth through active aeration and beneficial microbe which have been successful in increasing crop productivity per unit investment of seed, water, labor and land(Uphoff, 2015; Thakur and Uphoff, 2017; Thakur et al., 2016). It has been successfully demonstrated that modification in crop cultivation by adopting few principles of SRI, has amazingly increased the factor productivity in range of the crops such asfinger-millet, wheat, sugarcane, tef, mustard, legumes and various vegetables (Abraham et al., 2014; Adhikari et al., 2017).

SFMI is based on several local resource-based techniques such as the transplanting of younger seedling in wider spacing, seed and Seedling treatment with organic liquid manure (Beejamruth), weeding and hoeing with a special instrument known as cono-weeder (Pradhan, 2012; Mukhargee, 2012 and Abraham et al., 2014). This innovative method could reduce the cost of cultivation due to the utilization of mechanical weeder, since the weeding is considered to be the most labor-intensive work in finger-millet cultivation in Nepal (Devkota et al., 2013). Multiplier benefits with this method, such as increasing yield, reducing the disease incidence and enhancing the sturdy plant architecture have been observed (Abraham et al 2014). Furthermore, the manipulation of a specific microbial community through Beejamruth enhances the soil fertility in this system. Some of the Indian workers believed that SFMI was initially developed through the technique traditionally practiced in Haveri district of northern Karnataka state of India about four decades back known as *Guli Vidhana* (Praveen Kumar et al., 2019). The *Guli Vidhana*is also known as hole planting methods.In *Guli Vidhana* 12-day- old seedlings are transplanted in grid, at wide spacing 45 × 45 cm with a handful of compost or manure around the roots (Abraham et al., 2014). The grid-patterns were used to be developed either through iron frame or ox-drawn furrow. The higher productivity achievements maximum 6.25 t ha^{-1} (4.5-5.0 t ha^{-1}) in *Guli Vidhana* compared to maximum 3.75 t ha^{-1} (1.25–2.5 t ha-1) in traditional method, inspired the workers to test SFMI in India.

Testing, demonstration, and verification of SFMI has been initiated from the civil society organizations rather than formal research diaspora. So far, no rigorous study on SFMI has been done with a systematic scientific evaluation with validated experimental designs, appropriate replications, repetitions and control treatments. On the other hand, finger-millet blast caused by a fungal pathogen *Magnaporthe grisea* is one of the important diseases in finger-millet, which can cause complete harvest loss under a favorable environment (Jacob et al. 2019). The pathogen infects the crop at all stages and develops symptoms in leaf, finger and peduncle. Seedling stage is most vulnerable to leaf blast whereas neck and finger blast starts occurring after pre-flowering stage (Kiran babu et al. 2013). The pathogen is unique in nature because it established as biotrophs at initial stageand transformed to the necrotrophs at later stage of lifestyle. The average losses by blast ranged from 28-36% annually and losses can be as high as 80-90% under high humid condition (Gupta et al., 2017; Patil and Kumudini, 2019). The disease progression is favored by high-density planting and weak plant phenotypes.

The current study compared the performance of several finger-millet varieties recommended by Nepal Agricultural Research Council in SFMI management with standard finger-millet cultivation practices from agronomic and blast disease incidence perspectives. Due to the lack of appropriate kinds of literature in SFMI, the research in this innovative technique is not taking root. The results from the current study might stimulate other researchers around the world to increase their interest in SFMI and innovator growers to test and benefits from this technique.

MATERIALS AND METHODS

Field and climate: The experiment was conducted at Hill Crops Research Program, Dolakha in two consecutive seasons of 2018 and 2019. This research field is located at 27º38'7.09" north latitude, 86º 8'23.73" east longitude and an altitude of 1650 meter above sea level in a south-facing sloppy topography. Agro-climatically, this location represents central hill region of the country and characterized by warm temperate climate with moderate rainfall. Annual minimum and maximum temperature was 14 and 23 ºC during 2018 and annual rainfall of 2342 mm, whereas annual minimum and maximum temperature were 14 and 24 degree Celsius in 2019 with annual rainfall of 2119 mm. In 2018, the maximum temperature was recorded in June but it was April in 2019. Likewise, maximum rainfall was recorded in July in 2018 but it was august in 2019 (Fig 1 and 2).

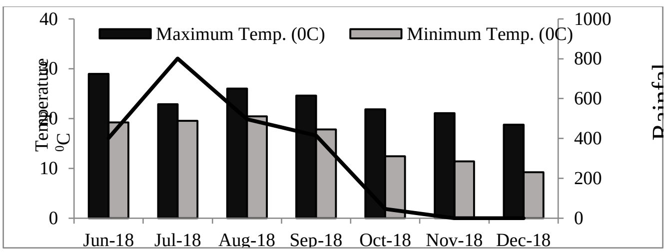

Fig 1

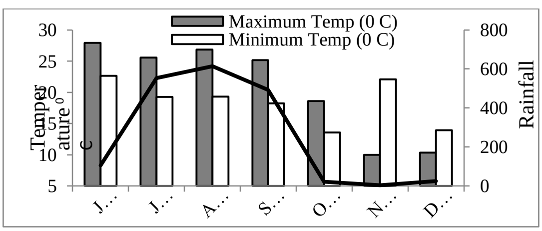

Fig 2

Figure 1 and 2: Temperature and rainfall during fingermillet growing season in 2018 and in 2019 at HCRP, Dolakha

The soil type in the experimental plot was sandy loam and was experimented on monoculture condition. Nitrogen content in the experimental plot was 0.1-0.2% categorized as low whereas extractable P_2O_5 and K_2O was >110 kg/ha and >500 kg/ha, respectively (NARC-Soil Science Division, Khumaltar Nepal).

Experimental Setup: Four finger-millet varieties Kabrekodo-1, Kabrekodo-2, Okhle-1 and Dalle-1 were used for this study in three different establishment methods. Cropestablishment methods were 1) direct sowing at the spacing of 25 cm row to row and continuous during sowing but maintained 10 cm distance plant to plant during thinning, 2) System of Finger-millet Intensification (SFMI) in which 15 days old seedlings were transplanted at the spacing of 25 cm row to row and plant to plant and 3) conventional method where 30 days old seedlings were transplanted in the spacing of 10 cm row to row and plant to plant. Experiments were conducted in split-plot design where the first factor was variety and the second factor was method of cultivation with three replications.The individual plot size was 6 m^2. Each plot and block were separated at 50 cm apart.

Crop was cultivated between June to November in both years. The same plots were used in both years' experiments and followed a similar cropping pattern.The previous crop (winter crop) was barley, which was fertilized at the rate of 45:30:30 Nitrogen, P_2O_5 and K_2O kg/ha. Whereas for finger-millet trial, 50:30:20 Nitrogen, P_2O_5 and K_2O kg/ha were used. Half nitrogen and a full dose of phosphorus and potash were applied during final soil preparation and half of the nitrogen was applied at tillering stage.Nitrogen, phosphorus and potash were supplied by urea, di-amonium phosphate (DAP) and muriate of potash (MOP). Farmyard manure was applied at the rate of 8 tha^{-1} in each plot and incorporated into the soil 20 days prior to sowing.Seeds were treated with Bavistin (Carbendazim 50% WP) at the rate of $2gkg^{-1}$ seed to protect from fungal diseases. Experimental plots and seedbeds were raised 15 cm above the ground surface to ensure the drainage. Hand sowing was done at 2-3 cm deep in moist soil surface. Seed sowing was done directly in the plots in directly sowing treatments. Finger-millet seedlings were raised in the nursery for SFMI and conventional methods. Thinning was done in the direct sowing method after 30 days of emergence and 40 seedlings per square meter were maintained in each plot. But in SFMI and in conventional methods, 16 seedlings of 15 days old and 100 seedlings of 30 days old were transplanted in m^{-2}, respectively. One to two sprinkler irrigations were applied in SFMI plot before seedling establishment. Hand weeding was done two times - one during thinning and another during tillering stage for directly sown plots - and two times weeding was required for

SFMI plots, one after 20 days of seedling establishment and another during tillering stage. But conventional methods plots required only one weeding during tillering stage. Last weeding was done for all treatments during the heading stage.

Data recording: Agronomic traits: Agronomic traits such as plant height, days to heading, days to maturity, number of tiller hill^{-1}, numbers of tiller m^{-2}, number of head hill^{-1} number of finger head^{-1}, grain yield, straw yield were recorded. Plant height, days to heading, days to maturity, number of tiller hill^{-1}, numbers of tiller m^{-2}, number of head hill^{-1} number of finger head^{-1}were measured during harvesting of crops. Crop was harvested when heads turned into tan-brown to black depending upon varieties. The harvested crop was taken only from those tillers which matured seven days later of the main head or tiller. Small head bearing branches were also excluded in harvesting as they matured more than two weeks later than the main tiller. Two border lines from each plot were excluded while recording data. Plant height was measure from base to apex of the finger-millet head. Tiller and heads were counted on one square meter area using quadrate. Grain and straw yields were converted to per hectare by simple unitary methods. Grain moisture measured using moisture meter (Wile 78 moisture meter, FARMCOMP OY Jusslansuora 8 Finland). The straw yield was taken in the field after sun drying for 1 month whereas moisture adjustment for gain yield was done with the formula

$$\text{Final Weight} = \text{Initial weight} \times \frac{100 - \text{Grain Moisture Content (Initial)}}{100 - \text{Grain Moisture Content (Final)}}$$

Disease parameters: Leaf blast, neck blast and finger blast were observed. Leaf blast scoring was recorded on overall plot by using the 0-9 scoring scale adopted from Kiran Babu et al., (2013) where 0 indicates no disease and 9 indicates blast lesion in more than 75 % leaf area (Table 1).

Table 1. Leaf blast scoring method (Kiran Babu et al., 2013)

Scale	Description
0	no spots
1	small brown specks
2	large brown spot (1-2 mm diameter) on lower leaves
3	large brown spot (1-2 mm diameter) on upper leaves
4	typical susceptible blast lesion (3 mm or longer) covering upto 2% leaf area
5	typical blast lesion covering 3-10% of leaf area
6	typical blast lesion covering 11-25% of leaf area
7	typical blast lesion covering 26-50% of leaf area
8	typical blast lesion covering 51-75% of leaf area
9	leaf spots covering >75% of leaf area

Leaf blast scorings were done three times at 7 days interval starting from 45 days after sowing in transplanted as well as in direct-seeded plots in both seasons. Whereas, twenty plants per plot were randomly selected and tagged at the flowering stage to record the neck and finger blast incidence. Neck and finger blast were recorded at dough stage.

Neck blast (NB),

Percent disease incidence (PDI-NB) = $\frac{\text{Numbers of Infected neck} * 100}{\text{Total numbers of ear head observed}}$

Finger blast (FB),

Percent disease incidence (PDI-FB) = $\frac{\text{Numbers ofInfectedfingersperplant} * 100}{\text{Numbersoffingerperplant}}$

All the data were entered into the excel sheet. Leaf blast score was converted into severity for each days score by using the formula;

$$\text{Leaf blast severity} = \frac{\text{sum of all disease rating}}{\text{total number of rating } \times \text{ maximum disease grade}} \times 100$$

Estimation of AUDPC and relative area under disease progress curve (AUDPC) was performed as follows (Milus and Line 1986): AUDPC= [N_1 (X_1+X_2)/2 + (N_2 (X_2 + X_3)/2] where X1, X2 and X3 are the severities recorded on the first, second and third recording dates. N1 is interval day between X1, X2 and N2 is interval day between X2, X3. Statistical analysis of data was calculated using MS-Excel.

RESULTS AND DISCUSSION

Analysis of variance: Effect of sources of variation, year, variety, method of cultivation and their interaction, on vegetative parameters- such as the days to heading, days to maturity, bearable head per m^{-2}, number of fingers per heading, plant height, tiller number per hill-, are presented in Table 2. Similarly, the effect of sources of variation, year, variety, method of cultivation and their interaction, on yield parameters- unit head weight, grain yield, straw yield, --, and disease parameters- leaf blast AUDCP and neck blast incidence are presented for both years in Table 3. The year did not have significant effects on days to heading, head weight, grain yield, straw yield and overall AUDPC of the leaf blast. However, significant effects of the year was observed in days to maturity, bearing head m^{-2}, number of fingers per head, plant height, tiller per hill, and neck blast incidence.

Variety significantly affected all the measured parameters with the exception of straw yield, overall leaf blast AUDPC and neck blast incidence. In addition, method of cultivation significantly affected the days to heading, days to maturity bearing head m^{-2}, number of finger per head, tiller per head, head weight, grain and straw yield, overall leaf blast AUDPC, however, method did not affect significantly on plant height, and neck blast incidence. The significant variety and method interactions were observed in bearing head m^{-2}, head weight, grain yield was observed.

Table 2. Analysis of Varieance table affected by method of cultivation and variety on combined mean squares of finger-millet yield parameters in central hill region of Nepal in 2018 and 2019

Source of Variance	DTH	DTM	BHm^2	NF/head	PH	Tiller/Head
Year (Yr)	4.5	231.13*	378.0*	60.50*	4371.10**	20.06*
Replication (Rep)	2.39	152.18	186.0	1.27	47.80	0.50
Error a (Yr× Rep)	3.5	8.37	17.0	0.69	12.50	1.06
Variety (Var)	81.15*	503.61***	17677.0***	9.05*	297.50	9.09***
Rep:Variety (Rep×Var)	10.31	21.44	237.0	0.41	17.40	0.15
Error b (Rep×Var)	12.61	8.96	189.0	1.95	137.90	0.46
Method (Meth)	2543.93***	2556.85***	99519.0***	8.30***	9.50	101.54***
Method:Rep (Met×Rep)	13.83	13.99	210.0	0.47	20.40	0.79
Method:Variety (Met×Var)	33.97	15.72	668.0***	0.89	80.40	1.75
Method:Rep:Variety (Meth×Rep×Var)	23.11	6.61	129.0	0.93	27.60	0.22
Error c (Rep ×Var× Meth)	14.62	14.42	81.0	0.77	43.30	0.78

df: degree of freedom; Significance: *P ≤ 0.05; **P ≤ 0.01; ns: non-significant i.e. P>0.05, Days to DTH- Note: DTH- Days to heading, DTM; Days to maturity, BH: Bearing head/m^2, PH- Plant height, NF: NF- Number of fingers, H- Head

Effect of variety and method of crop establishment in crop duration: Among the tested finger-millet varieties, days to heading and days to maturity was shorter in Dalle and Okhle compared to Kabrekodo1. However, days to maturity were significantly highest in Kabrekodo 2 and lowest in Dalle, but days to maturity was significantly lower in Kabrekodo1 and Okhle compared to Kabrekodo 2.

Among the tested methods of cultivation, the duration of heading and maturity was significantly lower in finger-millet grown in SMFI compared to finger-millet plants grown in direct-seeded methods. And also, the heading and maturity were observed earlier infinger-millet plants grown in SMFImethod compared to those grown in conventional transplanting.

In terms of interaction effects, earlier heading and maturity was observed in finger-millet varieties grown in SFMI method of cultivation in Okhle (75.8 vs 84.0 or 97.0), Dalle (73.0 vs 85.7 or 95.0), Kabrekodo1 (79.2 vs 93.2 or 95.7) and Kabrekodo2 (75.5 vs 89.7 or 95.7) compared to conventional and direct-seeded finger-millet cultivation respectively.

Table 3. Analysis of Varieance table affected by method of cultivation and variety on on combined mean squares of finger millet yield parameters in field experiments in central hill region of Nepal in 2018 and 2019

Source of Variance	Weight/head	GY (t/ha)	SY (t/ha)	500GW (gram)	LB-AUDPC	Arc_NBI
Year (Yr)	0.21	0.50	51.22	4.32*	263296.00	4.817*
Replication (Rep)	2.26	0.75	3.42	0.13	2292.00	0.082
Error a (Yr× Rep)	0.39	0.29	5.34	0.07	15361.00	0.086
Variety (Var)	6.68***	6.56**	23.69	0.57*	8987.00	0.046
Rep:Variety (Rep×Var)	1.70*	0.64	3.00	0.04	20765.00	0.067
Error b (Rep×Var)	0.37	0.55	13.77	0.10	8189.00	0.093
Method (Meth)	1.13**	4.83***	10.25*	0.01	71315.00**	0.021
Method:Rep (Met×Rep)	0.67*	0.13	1.46	0.01	22907.00	0.023
Method:Variety (Met×Var)	0.43*	1.29***	4.83	0.06	2457.00	0.026
Method:Rep:Variety (Meth×Rep×Var)	1.21***	0.36	1.16	0.02	3518.00	0.022
Error c (Rep ×Var× Meth)		0.22	2.05	0.03	12127.00	

Note: GY- Grain Yield, t/h- Ton per hectare, SY- Straw yield, GW- Grain weight, LB-Leaf blast, AUDPC- Area under disease progress curve, NBI- Neck blast incidence.

Similarly, days to maturity was also significantly reduced by SFMI in case of Okhle (141.3 vs or 151.8 or 163.7), Dalle (140.8 vs 147.3 or 157.3) Kabrekodo1 (148.5 vs 156.3 or 168.3) and Kabrekodo2 (149.3 vs 158.5 or 172.8) compared to conventional and direct-seeded finger millet respectively.

The overall duration of heading and maturity of finger-millet was significantly shortest in SFMI method of transplanting followed by conventional and was longest in direct-seeded finger millet for all the tested varieties.

Effect of variety and method of crop establishment in vegetative parameters: Number of bearing head m^{-2} was significantly highest in Kabrekodo 2 compared to all the other tested variety across the methods of cultivation. Furthermore bearing head m^{-2}were significantly higher in kabrekodo1 compared to Okhle, however which was not different from Dalle across all the tested method of cultivation. Number of fingers per head was significantly higher in Okhle and Dalle compared to Kabrekodo2. Tiller per hill were significantly higher in Kabrekodo 2 compared to all the tested varieties.

The number of bearing head m^{-2} was significantly higher in conventional transplanting compared to the direct-seeded and SFMI across all the tested varieties. There was no difference between direct seeding and SFMI in bearing head m^{-2} across all the tested varieties.The number of fingers per head was significantly higher in SMFI and direct-seeded compared to conventional transplanting. Across all the tested varieties, the number of tillers per hill was significantly higher in finger-millet crops planted in SFMI method compared to the finger-millet crop planted in direct-seeded and conventional transplanting methods.

The numbers of tillers per hill were significantly higher in SFMI cultivated finger millet plants than conventional and direct seeded crops for Okhle (5.3 vs 2.2 or 2.0), Dalle (5.0 vs 2.2 or 2.0), Kabrekodo1(5.7 vs 2.5 or 2.3) and Kabrekodo2 (7.8 vs 2.7 or 3.3). Bearing head m^{-2} was significantly lower in SFMI as number of seedlings maintained per square meter was also lower comparison to other establishment methods. But among varieties in SFMI, Kabrekodo-2 produced significantly higher number of bearing head per square meter. Number of fingers per head for variety Okhle was found significantly higher in SFMI (7.2) than to conventional (5.6) method but was at par to direct-seeded method (6.3). For variety Dalle, it was also significantly higher in SFMI (7.1) than to conventional (5.6) but at par to direct sowing method (6.7). But finger numbers per head was not varied significantly in varieties Kabrekodo1 (6.1 vs 5.2 vs 6.2) and Kabrekodo2 (4.8 vs 4.5 vs 5.5) in SFMI, Conventional and direct sowing methods respectively.

Effect of variety and method of crop establishment in yield parameters: Among the tested varieties the weight of head was significantly highest in Kabrekodo 1 and it was lowest in Kabrekodo 2 across the method of cultivation. The grain yield was significantly highest in Kabrekodo 2 compared to Kabrekodo1 and Okhle across the methods of cultivation. The grain yield in Kabrekodo-2 was not significantly different from Kabrekodo-1 and Dalle in conventional method however significantly higher than Okhle across all the crop establishment methods. Among the tested methods of crop establishment, weight of head was found significantly highest in SFMI and grain yield and straw yield were significantly highest in SFMI and Conventional method of crop establishment than direct-seeded finger millet. There were non-significant differences in grain yield and straw yield between the crop grown in conventional and SFMI method.

In terms of the interaction between the method of crop establishment and varieties, the highest number of tiller per hills, highest grain yield, and straw yieldwas recorded in Kabrekodo 2 cultivated in SFMI method whereas all these parameters were lowest in Kabrekodo 1 cultivated in direct-seeded method. The yield increment in Kabrekodo 2 in SFMI was 35.1 % higher than direct-seeded and 21.9 % higher than conventional transplanting. No yield increment was observed in Okhle, Kabrekodo1 and Dalle in SFMI compared to conventional transplanting; however, variety Kabrekodo 1 and Dalle responded higher grain weight output in SFMI compared to direct-seeded finger-millet cultivation.

Furthermore, the straw yield of Kabrekodo 2 was significantly higher in SFMI compared to that cultivated in the conventional and direct-seeded method of crop establishment. The straw yield increment in SFMI was 23.7 % higher than direct-seeded and 16.0 % higher compared to conventional transplanting in Kabrekodo 2. No significant increase in finger-millet straw yield in SFMI was observed in the case of the other three varieties compared to conventional and direct-seeded finger millet.

Effect of variety and method of crop establishment in disease parameters: The leaf blast AUDPC (LFAUDPC) was significantly reduced by the system of crop establishment. Significantly lower LFAUDPC was recorded in SFMI compared to direct-seeded crop. The conventional method did not reduce the LFAUDPC compared to the direct-seeded finger millet. The neck blast incidence was not significantly affected by the method of crop establishment. Finger-millet variety did not affect the LFAUDPC, neck blast and finger blast incidence. Leaf blast AUDPC was significantly reduced by SFMI compared to conventional and direct-seeded transplanting in Okhle (427.8 vs 538.3 or 538.0), Dalle (486.0 vs 570, 525) Kabrekodo1 (460 vs 479.8 or 583.5) and Kabrekodo 2 (447.5 vs 563.8 or 538.2). However, no significant interaction between varieties and methods was observed in the case of neck blast incidence.

DISCUSSION

The System of Finger-millet Intensification (SFMI) is a fairly new technique in finger-millet cultivation. SFMI has several components adopted from System of Rice Intensification (SRI). The major component of SFMI included early transplanting, wider spacing, transplanting single seedling per hill, seedling treatment with effective microorganisms and use of cono-weeder to enhance the active aeration in rhizosphere regions. The benefits of using those components in rice production, in terms of factor-productivity enhancement and environmentally benign, have already been proved from the several empirical and field experiments across the globe (Anas et al. 2011; Mishra and Salokhe 2011; Thakur et al. 2016). The biological mechanisms behind yield increment in rice due to SRI components have been well explored. However, effects of SFMI is still at infant stage informal research, though some components of SFMI has already been established traditionally in some states of India in the name of *GuliVarathee.* Literatures reported, SFMI resultedin higher yield than conventional transplanting. For example Bhatta (2017) reported significantly higher yield in SFMI compared to conventional standard cultivation practice. Similarly, (Praveen Kumar et al. 2019) reported the yield enhancement was significantly higher in SFMI compared to conventional transplanting. Another research done by Natarajan et al. (2019) also reported the significant effects of crop spacing and the source of nutrients in finger-millet yield and yield components in India. All the available limited literatures from the diversity of the fields, diversity of varieties and cultivation conditions indicate SFMI has great potentiality to enhance the productivity of finger-millet.

In our experiments, we only used two critical components of SFMI-- young stage of seedling and wider spacing—rather than other. Still the advantages of growing finger-millet in SFMI were superior to direct-seeded finger-millet in terms of grain yield, straw yield and weight of the heads across the tested varieties. However, the grain yield was not significantly different from conventional transplanting. Still the number of fingers per head, number of tillers per hills was significantly higher in SFMI compared to conventional transplanting across the tested varieties.

Interesting results from this study, which can direct the future SFMI research in new-turn, was the differential interaction of finger-millet varieties with a method of cultivation. Kabrekodo- 2 has highest grain yield in SFMI among all the varieties and cultivation methods interaction. However, there were no such comparative benefits of growing other varieties in SFMI compared to conventional transplanting. Therefore, these results provide strong evidence that the performance of SFMI is varietal dependent. All the millet heads that emerged from each hill depend on single seedling planted in SFMI rather than several seedlings as in conventional and direct-seeded methods. All the varieties have equal performance to enhance the tillers in SFMI due to wider spacing and early planting compared to direct-seeded and conventional narrow planting. However, the entire yield depends on the number of head bearing per unit area of land and synchronization in finger maturity. We observed the tiller initiation time is greatly influenced by finger-millet variety. For example Kabrekodo-2 had superior performance in SMFI, where majority of tiller emergence noticed in early stage, while the performance of rest of three varieties were not consistent in SFMI, since the substantial numbers of tillers emerged at late stage, which impacted the harvesting. (Krishnamurthy 1973) reported that final grain yield depends on the number of shoots arouse within 37 days of transplanting in finger-millet. He further stated that earliest formed tillers contribute the ear number and grain yield in finger-millet. The late tillering might be counterproductive due to the divergence of photosynthates to vegetative growth, which needs to be assimilated to the grains after the onset of the reproductive stage. The tiller pattern in finger millets differs from other crops such as rice, wheat and barley in several ways. The development of secondary tiller from upper node of the main axis is very common in finger-millet, which is not common in other cereals. Furthermore, Krishnamurthy (1973) reported that tiller retention to bearing head is higher in finger-millet compared to wheat which accounts 80-90% for early emerged tillering and 70% for late tillers compared to 50 % in narrow planting on 70% of total shoots formed in wide spacing wheat. The tiller retention percentage might be further enhanced by ensuring the availability of N where the amount of carbohydrate can control the tiller initiation. Thus, environmental conditions or varietal traits that favor the early initiation and growth of shoot buds might have great roles in grain yield by developing into an ear-bearing shoot. The grain yield contribution is mostly from secondary tillers in SFMI due to low number of initial seedlings per unit area, which is not a case in conventional and direct-seeded cultivations.

We observed, initiation of tillers were earlier in Kabrekodo 2 and there was perfect synchronization in the maturity of bearing heads; however, the continuous tillering as well as branching on tillers were observed in other varieties where size of the head were quite small at final maturity. Synchronization in head maturity was not observed in other varieties as in Kabrekodo 2. We observed number of tillers have heads but not matured perfectly and also impacted the grain filling before the harvesting stage. Multiple harvesting of finger-millet heads in Dale and Kabrkodo1 might be necessary to harvest all the tillers but it is not practical. Therefore, we believe that selection of appropriate variety is very critical in SFMI. The effect of variety is much less critical in SRI, where late tillering is discouraged by flooding the soil after 60-80 days of transplanting. Unfortunately, finger-millet is cultivated in upland condition and there is no any such approved strategy that can reduce the late tillering in finger-millet. It has been reported that late tillering is counterproductive for grain yield because of the divergence of photosynthesis assimilation to vegetative growth which needs to be diverted to grain filling and formation. Wang et al. (2017) reported late tillering greatly reduced the rice grain yield. However, they further reported the increasing nitrogen level help to increase the productivity of late tillering rice varieties. Contrasting results were reported by (Ao et al. 2010). They reported the reduction in tillering also reduced the leaf area and plant biomass at the heading stage and number of panicles at maturity but no reduction in grain yield in rice (Fukushima 2019). That should not be the case in finger-millet since finger-millet tillering behavior is different from rice.

The genetic variation among the *Eleusinecoracana* subsp. Corocana L. lines are limited based on isozyme and DNA markers but great diversity prevailed in morphological traits. *S*ignificant diversity ranged in flowering time (54–120 days), plant height (45–165 days), number of basal tillers (1–70), peduncle length (2–28 cm), inflorescence length (1–32 cm) and other morphological traits(Dida et al. 2008) in finger-millet varieties across the world.

Significantly higher tiller number in SFMI compared to direct-seeded and conventional transplanting might be due to wider spacing, and young seedling, and increased root biomass. The SFMI might help to increase the root morphologies due to wider spacing to use the available resources efficiently. Goron et al. (2015) reported a strong correlation between tiller numbers and crown root numbers, indicating a strong linkage between above ground and below ground morphologies.

No doubt that SFMI induces better plant architectures, which is efficient in utilizing soil nutrients, moistures and solar interceptions to give strong phenotypes for higher yield and resistance to biotic (diseases and insects) and abiotic stresses (drought, storm etc.). Research conducted at Regional Agricultural Research Station Khajura indicated the higher chlorophyll value as in SPAD (Soil Plant Analysis Development (SPAD) chlorophyll meter in SFMI cultivated finger-millet plants compared to direct-seeded and conventionally transplanted finger-millet (Khadka and Marasini, 2016; unpublished). The SPAD value was further increased by inoculation of beneficial microbes *Trichoderma asperellum* in seedling before transplanting in SFMI. Still, more investigations are required to understand the effects of individual SFMI components in plant architecture changes.

SFMI has been reported to reduce disease and pest incidence. Our results provide strong evidence that SFMI reduced the area under the foliar blast progressive curve. The AUDPC was 24 % lower in SFMI than directed seeded and 10 % lower than conventional transplanting. The reason behind this might be the lower plant density in SFMI, which is not favorable for pathogen due to better penetration of light and air, and induction of healthy plant phenotypes in SFMI. However, further researches are warranted to understand the in-depth relationship between finger-millet blasts in SFMI method of cultivation.

CONCLUSION

The demand for finger-millet is increasing globally due to increasing awareness of benevolent health properties associated with finger-millet grains; however, cultivation is limited due to low productivity. Current study indicated that the productivity of finger-millet can be enhanced by introducing SRI components in finger-millet with careful selection of early tillering varieties. The study only focused in early transplanting and wider spacing; however other SFMI components such as use of cono-weeder, inoculation of beneficial microbes, and amendments of organic matter might be further beneficial in enhancing finger-millet yield. Therefore, more investigations are warranted to explore, demonstrate and document the synergistic, antagonistic and additive effects of one and other SFMI components in different finger-millet varieties in multiple environmental conditions.

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AUTHORS’ CONTRIBUTIONS

SBG and RBK conceived, and designed the experiments, SBG executed the experiments, RBK analyzed the data, RBK and SBG organized figures, tables, and drafted the initial manuscript and NBD wrote and reviewed the manuscript, the entire author approved the article before submission.

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EFFECT OF INCLUSION OF DRIED BREWER'S WASTE IN BASAL DIET OF DAIRY ANIMALS ON MILK PRODUCTION AND ITS PARAMETER

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ABSTRACT

An experiment was conducted at National Cattle Research Programme, Rampur, Chitwan from 26th April to 15th May to test the effect of dried brewers waste in basal diet of dairy animals on milk production and its parameters. Altogether 16 crossbreed cattle were selected and divided into 4 replications (one animal in each replication) by using Randomized Complete Block Design (RCBD). Before experimentation the average daily milk productions of T0, T1, T2 and T3 group of cattle were 9.06, 9.15, 9.23 and 9.55 liter, respectively. The dry matter was offered to dairy animals at the rate 3% by their body weight. The control (T0) and treatment group (T1, T2 and T3) were offered daily with 15kg green mixed forage along with concentrate @ 2.5 kg per day. The T1, T2 andT3 groups concentrate feed were replaced by 15%, 20% and 25% dried brewers waste whereas in control group normal concentrates (16% CP) were provided. Feed intake and milk production were recorded daily. The average milk production of first to seventh week between treatment groups of animals were 9.84±1.59, 9.94±1.06, 10.46±1.15, 10.46±1.26, 10.84±1.32, 10.87±1.29 and 11.09±1.74 liter, respectively. There was non- significant effect among diet groups at (P>0.05) in terms of milk production. There was non- significant effect among diet groups at fifteen days for quality content of the milk. There was non- significant effect among diet groups at in terms of fifteen days, thirty days, forty-five days and sixty days for quality content of the milk. So, dried brewers waste could replace normal concentrate by 15%, 20% and 25% of its total mass. Experiment suggested that further study should be carried out to precise the other inclusion level of dried brewers waste and higher cost benefit ratio.

Key words: Dairy cattle, Brewers waste feeding, Concentrate, Cost benefit ratio

INTRODUCTION

Brewers waste is the byproduct of brewery industry which uses malted barley grains feed stock (Westendorf *et.al,* 2002). When grain is fermented to produce ethanol, primarily the starch is utilized, leaving behind a protein rich residue that can be used in livestock diets and locally known as Beer waste. Anton, (2010) stated that the interest in feeding brewers waste has increased because of comparatively less cost. Feeds and fodders are the important factor for meat and milk production. The farmers are paying high cost for the feeds as they are being purchased from neighboring countries because the raw material or the ingredients needed for the feed which we have are not in sufficient amount. To minimize the feed cost there are many industrial by products such as brewery waste which can be used somehow to replace the cost of concentrate feed in the diet of cattle and goat. Most of the cattle rearing farmers are having marginal and small farmers who depend mainly on the raw materials for feeding the animals as the agricultural land availability is not sufficient to meet their requirement. In order to make the dairy farming sustainable, the locally available unconventional agro-industrial by products is increasingly used as animal feed. In Nepal the total population of milking cattle is about 1209041 MoAC (2020/21). In our context the feeding of brewers waste is not commercial but the farmers are using the wet brewers waste because of their availability only in beer industry areas. They are feeding their cattle’s and dairy animals in traditional ways without any effective feeding package. Therefore, brewers waste feeding technologies are necessary. During winter season the brewers waste would be good dietary supplement for the ruminants. For feeding ruminant animals the brewers waste is beneficial to increase milk and during advance pregnancy stage because of high protein content. In dairy farming, feeding of roughages requires so much labour, mostly because of bulkiness of roughages like hay, silage, mechanical handling, transport and pro-vendering is difficult. But the brewers waste is sundried because of high moisture content and then can be stored for a longer period. In winter season feed scarcity is great problem in Nepal so; dried brewers waste feeding in dairy animal is definitely good feeding method. This feeding technology definitely improves the milk production and reduces the feed cost.

MATERIALS AND METHODS

The experiment was carried out at National Cattle Research Programme, Rampur, Chitwan for 50 days from 26th March 2019 to 15th May 2019.with one week adaptation period. There were 16 animals with 4 treatments and were replicated four times having one cattle in each replication by using Randomized Complete Block Design (RCBD). In each treatment the three animals were of same breed i.e., Jersey and one was Holstein frezien. All experimental animals' health was examined and they were dewormed by albendazole@10mg/kg body weight following the adjustment period of one week before the trial initiation. The average milk production of T0, T1, T2 and T3 group of cattle were 9.06, 9.15, 9.23 and 9.55 Liters, respectively.

Diet composition: All the group of animals was fed with concentrate at the rate 2.5 kg for 4 liter milking animals along with 15 kg farm forage per animal with access drinking water. The control group (T0) was offered without dried brewers waste inclusion in their diets whereas T1, T2 and T3 group of cattle were offered concentrate mixture replaced with 15%, 20% and 25% dried brewers waste respectively in their diets.

Chemical analysis: Representative samples were analyzed for dry matter (DM), crude protein (CP), crude fiber (CF), total ash content (TA) and gross energy (GE). The dry matter was determined by oven drying the sample overnight at 100C for 24 hours. Crude protein of the samples was determined by using the Kjeldahl method. Ash content of the samples was determined by aching the sample at 550C in Muffle furnace for 3 hours (AOAC, 1990). Crude Ether of the samples were determined by using the Van Soest method (Goering, H.K and Van Soest 1970).

Experimental diet: The following experimental diet was provided to the experimental animals (Table 1).

Table 1. Experimental diet for cattle

Treatment	Diet
T0	Concentrate mixture @ rate 2.5 kg for milking animals + 15 kg forage per cattle
T1	Concentrate mixture (replaced by 15% dried brewers waste) @ rate 2.5 kg for milking animals + 15 kg forage per cattle
T2	Concentrate mixture (replaced by 20% dried brewers waste) @ rate 2.5 kg for milking animals + 15 kg forage per cattle
T3	Concentrate mixture (replaced by 25% dried brewers waste) @ rate 2.5 kg for milking animals + 15 kg forage per cattle

Feeding regime: Concentrate mixture was given on group basis and was provided to the experimental animals twice a day (morning and evening) at the rate 2.5 kg for 4 liter milking cattle till 50 days of the experiment. Daily 15 kg forage was also offered to each cattle. Drinking water was provided in adequate amount.

Data measurement: The trial period lasted for 50 days. Quantity of concentrate and forage given daily to the cattle was weighted. The daily intake of concentrate and forage was also recorded. The milk production was recorded daily and the milk quality like Fat, SNF, Protein and Lactose were recorded at 15 days interval.

Data analysis: Data of daily milk production and milking parameters were analyzed by "One way Anova" test for every measurement using statistical package SPSS software 2006, with released versions 15.0.

RESULTS AND DISCUSSION

Chemical composition of concentrate mixture

The chemical composition of concentrate mixture and dried brewers waste is given in Table 2. The average feed intake of the experimental animal is presented in Table 3. There was non-significant (p>0.05) effect between treatment groups in feed intake during the experimental periods.

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

Concentrate mixture	FDM	CP	CF	EE
Cattle feed	89.92	13.98	9.08	0.89
Dried brewers waste	22.72	17.58	27.72	2.71

Table 3. Concentrate intake of the experimental cattle/day, kg (Mean± SD)

	Days							
TRT	**1**	**7**	**14**	**21**	**28**	**35**	**42**	**49**
T0	6.62±0.82	6.62±0.86	5.86±0.75	5.86±0.75	5.86±0.02	6.62±0.82	6.87±0.89	6.46±0.92
T1	6.08±0.90	6.08±0.90	6.87±0.89	6.87±0.89	5.86±0.42	6.08±0.82	6.94±0.82	6.43±0.47
T2	5.89±0.96	7.46±0.74	6.59±0.67	6.95±0.67	5.24±0.02	6.59±0.74	6.34±0.82	6.43±0.47
T3	6.86±0.97	6.53±0.67	6.94±0.67	6.54±0.78	6.28±0.43	6.35±0.87	6.67±0.28	8.29±0.74
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**

The average forage intake of the experimental animal is presented in Table 4. There was non-significant (p>0.05) effect between treatment groups in forage intake during the experimental periods.

Milk production of animal: The milk production and milk composition of the experimental animal was given in Table 4, 5, 6, 7 and 8 respectively. At the 7 days experiment, highest milk production was observed at T3 (9.72) followed by T1 (9.45). During 7 days of experiment, higher milk production was found in T3 (10.20) followed by T1 (9.76). Similarly, at 21 days of experiment, the higher milk production was found in T3 (10.56) followed by T0 (10.39). Likewise at 28

Table 4. Forage intake of experimental animal/day, kg (Mean±SD)

TRT	Days								Cumulative forage intake
	1	7	14	21	28	35	42	49	
T0	15±0	15±0	15±0	15±0	15±0	15±0	15±0	15±0	600
T1	15±0	15±0	15±0	15±0	15±0	15±0	15±0	15±0	600
T2	15±0	15±0	15±0	15±0	15±0	15±0	15±0	15±0	600
T3	15±0	15±0	15±0	15±0	15±0	15±0	15±0	15±0	600
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**	**p>0.05**

days of experiment, the higher milk production was found in T3 (10.84) followed by T0 (10.69). Similarly at 35 days of experiment the higher milk production was found in T3 (10.91) followed by T0 (10.78). Likewise at 42 days of experiment the higher milk production was found in T3 (11.36) followed by T0 (10.90). And also at 49 days of experiment the higher milk production was found in T3 (11.94) which was also followed by T1 (11.30) respectively. However, experiment revealed that there was non-significant effect among diet groups at (P>0.05) in terms of weekly milk production.

Table 5. Weekly milk production of experimental animals, liter/day

	Days							
TRT	1	7	14	21	28	35	42	49
T0	9.06±1.78	9.21±1.46	9.56±1.98	10.39±1.07	10.69±1.42	10.78±1.56	10.90±2.64	10.52±1.08
T1	9.15±1.49	9.45±1.72	9.76±1.58	9.87±1.47	10.18±1.59	10.55±1.78	10.87±1.49	11.30±1.68
T2	9.23±0.90	9.28±0.89	9.67±2.04	10.28±0.43	10.52±0.79	10.67±0.42	10.81±1.53	11.04±1.03
T3	9.55±1.84	9.72±2.82	10.20±0.71	10.56±1.54	10.84±1.77	10.91±0.71	11.36±1.64	11.94±1.61
Mean	9.09±2.72	9.84±1.59	9.94±1.06	10.46±1.15	10.46±1.26	10.84±1.32	10.87±1.29	11.09±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

During 15 days of experiment, higher milk Fat % was found in T2 (4.45) followed by T3 (4.24). Similarly SNF % was found higher in T2 (9.08) followed by T0 (9.01). Similarly protein % was found highest in T2 (3.31) followed by T0 (3.29). Likewise lactose % was found higher in T2 (4.99) followed by T0 and T3 (4.95). Experiment revealed that there was non-significant effect was found among the treatment groups at (P>0.05) in terms of parameters of milk.

Table 6. Comparison of milk parameters of experimental animals at 15 days

Treatment	Fat %	SNF %	Protein %	Lactose %
T0	3.77±0.71	9.01±0.55	3.29±0.19	4.95±0.30
T1	3.70±0.27	8.74±0.50	3.19±0.18	4.80±0.28
T2	4.45±0.59	9.08±0.20	3.31±0.78	4.99±0.11
T3	4.25±0.81	9.00±0.17	3.28±0.06	4.95±0.09
Mean	4.04±0.65	8.96±0.38	3.27±0.13	4.92±0.21
P>value	P>0.05	P>0.05	P>0.05	P>0.05

Table 7. Comparison of milk parameters of experimental animals at 30 days, (Mean±SD)

Treatments	Fat %	SNF %	Protein %	Lactose %
T0	3.86±1.28	8.88±0.61	3.24±0.21	4.88±0.33
T1	3.74±0.48	8.76±0.40	3.20±0.14	4.81±0.22
T2	4.19±0.37	8.96±0.15	3.27±0.05	4.93±0.08
T3	4.21±0.91	8.95±0.15	3.26±0.06	4.92±0.09
Mean	4.00±0.78	8.89±0.35	3.24±0.12	4.88±0.19
P>0.05	P>0.05	P>0.05	P>0.05	P>0.05

During 30 days of experiment, higher milk Fat % was found in T3 (4.21) followed by T2 (4.19). Similarly SNF % was found higher in T2 (8.96) followed by T3 (8.95). Similarly protein % was found highest in T2 (3.27) followed by T3 (3.26). Likewise lactose % was found higher in T2 (4.93) followed by T3 (4.92). Experiment revealed that there was non-significant effect was found among the treatment groups at (P>0.05) in terms of parameters of milk. During 45 days of experiment, higher milk Fat % was found in T2 (4.11) followed by T0 (3.55).

Table 8. Comparison of milk parameters of experimental animals at 45 days, (Mean±SD)

Treatment	Fat %	SNF %	Protein %	Lactose %
T0	3.55±1.02	8.63±0.79	3.16±0.29	4.74±0.44
T1	3.39±0.38	8.56±0.69	3.12±0.25	4.70±0.38
T2	4.11±0.57	8.79±0.27	3.21±0.10	4.83±0.15
T3	3.43±0.57	8.91±0.21	3.27±0.09	4.90±0.11
Mean	3.62±0.67	8.72±0.51	3.19±0.19	4.79±0.28
P>0.05	P>0.05	P>0.05	P>0.05	P>0.05

Similarly SNF % was found higher in T3 (8.91) followed by T2 (8.79). Similarly protein % was found highest in T3 (3.27) followed by T2 (3.21). Likewise lactose % was found higher in T3 (4.90) followed by T2 (4.83).

Experiment revealed that there was non-significant effect was found among the treatment groups at (P>0.05) in terms of parameters of milk. During 60 days of experiment, higher milk Fat % was found in T0 (4.39) followed by T2 (4.24). Similarly SNF % was found higher in T3 (9.02) followed by T2 (8.98). Similarly protein % was found highest in T3 (3.29) followed by T2 (3.28). Likewise lactose % was found higher in T3 (4.95) followed by T2 (4.93). Experiment revealed that there was non-significant effect was found among the treatment groups at (P>0.05) in terms of parameters of milk.

Table 9. Comparison of milk parameters of experimental animals at 60 days, (Mean±SD).

Treatment	Fat %	SNF %	Protein %	Lactose %
T0	4.39±1.70	8.89±0.38	3.24±0.13	4.88±0.20
T1	3.77±0.53	8.67±0.30	3.16±0.10	4.76±0.16
T2	4.24±0.24	8.98±0.11	3.28±0.04	4.93±0.06
T3	4.11±0.64	9.02±0.29	3.29±0.11	4.95±0.16
Mean	4.13±0.88	8.89±0.29	3.24±0.10	4.88±0.16
P>0.05	P>0.05	P>0.05	P>0.05	P>0.05

DISCUSSION

This experiment was initiated with an aim to increase the milk production of dairy animals by the inclusion of different level of dried brewers waste for the reduction of feed cost. The average milk production of experimental animals at day 60 was T4 (11.94), T1 (11.30), T2 (11.04) and T0 (10.52) respectively. There was non-significant (p>0.05) effect in feed intake, milk production and also in milk parameters (Fat %, SNF %, Protein % and Lactose %) at 15, 30, 45 and 60 days. According to Subba *teal*; (1999) in series of feeding trial including measurement of intake and palatability of fodder and unconventional feeds by ruminants varies according to the locality in our Nepalese context. Nyokabi *et,al*: 2011, reported that there was no difference in milk production who replaced forage in the diet upto 30% DM and 26% DM respectively. However, according to Asghar (2017), tested three different levels of wet brewers waste inclusion (13.0 %, 20.6 % and 29.0 % DM) and compared them to the basal diet, the cows fed with wet brewers waste produced more milk. Meanwhile, Aliyu and Bala, (2011) observed significant reduction in milk production of dairy cows fed with diets containing wet brewers waste. According to Erickson *et,al*: 2020 upto 35% (dry matter basis) brewers spent grain can be included in finishing diets of cattle by as a forage source without any adverse effect and also said that by using of byproduct in diets is seen to be a way to reduce pollution by industries and a way to provide inexpensive animal feed ingredients and it was also supported by Alura (2019). The use of brewers spent grain as a partial replacement for corn silage in beef cattle diet can be adopted as a strategy to reduce feeding cost and also as an alternative source of polyphenols from a material that needs to be recycled by Chandel *et,al*;2010. As brewers waste is easily available from beer industries we can use them in our animal's diets.

CONCLUSION

Brewer's dried waste is relatively cheap and easily available with no competition between human, farm animals and industries. As this present study was therefore designed to determine the feeding value of brewer's dried waste as a replacement for concentrate feed and there was no significant difference found in milk production and in milk parameters. Obviously, the concentrate feed can be easily replaced by 15 – 25 % dried brewer's waste in cattle feed.

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TECHNICAL EFFICIENCY AND RETURN TO SCALE OF OKRA (*Abelmoschus species*) PRODUCTION AMONG SMALLHOLDER RURAL WOMEN FARMERS IN KADUNA STATE, NIGERIA

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ABSTRACT

This research study evaluated technical efficiency and return to scale of okra (Abelmoschus species) production among smallholder rural women farmers, Kaduna State, Nigeria. Specifically, the objectives were to: determine the socio-economic profiles of smallholder rural women okra farmers, determine the profitability, costs and returns of okra production, examine factors affecting or influencing output of okra production, evaluate the technical efficiency scores of okra producers, determine the elasticity of production (Ep) and return to scale (RTS) of okra production, and determine the constraints faced by smallholder rural women okra producers. Multi-stage method of sampling was adopted. One hundred (100) smallholder rural women okra producers were sampled and selected. Primary data were collected using well-designed and also well-structured questionnaire. Data were analyzed using both econometric and statistical tools: descriptive statistics, financial analysis, farm budgeting technique, stochastic frontier production function model, elasticity of production (Ep), return to scale (RTS), and principal component model or factor analysis. The results show that 72% of smallholder rural women okra producers were between 31 to 50 years of age. The mean or average age of smallholder rural *women okra farmers was 46 years. About 84% of smallholder rural women okra producers had formal education and were therefore literate. The mean experience in okra farming was 6.90 years, and 82% of smallholder rural women farmers had between 1 to 10 years' experience in okra production. Also, 48% had contact with extension agents, and 63% belongs to members of cooperative organization. The gross margin (GM) and net farm income (NFI) of okra production were 1,413, 258 Naira per hectare, and 1,389,358 Naira per hectare respectively. Okra production among smallholder rural women farmers was profitable. In the technical efficiency component, the statistically and also significant factors influencing or affecting output of okra produced were seed input, fertilizer input and farm size . Also, labour input , chemical input , were statistically and significantly factors influencing output of okra produced at In the technical inefficiency component, educational level , and experience in farming were statistically significant socio-economic factors reducing technical inefficiency at , while age , marital status gender and size of household were statistically and significant socio-economic factors reducing technical inefficiency at . The return to scale was 1.216, which signifies increasing return to scale. The average technical efficiency was 46.5% leaving about 53.5% for improvement. The constraints encountered by smallholder rural women okra producers were high cost of fertilizers, inadequate extension services, lack of improved seeds, high cost of labour, and lack of credit or loan facilities. The research study recommends that credit or loan facilities should be made available at low interest rate and extension services should be employed to disseminate research results, innovations, and new farm technologies to smallholder rural women farmers for increased productivity.*

Key words: Technical Efficiency, Smallholder Rural Women Farmers, Okra Production, Kaduna State, Nigeria

INTRODUCTION

Okra (*Abelmoschus species*) belongs to *Malvaceae* family; it is an annual staple food crop, important and commonly grown fruit vegetable for human consumption in Nigeria (Alimi, 2004). It is widely cultivated in the subtropics, tropics, and warmer portions of the temperate region (Ume *et al.*, 2018). The vegetable crop (okra) can be found in most markets in Africa (Adiaha, 2017). The vegetable crop is among the staple, stable food crops, and has continued to get attention and its production is increasing in most countries across the world (Udoh and Akpan, 2007). Okra contains valuable food ingredients that can be successfully used to repair and build up the human body. Okra contains 2.2%

protein, 86% water, 10% carbohydrates, 0.2% fat, minerals, iron, magnesium, phosphorus, oil, vitamins A, B and C (Nwaobiala and Ogbonna, 2014). The fruits of okra can either be eaten in cooked form or in processed form. Okra contributes to nutritional and dietary roles and plays a significant role in the economy of rural farmers. In Nigeria okra is grown in some states of the federation both or either as irrigated or rainfed crop. Okra farming has been practiced widely by smallholder farmers because of its significance to the rural economy and okra produce can be seen in almost every market in Africa. Okra can be planted or grown on different types of soil types, and its yields are mostly limited by cultural management and soil fertility. Okra production of Nigeria in 2020 was 1,837, 904 tons and its 0.17% increase over that of 2019 which was 1,834,782 tons (FAO, 2020). Average yield of okra in Nigeria was between 2,500 kg to 3,000 kg per hectare. The total cultivated area for okra production in Nigeria was 1,603, 846 hectares in 2020 and the yield was 11, 459 hg/ha in 2020 (FAO, 2020). The major sources of farm income for peasant, and resource poor farmers come from arable crop production, non-vegetable and vegetables crops (Ekunwe *et al.*, 2018). Okra production serves as source of income by smallholder rural women in form of producers, marketers and laborers. Okra producers is a small-scale or smallholder enterprise that can empower financially farmers with those with small size of land, limited capital and working under limited sources of labour (Osalusi *et al.*, 2019). Okra producers at household level provides cash that significantly contributes to food security, and enables smallholder okra women farmers attained some degree of independence within the family budget. Okra farmers were faced with low production and productivity making the producers predisposed to food insecurity and poverty. Smallholder resource-poor farmers constitute 90% and rural women accounted for 75% of farming population respectively in Nigerian agriculture (FMARD, 2016). In sub-Saharan Africa (SSA), rural women are involved in farm activities than men, rural women accounted for 60-80% of the agricultural labour force (FAO, 2011,). Marginal okra farmers had less than one (1) hectare of cultivated farm land, the smallholder okra producers had less than 2 hectares of cultivated farm land.

Rural women are economically active population and they played significant roles as farmers, entrepreneurs and laborers (Ume *et al.*, 2018). Rural farmers are mostly women and 80% of farm labour in sub-Saharan Africa (SSA) is from rural women farmers (Lawal, Alabi, and Oladele, 2017). In sub-Saharan Africa, rural women are responsible for 80% of staple foods (Afolabi, 2008; Ogunlela and Mukhtar, 2009). Smallholder rural women farmers made up higher percentages of rural dwellers. Smallholder rural women farmers in sub-Saharan

Africa faces poor access to credit or loan facilities, farm inputs, extension services, land, and they have low level farm decisions making power. Smallholder rural women farmers therefore experience economic denials, food-insecurity, illiteracy, unemployment, malnutrition, poverty and diseases. Men and women significantly differ in their undertakings and activities with respect to access and control over limited resources available and level of participation in farm decision making. Agricultural task may be gender specific, women are responsible for such task as weeding, hoeing, harvesting, movement or transportation of agricultural produce from farms to their house, processing, preservation, and marketing of farm produce, rural women also participate in rearing of domestic animals. Rural women's role is very important for overall efforts directed towards increasing agricultural productivity and rural development (Abdullahi *et al*., 2017). Rural women are as efficient as men and contribute significantly to agricultural productivity (World Bank, 2008). In spite of the high percentage of women involvement in agriculture, productivity is still generally low for female farmers compare to their male counterparts (Olakojo, 2017). Closing the gender gap in agriculture, would increase the yields on rural women's farms and this will raise the total output of agricultural products in developing countries thereby reducing number of people who suffered from hunger and poverty across the world (FAO, 2013). Increasing rural women farmers' control of income, resources and farm decision making power will have significant positive effects of development goals such as agricultural productivity, child nutrition, education and general welfare (Quisumbing, 2003[b]). This research focused on technical efficiency and return to scale of okra (*Abelmoschus species*) production among smallholder rural women farmers Kaduna State, Nigeria.

MATERIALS AND METHODS

This research study was conducted in Kaduna State, Nigeria. Kaduna State occupies between Longitudes 06^0 $15^{|}$ and 08^0 $50^{|}$ East and Latitudes 09^0 $02^{|}$ and 09^0 $02^{|}$North of the equator. The State has land area totaling 4.5 million hectares. The state vegetation is divided into two (2), the Southern guinea savanna and Northern guinea savanna. There are two (2) seasons in Kaduna State. The seasons are: wet and dry seasons, the dry season is between October to March, and the wet season starts from April to October, in between the wet and dry seasons is the brief harmattan period which span from November to February. The mean or average rainfall is about 1,482mm, the temperature of Kaduna State ranges from 35^0C to 36^0C, which can be as low as 10^0C to 23^0C during the harmattan period. The population of Kaduna as at 2021 was 8.9

million people. They are involved in agricultural activities. Crops grown include: okra, pepper, maize, ginger, sorghum, rice, yam, cassava, millet, and tomatoes. Animal reared include: cattle, goats, sheep, rabbit, and poultry. Multi-stage method of sampling was used. One hundred (100) smallholder rural women okra farmers were selected. Data obtained from smallholder rural okra farmers were of primary sources and were collected using well-designed and also well-structured questionnaire. The questionnaire was administered to smallholder rural women okra producers using well trained enumerators. Data were analyzed using the following analytical tools:

Descriptive Statistics: This involves measures of central tendency such as mean, range, frequency distributions and percentages to summarize the socio-economics profiles of smallholder rural women okra farmers as stated specifically in objective one (i).

Farm Budgetary Technique: The farm budgetary techniques used was Gross Margin model (GM) and is defined as the estimated difference between gross farm income (GFI) and total variable cost (TVC). This statistical tool of analysis was used to determine the costs and returns, profitability of okra production among smallholder rural women farmers as specified in objective two (ii). Gross Margin Model is thus stated as:

$$GM = TR - TVC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$
$$GM = \sum_{i=1}^{n} P_i Q_i - \sum_{j=1}^{m} P_j X_j \ldots\ldots\ldots\ldots\ldots\ldots (2)$$
$$NFI = TR - TC \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..\ldots. (3)$$
$$NFI = \sum_{i=1}^{n} P_i Q_i - \left[\sum_{j=1}^{m} P_j X_j + \sum_{k=1}^{k} GK\right] \ldots\ldots\ldots. (4)$$

Where

P_i = Price of Okra ($\frac{₦}{Kg}$),

Q_i = Quantity of Okra (Kg),

P_j = Price of Factor Inputs ($\frac{₦}{Unit}$),

X_j = Quantity of Factor Inputs (Units),

$TR =$ Total Revenue (TR) obtained from Sales from Okra (₦),

TVC = Total Variable Cost (₦),

GK = Cost of all Fixed Inputs (Naira)

NFI = Net Farm Income (Naira)

Financial Analysis: This is an analytical tool used to determine the profitability of okra production among smallholder rural women farmers. The financial analysis was used specifically to achieve part of objective two (ii). Gross margin ratio according to Ben-Chendo *et al*. (2015) is defined as:

$$Gross\ Margin\ Ratio = \frac{Gross\ Margin}{Total\ Tevenue} \ldots\ldots\ldots\ldots . (5)$$

The operating ratio (OR) in line with Olukosi and Erhabor (2015) is defined as:

$$Operating\ Ratio = \frac{TVC}{GI} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Where,
TVC = Total Variable Cost (Naira),
GI = Gross Income (Naira),
According to Olukosi and Erhabor (2015) an operating ratio of less than one (1) implies that the gross income from okra enterprise was able to pay for the cost of the factor inputs used in the okra enterprise.
The rate of return per naira invested (RORI) in okra production among smallholder rural women farmers is defined as:

$$RORI = \frac{NI}{TC} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

Where,
$RORI =$ Rate of Return per Naira Invested (Unit),
$NI =$ Net Income (Naira),
$TC =$ Total Cost (Naira).

Stochastic Production Frontier Model
The stochastic production frontier model is stated thus:

$$Y_i = f(X_i, \beta_i)e^{v_i - u_i} \ldots\ldots (8)$$
$$l_nY = \beta_0 + \beta_1 l_n X_1 + \beta_2 l_n X_2 + \beta_3 l_n X_3 + \beta_4 l_n X_4 + \beta_5 l_n X_5 + V_i - U_i \ .(9)$$

where,
$Y_i =$ Output of Okra (kg)
X_i = Vectors of Factor Inputs
β_i = Vectors of Parameters
V_i = Random Variations in Okra Output
U_i= Error Term due to Technical Inefficiency
X_1 = Labour-Input in mandays
X_2 = Seed-Input in kg
X_3 = Fertilizer-Input in kg
X_4 = Chemical-Input in litre
X_5 = Farm Size (ha)

$$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \dots\dots\dots\dots\dots\dots (10)$$

where,

Z_1 = Age in years

Z_2 =Gender (as Dummy, 1, male; 0, otherwise)

Z_3 =Marital Status (as Dummy, 1, married; 0, otherwise)

Z_4 = Educational Level Attained (Likert, 0, non-formal; 1, primary; 2, secondary; 3, tertiary)

Z_5 = Size of Household (number)

Z_6 = Experience in Farming (years)

α_0 = Constant Term

$\alpha_1 - \alpha_6$ = Parameters to be Estimated

U_i= Error Term due to Technical Inefficiency

This will be used specifically to achieve objectives three (iii) and four (iv)

Elasticity of Production (Ep) and Return to Scale (RTS): Elasticity of production (Ep) and return to scale (RTS) of okra production among smallholder rural women farmers can be defined as:

$$RTS = \sum_i^n EP \dots\dots\dots\dots\dots\dots\dots (11)$$

$$RTS = \sum_1^5 \beta_i \dots\dots\dots\dots\dots\dots (12)$$

RTS equal to 1 = Constant Return to Scale,

RTS greater than1 = Increasing Return to Scale

RTS less than 1 = Decreasing Return to Scale

Where

RTS = Return to Scale (Units), and

EP = Elasticity of Production (Ep) Inputs (Units),

This was specifically used to evaluate the elasticity of production (Ep) and return to scale (RTS) of okra production as stated in specific objective five (v).

Principal Component Model or Factor Analysis: The constraints faced by smallholder rural women okra farmers were subjected to principal component model or factors analysis. This was specifically used to achieve objective six (vi).

RESULTS AND DISCUSSION

Socio-economic characteristics of smallholder rural women okra farmers

The socio-economic characteristics of smallholder rural women okra farmers under consideration were age, household size, marital status, farming experience level of education, extension contact, and membership of cooperatives as presented in Table 1. They were examined using descriptive statistics. The results of age classifications show that 72% of smallholder rural women okra producers were between 31 to 50 years of age. The average or mean age was 46 years, this implies that smallholder rural women were energetic, active, resourceful, and young okra farmers. This conforms with findings of Ume *et al.* (2018) who obtained 36 years as mean age of okra farmers among female headed household in south east Nigeria. According to Ekunwe *et al.* (2018), age plays a significant and important role in okra farming and this determines the smallholder rural women farmer's ability to carry out rigorous and tedious farm work as defined by some activities in okra production. Farmers with the ages of 31 to 50 years were reported to be energetic, young, resourceful and within the active group. About 59% of smallholder women okra farmers were married, 12% were single, and 29% were divorced. Averagely, there were 7 people per household, also, 85% of smallholder rural women okra farmers had between 1 to 10 members as household size. Household size serves as readily available sources of farm labour. Similarly, Esiobu and Onubuogo (2014) reported that larger household size compliments hired labour to enhance production and reduce cost incurred in payment of hired labour. In line with this, Sani *et al.* (2010) observed that larger household sizes are expected to provide enough people for family labour this implies less or little money will be used or needed to pay for hired labour. Furthermore, 76% of smallholder rural women okra farmers had formal education, while 26% had non-formal education. It is expected that higher level of education will significantly contribute positively to smallholder rural women okra farmers' decision making power and the ability to adopt innovations and new farm technology. Educated young smallholder rural women farmers gains more farm experiences and acquaints themselves with new farm technologies and they are expected to adopt and use new farm technologies efficiently. Also, 82% of smallholder rural women had between 1 to 10 years' experiences in okra farming. Averagely, they had 6.90 years' experiences in okra farming. The number of years of farm experience could improve smallholder rural women farmers' skills and enhance better methods to farming practices. Farm experience can correct previous mistakes or errors and contract or expand the scales of the application of tested farmers' skills. Farmers with many years of farm experience could be able to better forecast future okra market situations in which they will dispose their produce at higher prices and make better profits. About 48% of smallholder rural women farmers had extension contact, while 52% do not have any extension contact. Extension officers are responsible in disseminating information on modern farm technologies, innovations and research findings to farmers. In addition, 63% belongs to cooperative organizations, while 37% do not belongs to any cooperative organizations. Membership of cooperatives affords the smallholder rural women okra farmers the privilege to obtain credit or loan facilities, shares information on modern farm technologies, purchase farm inputs in bulk and exchange of labour.

Table 1. Socio-economic profiles of smallholder rural women okra producers

Variables	Frequency	Percentage	Mean
Marital Status			
Single	12	12.00	
Divorced	29	29.00	
Married	59	59.00	
Age (Years)			
31 – 40	23	23.00	
41 – 50	49	49.00	**46.00**
51 – 60	28	28.00	
Level of Education			
Non-Formal	26	26.00	
Tertiary	05	05.00	
Secondary	48	48.00	
Primary	21	21.00	
Household Size (Units)			
1 – <5	34	34.00	
5 – <10	51	51.00	**7.00**
10 – <15	15	15.00	
Farming Experience (Years)			
1 – <5	48	48.00	
5 – <10	34	34.00	**6.90**
10 – <15	10	10.00	
15 – <20	08	08.00	
Extension Contact			
Yes	48	48.00	
No	52	52.00	
Membership of Cooperatives			
Yes	63	63.00	
No	37	37.00	
Total	**100**	**100.00**	

Source: Field Survey (2021)

Estimates of net farm income and financial analysis of okra production per hectare

The financial analysis, costs and returns of okra production by smallholder rural women farmers are presented in Table 2.

Table 2. Costs, returns and financial analysis of okra farming per hectare

Items	Amount (Naira)	% of Total Cost
Total Revenue/Gross Income	1,650,000	
Variable Cost		
Seed Input	12,000	04.60
Fertilizer Input	32,500	12.47
Insecticides	13,451	05.16
Herbicides	13,271	05.09
Labour Cost:		
• Land Clearing	23,700	09.09
• Land Preparation	31,200	11.97
• Planting	17,800	06.83
• Weeding	27,200	10.44
• Fertilizer Application	17,780	06.82
• Chemical Application	16,340	06.27
• Harvesting	11,200	04.30
• Bagging	04,000	01.53
• Transportation	13,500	05.18
• Loading and Offloading	02,800	01.07
Total Variable Cost	236,742	90.83
Fixed Cost		
Estimated Depreciation Value on Tools (Hoes, Machetes)	01,200	0.46
Rent on Land	22,700	08.71
Total Fixed Cost	23,900	09.17
Total Cost	260,642	100.00
Gross Margin	1,413,258	
Gross Margin Ratio (GMR)	0.86	
Net Farm Income (NFI)	1,389,358	
Rate of Return on Investment (RORI)	5.33	
Operating Ratio (OR)	0.14	

Source: Field Survey (2021)

The various costs incurred and the revenue obtained on okra production by smallholder rural women farmers were based on the prevailing market price as at the time of the field survey. Estimated total variable cost (TVC) was 236, 742 Naira, and this constitutes about 90.83% of total cost of okra production per hectare. The total variable cost includes: seed input (04/60%), fertilizer input (12.47%), insecticides (05.16%), herbicides (05.09%) and labour cost (63.5%).

The fixed cost was estimated at 23,900 Naira and this constitutes about 09.17% of total costs. The total cost was estimated at 260,642 Naira. The gross margin

(GM) and net farm income(NFI) of okra production by smallholder rural women farmers was estimated at 1,413,258 Naira per hectare and 1,389,358 Naira per hectare respectively. This signifies that okra production by smallholder rural women farmers is profitable in the study area.

The gross margin ratio (GMR) was estimated at 0.86, this signifies that for every one (1) Naira invested in okra production by smallholder rural women farmers 86 kobo covered taxes, expenses, profits, and depreciation. Operating ratio of okra production was estimated at 0.14, this means that 14% of okra produce sales revenue was used to cover cost of okra sold and other operating expenses. Operating ratio is used to measure operating efficiency and profitability of okra production, low operating ratio is preferable and it's reported to be a positive sign. The estimated rate of return on investment (RORI) was 5.33, which signifies that for every ₦1 (one Naira) invested in okra production about 533 kobo was realized. This finding is in line with results of Ume *et al.* (2018) who observed that the net farm income of 1,200,900 Naira per hectare for okra production among female headed household in south-east Nigeria. This finding is in agreements with results of Ekunwe *et al.* (2018) who stated that the return on investment of 2.03 for okra production per hectare Delta State, Nigeria

Technical efficiency of okra farming among smallholder rural women farmers in the study area

Table 3 shows the outcome of the stochastic production frontier function model of okra production among smallholder rural women farmers. The factors influencing output or technical efficiency of okra production among smallholder rural women farmers are presented in the first component, the technical efficiency component of Table 3. The factors under consideration in the model are labour -input seed-input, fertilizer-input, chemical-input, and farm size. All factors included in the technical efficiency first component of the stochastic frontier production model had positive coefficients and were statistically significant. In the technical efficiency component, seed-input, fertilizer-input, and farm size were statistically significant at . A one percentage (1%) increase in fertilizer input holding all other variables fixed or constant will lead to 30.20% increase in output of okra production among smallholder rural women farmers in the study area. Similarly, a one percentage (1%) increase in farm size holding all other variables constant will lead to 31.0% increase in output of okra production. In the technical inefficiency second component of the stochastic production function model, the socio-economic factors or variables under consideration were age , marital status , gender, educational level , size of households , and experience in farming .The negative coefficients in the technical inefficiency component decrease technical inefficiency, while positive coefficients increase technical inefficiency. Educational level , and experience in farming had negative coefficients and were statistically significant at .A 1% increase in educational level of smallholder rural women okra farmers holding all other variables constant will lead to 30.10% decrease in technical inefficiency. As smallholder rural women acquire more education, they will therefore gain technical knowledge, develop mastery of allocation of resources, and hence become more technically efficient. The coefficient of variance ratio was 0.8120, this implies that 81.20% of variations in the output of smallholder rural women okra producers were due to differences in technical efficiency. The coefficient of total variance was 1.5001, which was statistically significant at . This implies a good fit for the model. The Log-Likelihood function was 421.32.

Elasticity of production (ep) and return to scale (rts) of okra production

The regression coefficients in the technical efficiency first component of the stochastic frontier production function model are the elasticity of production (Table 3).

Table 3. Maximum likelihood results of the stochastic frontier production model

Variables	Parameters	Coefficient	SE	t-Value
Constant		3.021*	1.367	2.21
Labour-Input		0.203**	0.076	2.67
Seed-Input		0.192***	0.059	3.21
Fertilizer-Input		0.302***	0.085	3.57
Chemical-Input		0.209**	0.074	2.79
Farm Size		0.310***	0.088	3.51
Return to Scale (RTS)		**1.216**		
Inefficiency Component				
Constant		0.661*	0.299	2.21
Age		-0.180*	0.074	-2.42
Gender		-0.109*	0.047	-2.31
Marital Status		-0.201*	0.087	-2.30
Educational Level		-0.301***	0.086	-3.52
Size of Household		-0.102*	0.044	-2.31
Experience in Farming		-0.215***	0.059	-3.59
Diagnostic Statistics				
Total Variance		1.5001***		
Variance Ratio		0.8120		
Log-Likelihood		421.32		
Likelihood Ratio Test		306.71		

Source: Data Analysis (2021)

*Significant at ($P < 0.10$).,**Significant at ($P < 0.05$); ***Significant at ($P < 0.01$).

The values of elasticity of production were positive for all the explanatory or independent variables included in the model. The elasticity of production for labour input and seed input were 0.203 and 0.192 respectively. The return to scale) is the sum or addition of coefficients of estimated elasticity of production. The estimated return to scale) was 1.216, which implies increasing return to scale. At this stage, every additional unit of production inputs would lead to more than proportionate addition to okra output.

Technical efficiency scores among smallholder rural women okra producers

Table 4 shows the frequency distribution of smallholder rural women okra producers at the different levels of efficiency. Majority (41%) of smallholder rural women okra farmers were between 41 to 60% efficiency levels, this implies that most farmers were averagely technically efficient. The mean technical efficiency was 46.5% leaving a gap of 53.5% for improvement. In addition, the least technical efficiency score was 12.0% while the best performing okra farm had the maximum technical efficiency of 82.0%.If the average smallholder rural women okra producers were to achieve the level of technical efficiency like most of its efficient counterparts, then the average okra farmers could make 43.3% cost savings .

The calculated value for the most technically inefficient smallholder rural women okra farmers reveal a cost savings of 85.4% .This conform with findings of Ume *et al.* (2018) who obtained mean technical efficiency of 0.56 for okra producers among households headed by female in rural areas of south-east, Nigeria.

Constraints militating against okra production among smallholder rural women farmers in the study area

The constraints militating against okra production among smallholder rural women farmers was subjected to principal component model or factor analysis as presented in Table 5. Principal component model (PCA) is a statistical package, technique and applications that transform interrelated and many constraints into smaller and few ones that are not related and uncorrelated. Constraints with Eigen-values equal or greater than one (1) were retained by the principal component model.

Table 4. Summary statistics of technical efficiency scores

Efficiency Score	Frequency	Percentage
0.00 – 0.20	11	11.00
0.21 – 0.40	27	27.00
0.41 – 0.60	41	41.00
0.61 – 0.80	12	12.00
0.81 – 1.00	09	09.00
Mean	0.465	
Standard Deviation	0.2169	
Minimum	0.12	
Maximum	0.82	

Source: Field Survey (2021)

Table 5. Principal component model of constraints encountered by smallholder rural women okra producers

Constraints	Eigen-Value	Difference	Proportion	Cumulative
High Input Cost of Fertilizers	1.712	0.821	0.1821	0.1821
Lack of Improved Seeds	1.612	0.320	0.1701	0.3522
Lack of Credit or Loan Facilities	1.402	0.024	0.1656	0.5178
Inadequate Extension Services	1.341	0.203	0.1421	0.6599
High Labour Cost	1.201	0.410	0.1302	0.7901
Bartlett Test of Sphericity				
Chi Square	760.01***			
KMO	0.6201			
Rho	1.00000			

Source: Computed from Data Analysis (2021) ***Significant at 1% Probability Level

Those constraints with Eigen-values less than one (1) were discarded by the model. Five (5) constraints militating against okra production were retained by the model and were therefore processed for further analysis. High cost of fertilizer was ranked 1st among all constraints retained in the model in the order of statistical importance based on index of perceptions of the smallholder rural women okra producers. High cost of fertilizer was ranked 1st among the constraints with Eigen-value of 1.712 and this explained 18.21% of all constraints militating against okra production. Lack of improved seeds was ranked 2nd with Eigen-value of 1.612 and this constraint explained 17.01% of all constrained retained by the model. All retained constraints by the model jointly explained 79.01% among the constraints militating against okra production in the area. The chi square value of 760.01 was statistically significant.

CONCLUSION AND RECOMMENDATIONS

This research study has established that okra production among smallholder rural women farmers was profitable. The smallholder rural women okra farmers were resourceful, young, active, and energetic with an average or mean age of 46 years. They are mostly married, with an average of 7 people per household. Majority attended formal education and averagely had 7 years' experiences in okra farming. The gross margin (GM) and net farm income (NFI) of okra production per hectare were 1,413, 258 Naira and 1,389, 358 Naira respectively. In the technical efficiency first component of the stochastic frontier production model, labour-input, fertilizer-input, chemical-input, seed-input, and farm size were the statistically and significant factors influencing output of okra produced among smallholder rural women farmers. In the technical inefficiency component, age, educational level, gender, marital status, size of household, and experience in farming were statistically and significant factors reducing technical inefficiency among smallholder rural women okra producers. The mean technical efficiency index for smallholder rural women okra farmers was 46.5%, about 53.5% for improvement. Return to scale (RTS) was calculated at 1.216, which signifies increasing return to scale. In addition, the constraints facing smallholder rural women okra producers were high input cost of fertilizers, lack of credit or loan facilities, lack of improved seeds, inadequate extension services, and high labour cost. The research study recommends that:

- Credit or loan facilities should be made available for smallholder rural women okra farmers at low interest rate to increase productivity and efficiency.
- Farm inputs such as improved seeds, adequate fertilizers should be provided for smallholder rural women okra farmers to increase productivity and efficiency.
- Extension services should be employed to disseminate research results, innovations, and new farm technologies to smallholder rural women okra farmers.
- Smallholder rural women okra farmers should join cooperative organizations for easy access of loan and farm inputs.

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PREVALENCE OF TICK-BORNE HAEMOPARASITIC DISEASES AND HAEMATO-BIOCHEMICAL CHANGES IN CATTLE OF KATHMANDU VALLEY

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ABSTRACT

Tick-borne haemo-prarasitic infections are very common in cattle and cause devastating losses to the livestock industry. The present study was conducted to determine the prevalence of haemo-parasites and impact of Tick-Borne Haemo-harasitic Disease (TBHD) in haemato-biochemical parameter of cattle in Kathmandu valley. A total of 285 blood samples were collected during the month of October to December, 2020. Blood samples were prepared smears and stained with Giemsa's stain and examined under oil immersion microscope (100x) at Animal health and research division, NARC laboratory, Khumaltar. The overall prevalence of TBHP was found to be 9.12% i.e. 26 samples were positive. Among the positive higher no of samples were positive for Anaplasma sp. followed by Babesia and then Theileria with prevalence rate 46%, 27% and 12% respectively. The prevalence of Tick Borne Haemo-Parasite (TBHP) infection in cattle were found statistically significant (P<0.05). The prevalence in Bhaktapur district (14.47%) was found higher followed by Kathmandu (7.31%) and then Lalitpur (6.97%) district. Among positive group 73.07 % of samples were found to have history tick infestation in recent period and also 81% of positive group were at least one clinical sigh of TBHD. Regarding the biochemical profile the serum ALT, AST and total bilirubin concentration were found to be significantly low (p<0.05) similarly mean Haemoglobin, PCV and TEC in TBHP positive group were found to be lower than negative group, which was statistically significant (P<0.05). There is lack of knowledge and awareness about TBHD in farmers level resulting late reporting of infection and spreading of parasite. Thus, this study has indicated significant prevalence of tick-borne hemo-prarasite in cattle of Kathmandu valley.

Key words: Haemo-Parasites, Prevalence, Biochemical profile, Hematological Profile, Kathmandu valley

INTRODUCTION

The population of cattle in 2019 was 73,02,808 annual growth rate of cattle population was 0.42% with milking population of about 10,26,135 with annual growth rate of 1.8 % Population of cattle in Kathmandu valley according to latest census was 48547 (MoAD, 2017). Tick-borne haemoparasitic diseases (TBHDs) are one of the major constraints of cattle production in Nepal.

Haemoparasitic diseases account for substantial losses in terms of decreased working capacity, growth and productivity of cattle. Haemoparasites have generally been shown to cause destruction of red blood cells resulting in anaemia, jaundice, anorexia, weight loss and infertility (Akande, Takeet, & Makanju, 2010). The direct losses caused by the parasites are attributed to acute illness and death. *Babesia, Theileria* and *Anaplasma* are the major Tick-borne haemoparasites which globally impact on animal health and economy in view of mortality, reduced milk, meat and hide production and lower animal draft power (Blood, 2000).

Problem of tick infestation and tick-borne diseases is in increasing trend from Terai and mid-hills to upper Mahabharat range and higher mountain region. Survivals of potential vectors such as ticks are mainly responsible for transmitting most of the haemo parasites such as *Anaplasmosis, Babesiosis and Theileriosis* in hot and humid climate. Generally, cattle tend to develop fever, anorexia, and lethargy and weight loss within 7-10 days of tick infestation (Yadav, 2015). Blood smear prepared from blood sample collected from some of the sick cattle during field visit to Mulpani, Sirutar and Dharke also showed presence of *Anaplasma centrale, Anaplasma marginale, Babesia spp.* and *Theileria spp.* Complaint from the owners of the farms visited and physical examination of the sick animals directs towards the clinical signs similar to blood protozoal diseases such as labored breathing, fever (104-106^{o}F), anorexia and/or intermittent feeding, swollen lymph nodes, pale mucus membrane, yellowish to reddish urine etc. Common blood protozoal diseases such as *Anaplasmosis, Babesiosis, and Theileriosis* etc. have been reported recently in the lab reports of Central Veterinary Laboratory, Tripureswar. Haemoprotozoal infection cause huge production loss with lifelong morbidity, debility, weakness and bone marrow depression and even death in many acute cases (Yadav, 2015).

With 80% of the world cattle population affected by ticks and tick-borne diseases, ticks transmit a greater variety of pathogenic micro-organisms during feeding and cause haemoprotozoal diseases. Anaplasmosis, Babesiosis and Theileriosis in cattle are caused by obligate intra-erythrocytic parasite with symptoms like anorexia, fever, weight loss, lethargy, cough, increased pulse rate, decreased milk production, jaundice, anemia, abortion etc. (Akande *et al.*, 2010). During the study on blood parasitic disease in cattle of Eastern Terai region, microscopic examination of blood smears collected from 83 crossbreed dairy cattle having high fever, revealed 28.9 % prevalence of *Anaplasma spp.*, *Babesia spp.* and *Theileria spp* (Shrestha and Singh, 1999). In Siraha district (Yadav, 2015), 18% prevalence was found from the sample collected from a total of 310 blood samples from domestic animals which included 130 cattle, 115 buffaloes and 65 goats.

The objective of this study was to focus on timely and proper diagnosis of the disease in the future during clinical practice for definitive and efficient treatment can be given timely and accordingly.

MATERIALS AND METHODS

The Cross-sectional descriptive study was conducted in between October, 2020, to December, 2020 in Kathmandu, Lalitpur & Bhaktapur districts of Nepal. These three districts have similar geographical background, and climatic conditions.

Sample size

The sample size necessary for detection of TBHD was calculated from Epi-Tools Epidemiological Calculators by Ausvet, assuming 50% of previous prevalence of TBHD in cattle of Kathmandu valley with 95% confidence level.

Sampling frame and procedure

To study the prevalence of TBHD of Kathmandu valley total of 285 samples were collected according to minimum sample requirement as calculated from Epitool:Ausvet, from all three districts of Kathmandu valley.

On the basis of cattle population density, i.e. statistical report from MoAD (2017), total of 123 (43.15%) samples were taken from Kathmandu district, 86 (30.17%) samples were taken from Lalitpur district & 76 (26.66%) samples were taken from Bhaktapur district.

Blood sampling and data collection

Selected animals were properly restrained and 5 ml blood was collected from jugular vein with the help of 10ml syringe. Immediately after collection, blood sample were transferred into Ethylene-Diamine Tetra Acetate (EDTA) vials and serum vial with proper labeling and recording. And serum was extracted by centrifugation at 3000 rpm for 10 minutes. Extracted serum was transferred into serum tube and was stored in deep freezer at -20˚C until laboratory analysis was performed.

Epidemiological data for this study was collected by using questionnaire. Data included age, breed, state of production, history of tick infestation, history of fever and anorexia.

Laboratory examination

The blood samples were examined/ screened for the presence of haemo-parasites by making thin blood smear and staining with Giemsa's stain.

Identification Procedure for Blood Parasites

Almost all erythrocytes within the smear were observed under microscopic examination. The characters of the individual parasite were sufficiently given specific attention to stain, shape, size, color, position (i.e., attachment to erythrocytes), characteristic appendages, inclusion bodies, the membranes etc. during the identification of blood parasites. ***Babesia***: It may be pear shaped or round, usually centrally located in the erythrocytes and often found in pairs that are at an obtuse angle to each other (OIE, 2010; Ristic, 1988; Soulsby, 2012)
Theileria is seen red blood cells and are mainly rod-shaped, 1.5- 2μm by 0.5-1μm; however, round, oval, comma and ring-shaped form may also occur in erythrocytes (Soulsby, 2012). Morphologically the genus *Anaplasma* can be described as a gram negative, small, often pleomorphic coccoid to ellipsoidal organisms that reside within cytoplasmic vacuoles, either singly and more often in compact inclusions. In mammalian hosts they are present in mature or immature haematopoietic cells, particularly myeloid cells and erythrocytes, in peripheral blood or tissues as well as organs of the mononuclear phagocyte system (Dumler *et al*., 2001, Soulsby, 2012)

After screening the blood and serum samples were subjected to estimate the hematological and biochemical changes as follows.

1. Haemoglobin concentration (Hb) was estimated by Sahlis' method as described by Schalm *et al.* (1986) and the value was expressed in gram/deciliter (g/dl).

2. Packed cell volume (PCV) was estimated by Wintrobe's haematocrit method and the value was expressed as percentage (%) of total volume as described by Schalm *et al*. (1986).
3. The total erythrocyte count (TEC) was estimated by haemocytometer (Jain 1993) and the value was expressed as millions per cubic millimeter (x 106/cmm.).
4. Total leucocytes count (TLC) was estimated by haemocytometer according to the method described by Jain (1993) and the value will be expressed as thousand per cubic millimeter (x 103/cmm.).
5. Biochemical parameters; alanine aminotransferase (ALT), aspartate aminotransferase (AST) and total bilirubin were analyzed by ERBA Biochemical analyzer, ERBA Germany, according to ERBA Lachema protocol.

RESULTS AND DISCUSSION

An epidemiological survey was also conducted simultaneously with samples collection obtaining clinical history of animals along with age, sex and production performance. Among positive group 73.07 % of samples were found to have history tick infestation in recent period and also 81% of positive group were at least one clinical sigh of TBHD.

Overall prevalence of tick borne haemo parasite in Kathmandu valley

Out of total 285 samples 26 (9.12%) were found to be positive.as shown in figure: 1 The Prevalence is statistically significant (P= 0.00001).

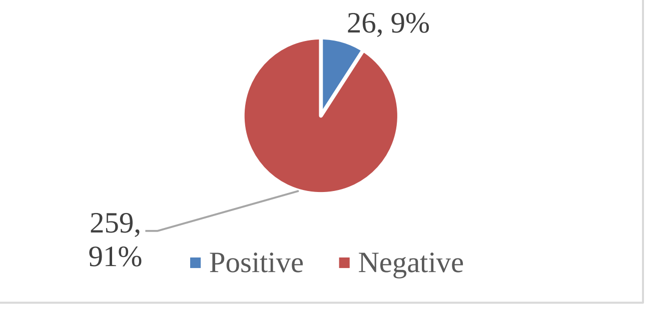

Figure 1. Overall prevalence of TBHP in cattle

Species wise prevalence of tick borne haemo-parasite in Kathmandu valley

Regarding the species of haemo-parasites, there was higher no. of infection with *Anaplasma sp*, followed by *Babesia sp* and then *Theileria sp.* as shown in figure: 2.

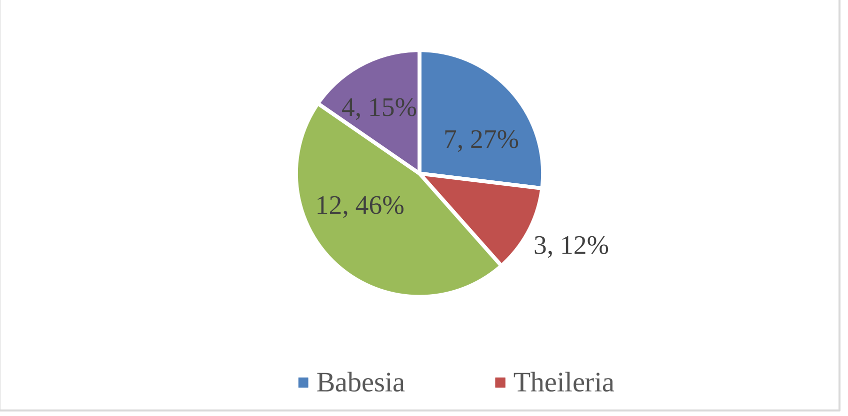

Figure 2. Species-wise prevalence of haemo-parasites

Hematological profile among TBHD positive and negative group

The hematological parameter like Total Erythrocytes Count (TEC), Haemoglobin concentration (Hb) and Packed Cell Volume (PCV) were estimated among positive and negative group. There was decrease in value in all three parameter among positive group as shown in figure: 3.

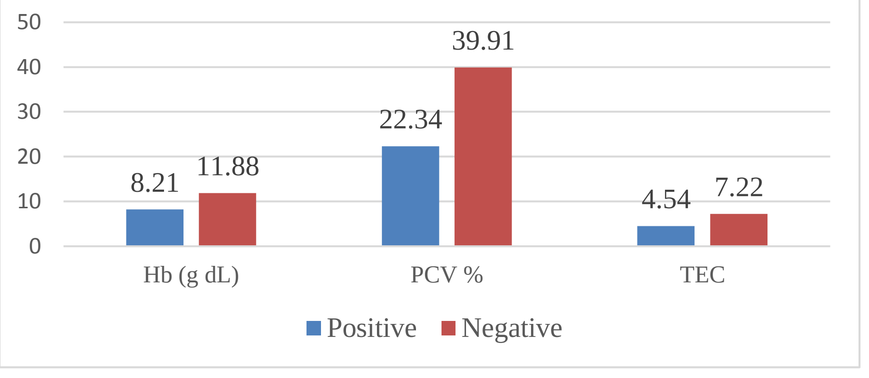

Figure 3. Mean hematological parameter

Biochemical profile among TBHD positive and negative group: The serum concentration of Alanine amino transferase (ALT), Aspartate amino transferase (AST) and total bilirubin concentration were found to be higher in positive group then in negative as shown in figure: 4.

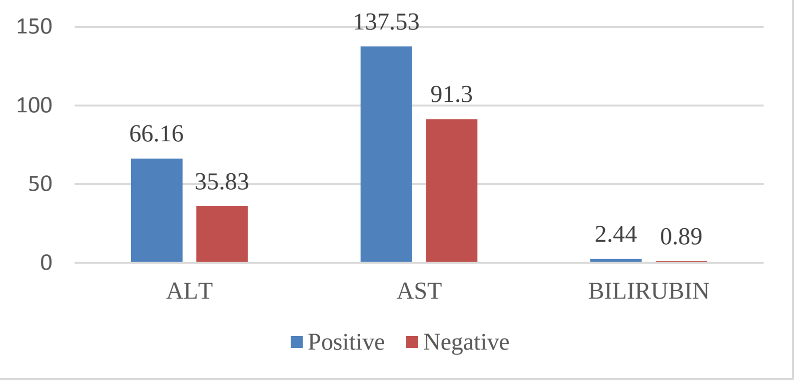

Figure 4. Mean biochemical parameter

DISCUSSION

Haemo parasites infections are very common in cattle and cause devastating losses to the livestock industry and pose a major threat to the dairy industry throughout the world (Shahnawaz *et al*., 2011). Babesiosis, anaplasmosis, theileriosis and trypanosomiasis are considered some of the major impediments in the health and productive performance of cattle (Rajput *et al.*, 2005). These diseases are transmitted through tick as well as other blood sucking flies in tropical and subtropical parts of the world (Salih *et al*., 2015).

In the present study, the prevalence of haemo-parasites was found to be 9.12% in cattle of the Kathmandu valley. The slightly higher result has been reported as 18.06% in Siraha district (Yadav, 2015). The present prevalence rate of haemo-parasites was less as compared to 23%, 28% and 36.36% reported by the Vahara *et al.* (2012) Shrestha and Singh (2000) and Deo and Neupane (2002) respectively. It may be due to the climatic variation in between Terai and hilly region.

The similar prevalence rate with this this study i.e 9% and 6.67%, 9.92% reported by the Bhatnagar *et al*. (2005), Velusamy *et al*. (2015) and Okorafor and Nzeako (2014). The variation in parasitic prevalence could be due to the climatic factors which directly influence the vector distribution.
Cattle were highly infected by anaplasmosis with the prevalence rate 12.46% in the present study as shown in figure: 4. which showed comparatively higher than 6.1%, 5.88% and 6.1% prevalence of anaplasmosis, reported by the Maharjan and Mishra (2006), Awad *et al*. (2011) and Birdane *et al*. (2006). This could be due to the improper management practices. While infection rate was less than the reports of Kumar and Sangwan (2010), Mtshali *et al*. (2004), Zhou

et al. (2016), Chowdhury *et al.* (2011), Khan *et al*. (2004), who revealed 46%, 87%, 89.9%, 29.1%, and 87%, respectively from different part of the world.

Bovine Babiosis is a tick-borne disease of cattle caused by the haemo parasites of the genus *Babesia*. It is common in Africa, India, Central Asia, Central and Southern America and Australia (Soulsby, 2012). With regard to *Babesia*, 7.27% infections of Babesiosis were reported from the present study, which showed comparatively similar to the 9.64%, and 9.2% prevalence of Babesiosis reported by the Shrestha and Singh (2000), and Parmar and Upadhya (2016).

Theileriosis is caused by the haemo-parasite of *Theileria* spp. (*Theileria annulata* and *Theileria parva*). In the present study, infection of theileriosis was comparatively less than the other haemo parasitc diseases. About 3% prevalence of *Theileria* was recorded from the present study, which is the similar to the 2.9% and 3.2% prevalences of Theileriosis reported by the Gebrekidan *et al*. (2016) and Kursat *et al*. (2008) respectively. The present prevalence of Theileriosis was found to be higher than 0.56% which is reported by the Okorafor and Nzeako (2014) from the Nigeria. While less than the Gupta *et al*. (2013), Yadav (2015), Shrestha and Singh (2000), Khan *et al*. (2004). Regarding the mixed infection there were concurrent infection of haemo-parasites in few of the samples which is 4.15% in total sample. The parasites involved in mixed infection were *Anaplasma* species and *Babesia* species. The prevalence of co-infection Babesia and Anaplasma was also evaluated and reported by Fakhar *et al*. (2012) and gave 24.4% which is higher than reported by present study.

Hematological impact of TBHD in cattle

The present study showed the negative impact of haemoparasites on haematological values in infected cattle as compared to non-infected group as shown in figure 3. The animals infected by bovine theileriosis, Babesiosis and anaplasmosis exhibited macrocytic hypochromic anemia with abnormal morphology of erythrocyte as anisocytosis, poikilocytosis, basophilic stippling, hypochromasia, cremated RBC and polychromasia. The value in respect of all the three haematological parameters were compared between the infected and uninfected and significant ($p<0.05$) negative impact of tick-borne haemo-parasitic diseases were found in infected and non-infected group of cattle on the mean value of Hb concentration (8.21 and 11.88), PCV value (22.34and 39.91), TEC level (4.54 and 7.22) respectively.

This decline in levels of Hb, PCV and TEC is attributed to persistent loss of blood caused by permanent blood sucking ticks leading to anaemia (Khalifa *et* *al*. 2009) and lysis of erythrocytes by piroplasms which infects and replicate in it and erythrophagocytosis (Khalifa *et al*. 2009).

This erythrophagocytosis has been initiated by parasitic damage to erythrocytes and increased level of activated complement products and removal of destroyed cells by bovine reticuloendothelial system (Brito *et al*. 2013). The decreased erythrocyte counts could also be attributed to increased levels of activated complement products (Orkun *et al.* 2017, Khan *et al*. 2004). Whereas, Vahara *et al*. (2012) reported all these changes in haemogram occur as a result of anaemia which occurs due to toxic metabolites of tick-borne haemoprotozoa which have harmful effect on bone marrow as they interfere with the process of erythropossis. The alteration in hematological indices observed during the infection was consistent with the findings of Ananda *et al*. (2009), in theileriosis; Zubairu *et al.* (2013) in Babesiosis and Aanaplasmosis.

Biochemical impact of TBHD in cattle

High activities of alanine transferase and aspartate transferase enzymes were recorded in infected group compared to healthy group ($P<0.05$) as shown in figure: 4 and are closely associated with hepatic injury caused by the protozoa, hemolysis (Fakhar *et al.* 2012). The significant ($P<0.05$) increase in the serum AST and ALT activities may also be due to muscle trauma caused by prolonged clinical recumbences in clinical condition (Salih *et al*. 2015). Significant increase in total bilirubin concentration ($P<0.05$) observed in the infected animals could be due to the hemolysis by parasites and immune response and damage to the liver in large ruminants infected with tick-borne pathogens.

CONCLUSION

Haemo-parasites infections are very common in cattle and cause devastating losses to the livestock industry and pose a major threat to the dairy industry throughout the country. This study reveals that there is significant prevalence of haemo-parasites infection Kathmandu valley and also impact of disease in blood parameter of cattle.

Low TEC, Hb and PCV value indicate that parasite cause severe hemolysis and anemia in cattle. There is significant impact on biochemical parameters like ALT, AST and total bilirubin content which suggest there is significant effect of haemo-parasites disease in liver.

Lack of knowledge and awareness about TBHD in farmer's level and unavailability of diagnostic facility in local level is supporting spread of diseases and causing great loss. So, government agencies need to be strengthened with well-equipped laboratory in order to diagnose common blood parasitic diseases. Vector control program needs to organize regularly in order to prevent common blood parasitic diseases in domestic animals and further research works on molecular level should be carried out in future.

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IMPACT OF CLIMATE CHANGE ON MAJOR CEREAL CROPS PRODUCTION IN PARIPATTLE, DHANKUTA, NEPAL

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ABSTRACT

A research on "impact of climate change on major cereal crops production in Paripattle, Dhankuta, Nepal" was done in 2020. About 75 households were selected randomly for the study. The local communities and farmers who were long experienced in autonomous adaptation of the study area were primary source of information & secondary data's were collected through published and unpublished materials from books, journals, NGOs and GOs publications & the collected data's were analyzed by social statistical tools. As per the result of research, about 70% farmers were familiar with the term climate change and its impact, the main climatic hazards found to be long drought & hailstones which affecting cereal crops in the area. Major climate change facts perceived by farmers were delay in monsoon rain & winter rain, increasing summer and winter temperature, which were seriously affecting cereal production. In case of production, it was found that rice & wheat yield was decreasing but maize was somehow increasing and millet had not so much changed as per past few years result according to majority of farmer's perception. As per majority of farmers' response, the planting and harvesting time of rice and wheat were delayed and maize become earlier and millet remained somehow same in the study area. About 51% of the farmers in the study area were just familiar with little knowledge and techniques of adaptation practices to cope with climatic hazards & changing climatic pattern but almost had not the actual knowledge and techniques of it, hence, the farmers in the area should focused for the knowledge and facts of climate change, adaptation & improvements techniques for improving the production of major cereal crops.

Key Words: Climate change, Impact, Climatic Hazards, Adaptation, Production.

INTRODUCTION

Climate change refers to changes beyond the average atmospheric condition that are caused both by natural factors such as the orbit of earth's revolution, volcanic activities and crustal movements and by artificial factors such as the increase in the concentration of greenhouse gases and aerosols. Climate change by global warming, which refers to the average increase in global temperature, has become a megatrend that will lead to significant global changes in the future. Concerning its impacts, the UN Intergovernmental Panel on Climate Change (IPCC) presented considerable scientific evidences in its fourth report on climate change (2007) and they have become clearly recognized worldwide.
Temperature has been increasing in Nepal in the past few decades. The maximum temperature in Nepal increased at a rate of 0.06 °C/year between 1978 and 1994, with higher rates at stations located at higher altitudes. Warming in winter has been especially pronounced (Shrestha et al., 1999). Similarly, a decreasing trend in cool days and cold nights and an increasing trend in warm nights has been observed (Baidya et al., 2008). Studies carried out in various parts of Nepal and river basins also suggest similar direction of changes. In the eastern Koshi river basin, maximum temperature has increased by 0.058 °C/year over the last four decades (Nepal, 2016). Another study indicated that daily maximum temperature increased by 0.1 °C /decade on average between 1975 and 2010 and the minimum by 0.3 °C /decade (Shrestha et al., 2017). In Karnali, both minimum and maximum temperatures were found to be increasing, and the increase in pre-monsoon season was significantly higher with 0.08 °C/year (Khatiwada et al., 2016).

The evidences of impact of climate change on crop production have drawn immense attention over the last decades (Tao et al., 2008). In Nepal, rice (Oryza sativa L.) is the most important staple crop which occupies 42.5% of total area under food grains and share about 51.6% on total grains production (ABPSD, 2016). Moreover, rice solely contributes 20% of agriculture GDP (CDD, 2015). Adaptation to changing climate is an effective tool at the farm level to reduce climatic vulnerability by making Nepalese farmer able to prepare themselves and their farming to changes and variability in climate along with avoiding projected damages and boosting up them in dealing with adverse events (IPCC, 2001).

The volume of wheat production, cultivated area and productivity increased substantially in Nepal during the last decade. But, surprisingly, about 60 percent variations in wheat productivity was due to weather variability in Nepal .The climate being one of the inevitable inputs in wheat cultivation, weather variability and farm level wheat production, its unpredictability might have some meaningful consequences. There is a dearth of empirical analysis on weather variability and wheat production in Nepal. Thus, this paper aims to untangle this puzzle analyzing district level panel information.
There were few studies completed on the pattern analysis of climatic variables and their impact at regional levels (Shrestha et al. 2012; Kulkarni et al. 2013) and limited studies were conducted at local levels (Bhatta et al. 2014; Uprety et al. 2017) in the Nepal Himalaya (Chaudhary and Bawa 2011) covering altitudinal gradient, so there exists a gap in knowledge on central Nepal.

Climate change influences crop yield crop production to a greater extent in countries like depends largely on natural circumstances. Plausible scenarios of climate change like higher temperatures and changes in precipitation will directly affect crop yields. Therefore, this study assesses the effect of observed climate variables on yield of major food-crops in Nepal, namely rice, wheat, maize, millet, barley and potato based on regression model for historical (1978-2008) climatic data and yield data for the food-crops. The yield growth rate of all the food-crops is positive. However, the growth rate for all crops, except potato and wheat, is below population growth rate during the period.

Climate variables like temperature and precipitation are the important determinants of crop yields. Trend of precipitation is neither increasing nor decreasing significantly during this period. Climate variables show some influences on the yield of these major food-crops in Nepal. Increase in summer rain and maximum temperature has contributed positively to rice yield. Also, increase in summer rain and minimum temperature has positive impact on potato yield. However, increase in summer rain and maximum temperature adversely affected the yield of maize and millet. Increase in wheat and barley yield is contributed by current trend of winter rain and temperature. Consideration of spatial variation in similar type of study in Nepal that will be helpful in identifying the region more vulnerable to climate change in terms of crop yield is highly recommended.

MATERIALS AND METHODS

Study area

The study was conducted in Paripatle village, Dhankuta municipality, Dhankuta district Nepal. The municipality altitude ranges from 350m-1545m indicating a huge variation and a diverse ecology within the municipality. Mainly Dhankuta municipality ward no. 10 was selected as study site.

Methods of data collection: Different source and techniques were deployed for collection of necessary information. In this study both the primary and secondary data were collected and analyzed.

Source of information

Primary source of data: The local communities and farmers who were long experienced in autonomous adaptation of the study area were primary source of information. The pretested interview schedule was piloted to the respondents to collect primary information. These data were supplemented by the information obtained from focal group dissection, direct observation and transect walk. Participatory methods were used to collect data, to share experienced and knowledge of affected communities towards climate change.

Secondary source: Secondary data were collected from the various published journals, research articles, proceeding of various NGOs and INGOs reports of District Agriculture Development Office (DADO), District Development Committee (DDC), National Agriculture Research Council (NARC), Central Bureau of Statistics (CBS), local leaders and working agencies were the source of secondary information.

Techniques of data collection:

Interview: The questionnaire was administered to collect the primary data. Information **regarding** various aspects of climate change as perceived by the farmers was collected. Information regarding the farm and household characteristics, their feelings and perceived impacts as compared to the pat, change in farming practices and new adaptation strategies were collected through face to face interview.

Focus group discussion: Information obtained from the interview was crosschecked during the focus group discussion. Additional information on various community based adaption strategies, different observed in the present and past regarding the farming practice were collected through focus group discussion.

Survey design and field survey

Preliminary survey: Pre- survey field visit was conducted to gather preliminary information regarding socio-cultural, topographical and institutional features of the study.

Interview Schedule Design: Interview schedule was prepared to collect primary information from farmers. A co-ordination schema was prepared in harmony with objectives of the study to identify the variables and to facilitate the interview schedule preparation. The major changes included in interview schedule were the household socio-economic characteristics livelihood options, farmers, perception, their adaption strategies, and cereal crop production trends.

Field survey: After finalization of the interview schedule, the schedule was prepared to collect information with the help of enumerator. Field survey was conducted during December to January 2019-2020. Respondents were interviewed by visiting their home. Validation of information was done immediately after filling the interview schedule. Focus group discussion and informal discussion were also done during field survey.

Method and techniques of data analysis: Information collected from the field survey was coded first and entered into the computer. Data entry and analysis were done by using Microsoft excel. The local units of measurement were corrected into scientific one. Both descripted and analytical methods were used to analyze the data Socio-economic and farm characteristics of the respondents like climate change pattern, land holding, crop production situation, disease and pest, distribution of economically active population were described by using simple descripted statistic like frequency count and percentage. Impacts and perception of farmers on the change of climatic variables over the time were studied by estimating frequency, percentage, charts and diagram.

RESULTS AND DISCUSSION

Farmer knowledge about climate change: The study revealed that majority (70%) of farmers had the knowledge about climate change & its impacts & remaining (30%) percentage were still unknown about it in the study area.

Farmer's perception about climatic hazards: It was found that there is increasing trend of climatic hazards in the study area. Majority (33.33%) of farmers perceived increase in long drought and hailstone, 30% landslide, 29.33% storm and only 6.67% hailstone that affect the major cereal crops.

Farmer's perception on timing of monsoon rain: Majority 69% of farmers experienced delayed monsoon onset, 11% experienced earlier and 20% experienced no change of monsoon rain in study area.

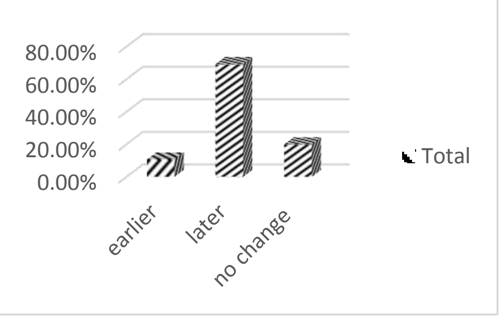

Figure 1. Farmer's perception on timing of monsoon rain

Farmers' perception on timing of winter rain: In case of winter rain, majority (73%) had experienced delayed winter rainfall pattern. Similarly 11% experience earlier winter and 16% experienced that there was no change on winter rainfall pattern.

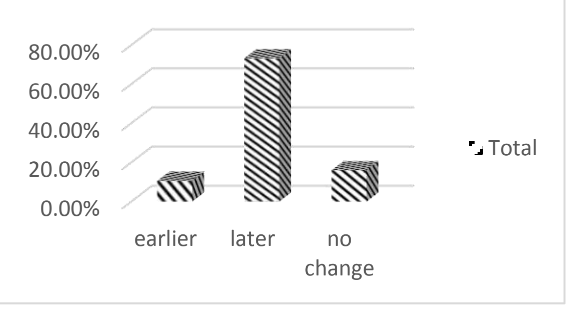

Figure 2. Farmer's perception on timing of winter rain

Farmer's perception on timing of summer and winter temperature: From the study, it was found that 70% of the farmers had experienced in increased pattern of summer temperature while 18% perceived decreased summer temperature. Similarly, 70% had experienced increased winter temperature and 18% had experienced the decreased winter temperature.

Table 1. Farmer's perception on timing of summer and winter temperature

Change in temp.	Perceptions	No. of farmer	Percentage
Change in summer	Increase	52	70%
Temperature	Decrease	13	18%
	No change	10	12%
Change in winter	Increase	52	70%
Temperature	Decrease	13	18%
	No change	10	12%

Farmer's perception on impact of climate change on cereal production:
Impact of climate change on rice production: There was found to be decreased trend of rice production in surveyed area. Majority (66%) of farmers perceived decreased rice production. It was found that decreasing in production may be due to delay summer rainfall and uses of same variety.

Impact of climate change on wheat production: Wheat production was found to be decreasing in surveyed area. Majority (60%) of farmers perceived wheat production was decreased. Decreasing in production was found due to fewer amounts of water availability, drought, delayed winter rainfall & hailstorm.

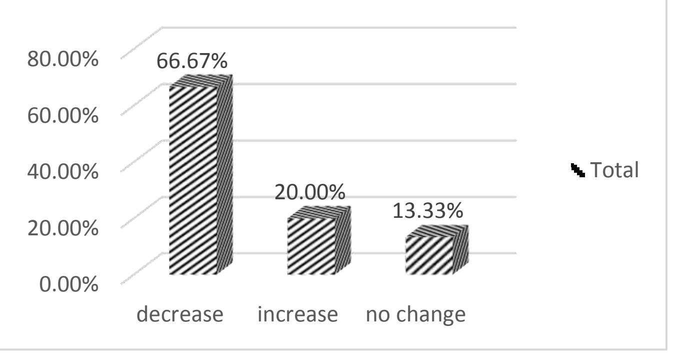

Figure 3. Impact of climate change on rice production

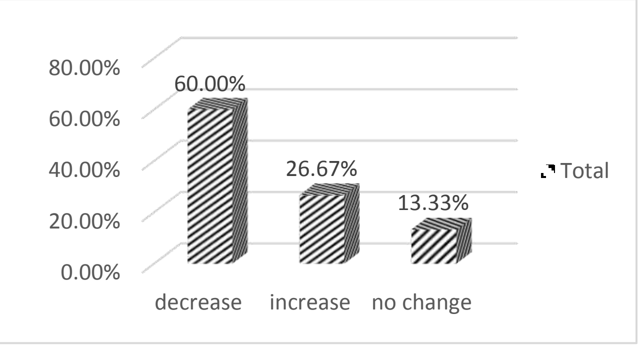

Figure 4. Impact of climate change on wheat production

Impact of climate change on maize production: Maize production in surveyed area was found as different scenario than other two major cereals (Rice & Wheat). Majority (60%) of farmers perceived maize production was increasing in the area. It was found that increased in production may be due to not more climate vulnerable plant like as Rice & wheat, and also due to varietal change & use of improved & hybrid varieties of Maize in the study area since few years.

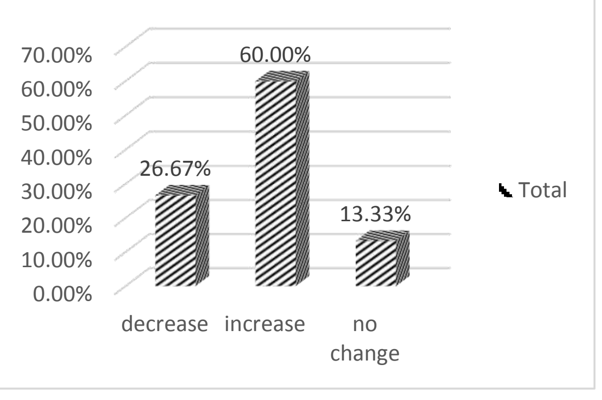

Figure 5. Impact of climate change on maize production

Impact of climate change on millet production: Majority of farmers (46%) perceived millet production was same i.e. not changing, 40% perceived decreasing and about 14% revealed increased in production. No change in production of millet found due to traditional farming practice and no change in variety and limited amount of manures and fertilizer use.

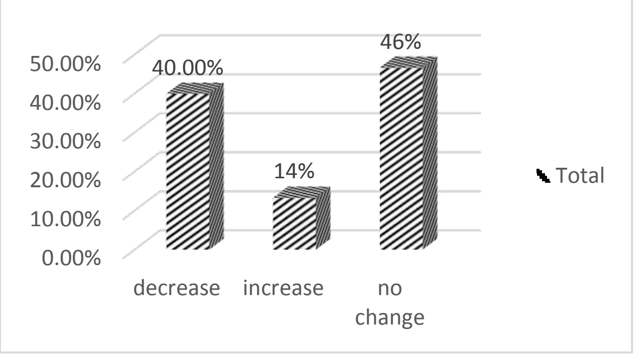

Figure 6. Impact of climate change (CC) on millet production

Effect of climate change (CC) on planting and harvesting time of cereal crops : According to the Farmers' views from the surveyed site, the timing of planting & harvesting of major cereal crops as compare to previous time for past few years, was given as follow, which was directly and indirectly affected by climate change. In case of rice, majority of farmers (66%) experienced planting and harvesting time somehow late. For wheat, also majority of farmers (60%) perceived late.

Table 2. Effect of CC on planting and harvesting time of cereal crops

	Perception	Number of farmers	%
Planting and harvesting Time of rice	earlier	2	16%
	later	50	66%
	No change	13	18%
Planting and harvesting Time of wheat	earlier	15	20%
	later	45	60%
	No change	15	20%
Planting and harvesting Time of maize	earlier	35	46%
	later	30	40%
	No change	10	14%
Planting and harvesting Time of millet	earlier	15	20%
	later	15	20%
	No change	45	60%

For maize, majority of farmers (46%) perceived it was earlier and for millet, majority of farmers (60%) perceived planting and harvesting time was not changed. These all may be due to changing rainfall pattern, drought condition, irrigation facility & varietal types.

Farmer's knowledge about adaptation practices: It was found that about 51% of farmers had the little knowledge about adaptation practice to cope with the climate change and about 17% know clearly about it while about 32% don't know about it. So, there is a huge gap in adaptation to cope with climate change impact for major cereal production in study area.

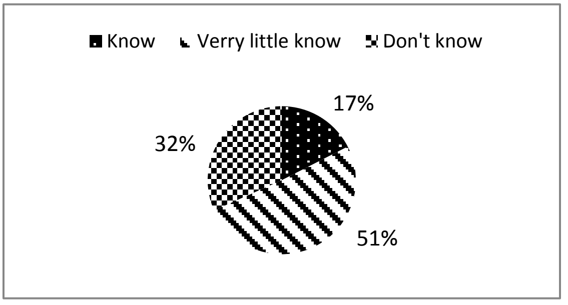

Figure 7. Farmer's knowledge about adaptation practice

CONCLUSION

The study survey which was carried out in Paripatle, Dhankuta (Eastern Mid hill area of Nepal), become effective in terms of farmers perception on climate change & its impact on major cereal crop production in the area. Most of the farmers perceived the change in climate in term of change in monsoon & winter rainfall pattern, onset of monsoon, change in summer & winter temperature, climatic hazards severity, etc. in the study area. Farmers were facing severe problems in production of rice & wheat mainly in the study area, which was major food source for Nepalese. Mainly rainfall problem, unavailability of irrigation facility, hailstones, delayed winter rainfall, increasing temperature as well as some climatic hazards like landslide, leaching & soil erosion become more problematic for cereal production in the area. The changed yield, planting & harvesting time in cereal crop production resulted due to climate change in the area. Thus some farmers were changing timing of cultivation, practices of cropping, cropping pattern, changing in varieties, etc. as adaptation practices to cope with climate change impact but still majority of farmers in the study area had not the proper knowledge on adaptation practices. Thus, the findings of this study may help to know the real scenario of climate change and its impact on major cereal crop production as representation of the eastern mid hill area of country. So, there should be minimize the gap on knowledge on climate change & its impacts & proper adaptation practices to cope with such problems among farmers of mid hill area of Nepal.

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EFFECT OF TURMERIC (*Curcuma longa*) POWDER AND WHEY PROTEIN INCLUSION IN BROILER DIET ON GROWTH PERFORMANCES OF BROILER CHICKENS

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ABSTRACT

An experiment was conducted at Directorate of Agricultural Research, Province N 2, Parwanipur, Bara for 42 days to evaluate the effect of Turmeric (Curcuma longa) powder and whey protein inclusion in broiler feed and its effect on growth of broiler production. Altogether 150 day old Cobb-500 broiler birds were divided into 5 treatments with 3 replications (10 birds in each replication) by using completely randomized design. Experimental birds were provided adlib grower feed (B1) for 21 days and that after finisher feed (B3) for 21 days and had easily access to drinking water. Feed intake was recorded daily and body weight gain was measured in 7 days interval. Control group (T1) was provided concentrate mixture only, whereas in T2 and T4 groups concentrate mixture was mixed with 1gm, 2gm turmeric powder per kg feed respectively. Where as in T3 and T5 groups concentrate mixture was mixed with 10ml whey protein per liter of drinking water. Body weight gain was found 178.13±0.2, 370.07±0.9, 834.04±0.2, 1225±0.2, 1800±0.5 and 2553±02 in T1, T2, T3 T4 and T5 respectively. There was significant difference (p<0.05) found only at 28, 35 and 42 days in (T4) group, whereas non- significant difference was found in total weight gain. Result showed non-significant difference (p>0.05) in feed intake during experimental period at 42 days between treatment groups (p>0.05).Similarly, mean FCR was observed similar among the treatment group (p>0.05). So, turmeric powder and whey protein could be added in broilers diet but further study should be carried out to precise its inclusion in broilers diet.

Key words: Turmeric powder, Growth performance, Whey protein, Broiler chicken

INTRODUCTION

Livestock farming is an important component of the Agricultural system of Nepal. The primary livestock species raised in Nepal includes cattle, buffaloes, sheep, goat, poultry, Himalayan goat (Chyangra), and yak depending upon the local agro climatic conditions. Livestock farming offers cash income to the farmers which are crucial to run their day-to-day financial activities (Karki and Bauer, 2004; Bhatta *et al.*, 2015). Among these several livestock species raised poultry especially chicken is one of the common species raised in the hills and terai areas of Nepal (Bhurtel and Shah, 2000). While poultry farming is one of the rapidly commercializing livestock subsectors in the peri-urban areas of Nepal (Sharma, 2010).

There is growing interest in developing natural alternatives to antibiotics as growth promoters in order to maintain both bird performance and health (Khan et al., 2012). In 2006, European Union banned the use of antibiotics as feed additives because of its residual effects in animal tissues and subsequently leading to antimicrobial resistance in human beings (Griggs and Jacob, 2005). Considering this harmful effect in many developed countries have made it legally not to be used in feed antibiotics (Amalraj *et al.*, 2017).

Turmeric (*Curcuma longa* Linn. Or *C. domestica* Val.) is the domesticated species of turmeric, while the wild one is called *C. aromatic*. It is rhizomatous herbaceous perennial herb belonging to Zingiberaceae family that is widely used and cultivated in the tropical and sub-tropical regions of the world, such as in Pakistan, China, Indonesia, India, Malaysia, Jamaica and Peru (Govindarajan and Stahl, 1980). Turmeric is a popular medicinal herb which shows a wide range of pharmacological properties like antioxidant, anti-protozoal, antimicrobial, anti-inflammatory, antitumor (Fallah and Mirzaei *et al.*, 2017).

Curcumin is the major component in turmeric having a potent antioxidant activity (Holt *et al.*, 2005; Mondal *et al.*, 2015). Turmeric falls in such a class of medicinal plant that provides an alternative method of natural antibiotic to feed poultry farm. Turmeric supplementation could effectively acts on growth, egg production and health status of chickens (Khan *et al.*, 2012). This medicinal plant possesses rhizomes and underground root-like stems (Araujo and Leon, 2001) that had been originally used as a food additives in curries to improve the storage condition, appearance, flavor, palatability and preservation of food (Sultan, 2003). Supplementation of turmeric powder and its extract has beneficial effects on the performance of birds and animals (Anantkawlas, 2014).

Whey is the main co-product of the cheese industry, although it is usually disposed as a waste product. It is rich source of protein. Whey protein concentrate is a co-product of cheese or rennet casein industries with relevant protein (30% CP of dry matter) and lactose 52% of dry matter) contents. Whey is considered as an excellent amino acid source in bird nutrition and is composed of biologically active proteins such as *β*-lactoglobulin, *α*-lactoalbumin and immunoglobulin (Szezurek *et al.*, 2017). These proteins have a higher biological value compare with soyabean meal (Akbarian *et al.*, 2012) the main protein source in poultry feed. The lactose of whey protein might promote broiler performance by stimulating the growth of beneficial cecal bacteria. The benefits of the inclusion of whey protein are reported on the performance and protein digestibility of broiler diets (Szezurek *et al*., 2017).

In Nepal commercial poultry farmers are using antibiotics in poultry fed for fast growth which is resulting negative effect in human health. In another hand, there is high mortality of poultry bird due to various reasons. In this context, inclusion of turmeric powder and rich source of protein i.e.; whey in broiler feed is most promising option to reduce the bird mortality and fast growing instead of antibiotics. Therefore, this study was carried out to evaluate the effect of addition of various levels of turmeric powder and different combination of whey as a natural growth promoter on the performance of broiler birds.

MATERIALS AND METHODS

Experimental Birds: 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 23rd March to 2nd May 2020 (2076/12/10 to 2077/01/20 BS) for 42 days. Hundred fifty experimental day old birds were procured from Shivam Hatchery,

Birjung, Parsa and were allocated into five treatments with three 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.

Diet composition: Compound feed was procured from Shakti Feed Industry of Birjung, Parsa and treated with turmeric powder @1gm per kg of feed with and without whey @10ml per liter of drinking water. Likewise compound feed was treated with turmeric powder @2gm per kg of feed with and without whey @10ml per liter of drinking water. The sample of these feed was brought to the

National Animal Nutrition Research Center, Khumaltar, Lalitpur for chemical analysis.

Chemical analysis: Representative samples were analyzed for Dry Matter (DM), Crude Protein (CP), Crude Fiber (CF), Organic Matter (OM) and Total Ash (TA) content. The DM was determined by oven drying at 100^0 C for 24 hours. Crude protein of the samples were determined by using the Kjeldahl method. Ash content was determined by ashing at 550^0 C in a Muffle furnace for 4 hrs (AOAC, 1980). Crude Ether of the samples were determined by using the Van Soest method (Goering, H.K and Van Soest, 1970).

Experimental diet: The following experimental diet was provided to the birds (Table 1).

Table 1. Experimental diet

Treatments	Diet
1	Adlib concentrate mixture (without inclusion of turmeric and whey)
2	Adlib concentrate mixture + Turmeric powder (1gm/kg feed)
3	Adlib concentrate mixture + Turmeric powder (1gm/kg feed) + 10ml whey/lit water
4	Adlib concentrate mixture + Turmeric powder (2gm/kg feed)
5	Adlib concentrate mixture + Turmeric powder (2gm/kg feed) + 10ml whey/lit water

Feeding regime: Concentrate mixture was given on group basis and was provided to the experimental birds once a day (morning) in adlib amount for both periods (starter-21 days and finisher-21 days) of the experiment. Drinking water was provided in adequate amount.

Data measurement: This trial period consisted for 42 days (21 days starter and 21 days finisher). Quantity of concentrate mixture was given daily to the birds in groups weighted daily and refusal was weighted in the next morning. The body weight gain was measured in group basis (replication-wise) in seven days interval in the morning before feeding.

Data analysis: Data of feed intake and body weight gain were analyzed by "One way Anova" test for every measurement using statistical package Minitab 2003, version 13.20.

RESULTS AND DISCUSSION

Chemical composition of concentrate mixture

The chemical composition of treated and non treated concentrate mixture is given in Table 2.

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

Concentrate mixture	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

Average mean body weight of the experimental birds was found 40.21 g at the beginning which reached 2553 g at the end of the experiment. At the 7 days of experiment, the highest body weight gain was found 179.20 g in T3 and T5 which was followed by T2 and T4 178.54 g. At 14 days experiment the highest weight gain was found highest in T3 378.09 g which was followed by 375.45 g in T1. At 21 days of the experiment the highest weight gain was found in T2 824.06 g which was followed by T4 812.16 g. At 28, 35 and 42 days the highest weight gain was found in T4 1265, 1852 and 2555 g respectively. The total body weight gain was found highest in T4 2511 g, likewise the daily weight gain was found highest in T4 63.80g. In the body weight gain trend of the experimental birds the significant difference was found at 35 and 42 days of the experimental period. There was no significant ($p>0.05$) effect of different level of turmeric powder and whey protein inclusion on body weight gain and FCR.

Mean feed intake of experimental birds was recorded 28.48 g in 7 days which reached 182.80 g at the end of experiment i.e., 42 days which is non-significant among the diet groups. At the 7 days of experiment, feed intake of T1 and T5 (29 g) is similar where as T2 and T3 is also similar (28 g) followed by T4 (27 g). At 14 days of experiment the feed intake was found highest in T1 (65 g) followed by T5 (64 g) where as in T2, T3 and in T4 was found similar (62 g). At 21 days of experiment the feed intake was found similar in T1, T4 and T5 (101 g) where as T2 (99 g) which was followed by T3 (98 g). At 28 days of experiment the feed intake was found similar in T1, T4 and T5 (102 g) where was followed by T2and T3 also was similar (98 g). At 35 days of experiment the feed intake was found highest in T1 (189 g) where as in T4 and T5 similar i.e., (178 g) followed by T2and T3 (172 g). At 42 days of experiment the feed intake was found similar at T1, T3 and T5 (185 g) where as inT4 it was found (184 g) which was followed by T2 (178 g). Even though there was no significant difference found among the treatments.

Table 3. Body weight gain trend of experimental birds/day, g (Mean±SD)

Treatment	0	7	14	21	28	35	42	Total weight gain(g)	Daily weight gain(g)	FCR kg
1	40.56 ±0.6	175.37± 0.3	375.45± 0.6	804.37± 0.7	1230± 0.2	1735± 0.3	2534 ±0.3	2488±0 .9	60.93±0. 3	1.49
2	40.22 ±0.8	178.37± 0.4	368.25± 0.9	824.06± 0.6	1231± 0.3	1830± 0.7	2541 ±0.7	2500±0 .9	61.42±0. 3	1.53
3	40.02 ±0.6	179.12± 0.2	378.09± 0.7	805.08± 0.2	1178± 0.5	1822± 0.5	2553 ±0.3	2451±0 .2	60.24±0. 1	1.52
4	40.13 ±0.4	178.54± 0.5	362.08± 0.5	812.16± 0.3	1265± 0.7	1852± 0.2	2555 ±0.3	2511±0 .1	63.80±0. 2	1.55
5	40.48 ±0.7	179.20± 0.8	368.47± 0.2	803.90± 0.3	1235± 0.3	1788± 0.6	2540 ±0.5	2431±0 .6	59.30±0. 1	1.49
Mean	40.21 ±0.1	178.13± 0.2	370.07± 0.9	834.04± 0.2	1225± 0.2	1800± 0.5	2553 ±0.2	2498±0 .5	60.94±0. 2	1.53
P-value	p>0.0 5	p>0.05	p>0.05	p>0.05	p>0.0 5	P<0.0 5	P<0. 05	p>0.05	p>0.05	p>0. 05

Table 4. Feed intake of the experimental birds/day, g (Mean±SD)

Treatment	7	14	21	28	35	42	Cumulative feed intake
1	29.65±0.2	65.27±0.8	101.02±0.4	102.02±0.4	189.73±0.4	185.55±0.2	3835.33
2	28.64±0.9	62.50±0.2	99.04±0.2	98.03±0.1	172.11±0.4	178.89±0.4	3868.11
3	28.09±0.1	62.27±0.4	98.03±0.4	98.04±0.1	172.54±0.1	185.02±0.5	3911.51
4	27.13±0.4	62.50±0.1	101±0.2	102.08±0.2	178.48±0.2	184.44±0.1	3828.06
5	29.07±0.1	64.04±0.3	101±0.5	102.04±0.2	178.22±0.7	185.02±0.1	3801.04
Mean	28.48±0.3	63.31±0.5	99.71±0.1	99.07±0.4	179.49±0.3	182.08±0.2	3851.87
P-value	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05

DISCUSSION

This study was initiated to evaluate the effect of different level of turmeric powder and whey inclusion in broiler diet and its effect on production performance. Experiment revealed that feed consumption was almost similar (3800 g) in T1, T2, T4 and T5 where as diet with 1gm turmeric powder with 10ml whey protein per liter of drinking (T3) water was found (3900 g). Increased level of inclusion did not reduce the consumption rate, however the total body weight gain was higher in T4 (2511 g) and FCR was similar in T1 and T5 (1.49) where as almost similar in T2 (1.53), T3 (1.52) and T4 (1.55) respectively. There was no any mortality of birds during the whole experiment.

Nouzarian *et al.,* (2011) also says that there was no significant effect on daily feed intake and body weight gain of chickens. Kumari *et al.,* (2007) observed that supplementation with 7.5g/kg turmeric powder in feed increases highest weight on birds. The variations in the values of body weight might be due to differences in agro climatic conditions (Mehala and Moorthy, 2008). Supplementation of 3.3, 6.6 and 10 g/kg turmeric powder in broiler chicken improves feed efficiency (Ahlawat *et al.,* 2018). These findings were also supported by Kafi *et al.,* (2017).

Arslan *et al.,* (2017) reported that turmeric supplementation at 0, 0.5, 1.0 and 1.5 percent improved feed conversion efficiency but supplementation at the rate of 1.5 percent showed the best result in comparison to other groups. Shohe *et al.,* (2019) observed that feed conversion efficiency was significantly ($p<0.05$) the lowest in the T4 group (7.5 g turmeric powder /kg feed) followed by T3 (5 g turmeric powder /kg feed), T2 (2.5 g turmeric powder /kg feed) and the highest in T1 (1.5 g turmeric powder /kg feed) group.

Malik *et al.,* (2015), reported that the supplementation of whey protein in broiler diets improved their feed conversion ratio. Ibrahim *et al.,* (2017), theorized that whey proteins support muscle building with its essential amino-acid content. The results of this study are in agreement with those reported by Bahari *et al*., (2015), who showed that the supplementation of 4% whey protein in broiler diets increases the relative weights of carcass, breast, drum sticks and wings. Moreover, Kermanshahi and Rostami (2006), reported that the carcass relative weight in broiler chickens fed 2% and 4% of dried whey reached its maximum ($p<0.05$) at 49 days of age.

The dietary supplementation of curcumin is limited because of its low solubility in alkaline pH and being subject to hydrolysis when exposed to sunlight, which result in poor absorption in animals (Kochhar, 2008). Studies on broiler chickens have shown increased weight gain and improved FCR (Hussein, 2013) with dietary supplementation of turmeric.

CONCLUSION

Inclusion of turmeric powder can be used as a growth promoter and whey as a protein source in broiler production. It has resulted better growth performance and reduction in bird mortality. However, further study should be conducted to validate this finding in farmer's field for wider dissemination of this study.

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ASSESSMENT OF ZUCHHINI GENOTYPES FOR GROWTH AND YIELD PARAMETERS IN MID HILLCONDITION OF NEPAL

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ABSTRACT

Zucchini (Cucurbita pepo L.) is a horticultural crop grown throughout the world. In order to evaluate the performances and yields on the mid-hill region of Nepal with sub-tropical climate, this experiment was carried out using five genotypes of zucchini namely: Anna303(T_1), Grey zucchini(T_2), Anna202(T_3), Slesha1214(T_4) and Sunny House (check genotype) as the treatments with four replications for each, on spring season. Several growth and yield parameters were taken and for analysis and comparison of performances and characters of these genotypes, set on the Randomized Complete Block Design (RCBD). Yields was found ranging from 28,450 kg/ha (for Sunny House) to 40,886 kg/ha (for Slesha1214), though the difference was by little margin and was insignificant ($p>0.05$). These taken genotypes showed significant variations on these morphological characteristics: leaf length, petiole length, no. of lobes and fruit length. Highest leaf length was observed on Anna303 (27.05cm) and lowest on Grey Zucchini (19.8cm). Slesha1214 had highest petiole length (26.2875cm) while Grey Zucchini had shortest petiole (17.75cm). Anna303 was found to have longest fruit of around 109.075cm, followed by Slesha1214 (98.7 cm) and fruit of Grey Zucchini being shortest among these genotypes. Leaf lobes were more on Anna303 (5.825) and Grey Zucchini had least leaf lobes (4.925). However, Male-to-female flower ratio was almost same for all genotypes. Although the variation was insignificant, it was found that yield of Anna202 can be harvested earlier (in 29.25 days) than other, while Sunny House was found to take lot more time/days for the first harvest i.e., on around 42 days. The range of the yields found suggests that on the mid-hill region, Slesha1214 is slightly superior among these genotypes, while Anna202 can give yield sooner than any of these varieties.

Key words: Zucchini, Genotypes, Mid-hills, Yield, Growth, RCBD

INTRODUCTION

Summer Squash (*Cucurbita pepo* L.), a Cucurbitaceous crop, is native to Mexico and US. Squashes which include zucchini are a large group within the cucumber family, Cucurbita, and include gourds, pumpkins, and summer and winter squashes. It is tender, annual, warm season vegetable crop that is harvested when fruits are immature (Sarhan *et al.*, 2011) which grow commonly as a bush or smaller weak-stemmed vining plant. Fruits vary in shape from round to cylindrical to scallop, while separate male and female flowers appear on the same plant. There are two groups of squash available namely: summer squash and winter squash, on which zucchini are among summer squash. Summer Squash grows on a wide variety of soil types even in proper managed soil but should have good drainage and use of the mulch is recommended. Summer squash can be planted almost any time after the danger of frost has passed. Production of pumpkins, squash and gourds were 27,449,481 Mt in 2,078,450 ha of land around the world in 2017 (FAO, 2019). Production of summer squash was 23,906 Mt 1,528 ha of land in Nepal in FY 2016/17 (MOAD, 2018). Only a small amount of this area and production is from summer squash as it is relatively new in case of Nepal while largest producers of summer squash are Turkey, Italy, Egypt, Spain, U.S. A and Mexico (Paris, 1996). It is grown in many temperate and subtropical regions and is the most economically important vegetable crop in the world (Paris 1996). The squash along with other vegetables: cauliflower, cabbage, potato, green beans, cucurbits, etc. and are most common high value cash crops as they provide almost 5 to 10 times higher economic value (Pun & Karmacharya, 1998). In case of Nepal, there are several agro-climatic zones ranging from tropical to temperate which provides an opportunity to grow wide range of crops. Vegetable farming thus, has a tremendous potential on improving economic status of people. One of the reasons of low average national productivity is unavailability of suitable varieties which can give higher yield and also tolerant to diseases and pests. The varietal selection of summer squash has changed in recent years and the number of varieties offered has greatly expanded as the result of new interest in gardening, hybridization and the introduction of diseases resistance varieties. Around 240 kg, 180 kg and 60 kg per ha (Urea, DAP and MoP) with 30 tons manure are recommended for squash pumpkin which are142.8 kg, 82.8kg and 36 kg per ha N P and K respectively (MOALD, 2022). According to Lorenz and Maynard (1988) N-fertilizer for squash production is around 78 to 151 kg/ha. Yield increased with N from 0%N to 100% of recommended, which is 120 kg/ha combined with bio-stimulants (Pokluda et al., 2017). High amount of N fertilization may increase vigor and extend the plant cycle, delayed harvest, nitrate accumulation in plant tissues and contamination of environment (Kant et al. 2011). It is reported that higher stem height, stem diameter, leaf area, leaf number, no. of leaves was found in plants where 160 N kg/ha is applied, while Maximum edible fruit yield was obtained from plants subjected to 120 kg N per ha (on average 11.3 tons ha^{-1}) (Ng'etich et al. 2013). 150 lb./acre N, and 120 lb. per acre P2O5, and 120 lb. per acre K2O is recommended by UF/IFAS only when soil concentrations of phosphorus (P) or potassium (K) are very low in concentration, which is related to and based on results of Mehlich-1(M-1) soil testing (Hochmuth and Hanlon 1995). Applied N can be partially leached, so additional N can be applied for extended harvesting seasons (Simonne and Hochmuth 2010). Zucchini genotypes like: Anna-303, Anna-202, Sunny house, Grey Zucchini and some other are recommended for Terai and Mid Hill regions of Nepal, and yield of 36-40 tons/ha can be expected from Anna202 and Anna303, around 52 tons/ha from Sunny House, while 80 tons/ha from Grey Zucchini (MOALD, 2022). For flowering properties, research carried out shows that number of days to flowering varied as much as 20 days, depending on cultivar and flower sex and also genotypes had different HU (Heat Units) required for the onset of both staminate and pistillate flowers, environment can have remarkable influence on both the number of flowers produced and onset of flowering of summer squash (NeSmith, 1994).

MATERIALS AND METHODS

Experimental site and design: The experiment on zucchini (*Cucurbita pepo* L.) genotypes was conducted under NHRC for its growth and yield potential of best zucchini varieties during the year 2022, in spring season, from March to May, 2022. NHRC is the horticulture division of NARC Khumaltar, Lalitpur which lies on 1350 meter above sea level having sub-tropical climate. It was carried out on the field with the Randomized Complete Block Design.

Treatment details: Five genotypes of zucchini were taken for the experiment as treatments. Those varieties were Anna303 (T1), Grey Zucchini (T2), Anna202 (T3), Slesha1214 (T4), and Sunny house (T5 as a check variety). Each treatment was replicated 4 times.

Layout details:
Total no. of plots: 20
Plot size: 1.8 x 1 m
Row to row distance: 30cm

Plant to plant distance (within plot): 45cm
No. of plants on a plot: 2
Plot to plot distance (within a block): 20 cm
Size of the experimental site: 5m x 10m

Cultural operations and field activities:

- Seed sowing on poly bags
- Field preparation
- Fertilizer application
- Transplanting of seedlings
- Interculture operation
- Harvesting

Growth Parameters:

1. Days for 50% germination

Dates of germination of 50% seedlings of each genotype were recorded.

2. Plant height and number of leaves

Plant height was measured using measuring scale in cm, from the base of plant to tip on 30 DAT, 45 DAT, 60 DAT AND 75 DAT. Total number of leaves was counted in selected each plant at 30 DAT, 45 DAT, 60 DAT and 75 DAT. Dried and senescing leaves were excluded in counting in each observation.

3. Spreading of leaves

Plant spread were measured with the help of measuring tape at 30, 45, 60, 75 DAT. Plant covers were measured by measuring the two lengths of leaves cover one perpendicular to other (in cm)

4. Number of nodes and lobes per plant

Nodes of plants from all plots were counted. Lobes on leaves were counted too, considering the veins present on the leaves before the maturity stage.

5. Leaf length and leaf width

They were recorded once, measured in cm, before the maturity stage.

6. Petiole length

Petiole of fully developed fresh leaves attached to the plants was measured in cm. Data of petiole length was taken once, before the plants' maturity.

Flowering parameters:

1. Days to 50% flowering

Date of 50% flowering was recorded observing plants of each treatment. The average was then recorded and calculated.

2. Number of male flowers, female flowers and Male-to-female flower ratio

The total number male and female flower of the plant was counted for each treatment. After counting the both male and female flowers, flower ratio was calculated.

Yield attributing characters

1. Number of fruit per plant and days to harvest

Fruits harvested were counted and analyzed for each treatment by averaging. Date of the first harvest was noted and days of first harvest was calculated and analyzed.

2. Fruit length (cm), diameter (mm), shape and colour

Measuring scale was used on fruit length measurement. While, diameter was measured using Vernier caliper at the point of maximum thickness. The shape and colour of fruits were recorded by visual observation and were evaluated.

3. Fruit weight (kg), total yield per plant and yield per hectare

At the time of harvest, fruits were weighed. Total yield per plant was calculated by adding weight of total harvested fruits. In a same way, yield per hectare was calculated for each treatment.

4. Data entry and analysis

The collected data were entered in the sheet of Microsoft Excel sheet and was analyzed by using GENSTAT software package. Data were analyzed statistically by performing analysis of variance and means were separated using Duncan's Multiple Range Test at 5% level of significance.

RESULTS AND DISCUSSION

1. Days to 50% germination

Germination percentage of all genotypes was found more than 85%, except check genotype (Sunny House), which was lower than 70%. 50% germination was found sooner on the Anna202 and Anna303 (on 10 days) while Slesha1214 took slightly longer time (13 days) for germination.

2. Plant height and number of leaves

Height was measured on 15DAT, 30DAT, 45DAT and 60DAT. Plant height values for the evaluated genotypes ranged from 37.875 to 48.75 cm on 60 DAT. Tallest plant was that of Slesha1214, while the least plant height was observed in Sunny House, without significant differences between the tested genotypes. In all observations, there were no significant differences between the heights among the different treatments.

Likewise, there was no significance difference in the number of leaves regardless of time of observation, though Anna202 and Slesha1214 had slightly higher no of leaves (35.25) on 60 DAT.

3. Spreading of leaf

Two lengths were taken one perpendicular to other in cm on 15 DAT, 30 DAT, 45 DAT and 60 DAT. was no significant difference found among treatments on all observations. Slightly larger leaves spread was found on Slesha1214 (182.875cm) on 60DAT.

4. Number of nodes and lobes per plant

On 60 DAT, number of nodes and lobes were enumerated and recorded. Number of nodes ranged from 31.625 (Anna303) to 38 (Anna202). But there was no significant difference in number of nodes among treatments. In case of the lobes of leaf, there was significant variation between genotypes of zucchini. Anna303 (5.8) and Slesha1214 (5.7) had highest number of leaf lobes, while Grey zucchini had least number of lobes (4.75).

5. Leaf length and leaf width

There was no significant difference on the leaf width among treatments. But variation was remarkable in leaf length. Slesha1214 (25.6cm) and Anna303 (27cm) had the longest leaf (leaf length) and Grey zucchini (19.8cm) had shortest leaf.

6. Petiole length

There was significant difference on the petiole length among treatments. Anna202 (24.5cm) and Slesha1214 (26.2cm) had significantly longer and Grey zucchini (17.5cm) had shortest among them.

7. Days to 50% flowering

The data on days to 50% flowering revealed that the 50% of flowering period was not significant ($p>0.05$) among genotypes. Early flowering was observed in Anna202 (21.75 days) genotypes, while late flowering was in Sunny House (29.25 days) and rest of the genotypes days to 50% flowering was Anna303 (26.25days), Grey Zucchini (26.5 days) and Slesha1214 (24.0 days).

8. Number of male, female flowers and Male to female flower ratio

Highest male flowers were recorded in Anna303 (9.25) and lowest in Slesha1214 (7.25). While female flowers in Slesha1214 (15) was highest and lowest in Sunny House (12.5). However, number of male and female flowers was not significantly different among these genotypes. Summer squash like other cucurbits is monoecious in nature having separate male (staminate) and female (pistillate) flowers in same plant. Among the tested genotype significantly different male to female flower ratio was observed. High female per a male (1:2.11) was recorded in Slesha1214 followed by Anna202 and low proportion was observed in Anna303.

9. Number of fruits per plant and days to harvest

Total number of fruits was not found significantly different among genotypes. Lowest number (10.5) of fruits harvested from Sunny House whereas, highest number (13.75) from Slesha1214. Rests of the genotypes were found at par with the values of 11.0, 11.25 and 11.25. Anna202 was harvested earlier (29.25 days), while Sunny House was had taken more days to harvest (42 days) while rest of the genotypes were harvested between these two genotypes as Anna303 (35.5days), Grey Zucchini (39.5days) and Slesha1214 (32 days). But the difference was not significance enough at 5% level of significance.

10. Fruit length, diameter, shape and colour

5 representative fruits were taken for this measurement. Upon analysis, there were significant variations on the fruit length among treatments. Anna303 (109.075cm) had highest length, followed by Slesha1214 (98.7cm) and Grey zucchini (91.625cm) while shortest fruit length was observed on Anna 202 (67.275cm).

Anna202 (486.125mm) and Slesha1214 (486.125mm) had slightly higher fruit diameter, but there was no significant difference observed on fruit diameter between treatments.

The measurement of fruit shape was done simply with differentiating by their shapes, without use of any scale or number. Anna303 (T1) found shiny elongated and oblong in shape, Grey Zucchini (T2s) was elongated, Anna202 (T3) was round Slesha1214 (T4) elongated and Sunny House (T5) was curved in shape.

Color of the fruits was almost same for all treatments, and was green in color. Grey Zucchini (T2), Anna202 (T3) and Sunny House (T5) had same color that was dark green, while Anna303 (T1) was dark green and shiny in appearance, light green with shine was the color of Slesha1214 (T4).

11. Fruit weight (kg), total yield per plant and yield per hectare

Fruit of zucchini was weighed and analyzed for each treatment. On average, Slesha1214 (7.3595kg) had slightly higher fruit weight, while Sunny House (5.121kg) had lowest. But the variation was not significant at 5% level of significance. Yield per plant was calculated for each treatment but there was no significant difference observed between treatments. Data of yield per plant showed that yield was highest on Slesha1214 (3.67kg) and Sunny House (2.56kg) had minimum. Yield was estimated highest on Slesha1214 (40886.11kg/ha) and least on Sunny House (28449.99kg/ha), but variation was not considerable.

Table 1. Table showing results of different growth and flowering parameters in zucchini

Treatments	Height 60DAT	No. of leaves 60DAT	Spreading of leaves 60DAT	No. of nodes per plant	No. of lobes per plant	Leaf Length (cm)	Leaf Width (cm)	Petiole Length (cm)	Days to 50% flowering	Male and female flower ratio
Anna303 (T_1)	45.875^{a}	35^{a}	169.75^{a}	31.625^{a}	5.825^{c}	27.05^{c}	24.0625^{b}	24.375^{bc}	26.25^{ab}	(1:1.38)^{a}
Grey Zucchini (T_2)	44.5^{a}	33.875^{a}	141.625^{a}	37.375^{a}	4.925^{a}	19.8^{a}	18.375^{a}	17.75^{a}	26.5^{ab}	(1:1.87)^{ab}
Anna202 (T_3)	47.875^{a}	35.25^{a}	153.5^{a}	38^{a}	5.225^{ab}	20.3125^{ab}	21^{ab}	24.525b^{c}	21.75^{a}	(1:1.91)^{ab}
Slesha1214 (T_4)	48.75^{a}	35.25^{a}	182.875^{a}	34.5^{a}	5.725^{c}	25.65^{c}	25.35^{b}	26.2875^{c}	24^{ab}	(1:2.11)^{b}
Sunny House (T_5)	37.875^{a}	34.375^{a}	158.875^{a}	33.5^{a}	5.55^{bc}	23.625^{bc}	20.6875^{ab}	21.1875^{ab}	29.25^{b}	(1:1.58)^{ab}
Statistical Analysis										

Grand Mean	45.0	34.75	161.3	35.0	5.450	23.29	21.89	22.82	25.55	1.77
P-value	0.531	0.986	0.615	0.440	0.002	0.003	0.061	0.002	0.208	0.189
LSD	14.55	6.459	58.52	8.18	0.4052	3.625	4.947	3.642	6.619	0.658
CV%	21.0	12.1	23.5	15.2	4.8	10.1	14.7	10.4	16.8	24.1

Table 2. Table showing results of different yield parameters in zucchini

Treatments	Days to Harvest	Number of Fruit	Fruit Length (cm)	Fruit Diameter (mm)	Fruit weight(kg)	Yield per plant (Kg)	Yield per hectare (kg/ha)
Anna303(T_1)	35.5^{abc}	11^{a}	109.075^{c}	317.8225^{a}	6^{ab}	2.87^{ab}	31945.83^{ab}
Grey Zucchini(T_2)	39.5bc	11.25^{a}	91.625^{bc}	449.8125^{a}	5.369^{ab}	2.68^{ab}	29827.77^{ab}
Anna202(T_3)	29.25^{a}	11.25^{a}	67.275^{a}	486.125^{a}	6.7195^{ab}	3.35^{ab}	37330.55^{ab}
Slesha1214 (T_4)	32^{ab}	13.75^{a}	98.7^{bc}	486.125^{a}	7.3595^{b}	3.67^{b}	40886.11^{b}
Sunny House(T_5)	42^{c}	10.5^{a}	87.275^{b}	382.185^{a}	5.121^{a}	2.56^{a}	28449.99^{a}
Statistical analysis							
Grand Mean	35.6	11.55	90.8	398.	6.06	3.03	33688
P-value	0.051	0.216	0.008	0.288	0.108	0.108	0.108
LSD	8.97	3.000	19.89	178.1	1.883	0.432	10463.3
CV%	16.3	16.9	14.2	29.0	20.2	20.2	20.2

CONCLUSION

From this research, some ideas regarding the zucchini yield are obtained in case of sub-tropical mid-hill region. Further, the answers to the questions what to expect on cultivations, how much to expect from the common practices using both source of nutrients (fertilizers combined with manure) and difference in performances and yield between the different genotypes of zucchini (taken genotypes: Anna202, Grey Zucchini, Anna303, Slesha1214 and Sunny House)

They vary on number of leaf lobe, which are their varietal characteristics. They vary on petiole length and leaf length too. Due to their own varietal characteristics, they have some differences on fruits shape and color, while also fruit lengths among varieties differ considerably. Their remarkable yield and shorter planting-to-harvesting period are the reason it is recommended for cultivation and moreover, it can fetch good price in market. The climate on the mid-hills around 1350 meter above sea level was found appropriate for the cultivation of zucchini. The yield of the zucchini in normal conditions with the use of the manure and NPK fertilizers on hilly region (mid-hills more specifically) can be around 20,000 kg/ha to slightly more than 40,000 kg/ha. Higher yield (40886.11) is expected from Slesha1214, while least yield is expected from Sunny House (28449.99). Quick harvest can be expected from Anna202 (29.25 days) while Sunny House can take most time (42 days). Fruit length and colour and shape of the fruit vary between the genotypes. Also, there was significant variation on number of lobes, length of leaves and petiole length among the taken genotypes.

The genotypes showed variations and some of them are remarkable enough and can be helpful deciding best and appropriate varieties to cultivate and consume. While considering total yield, the focus on the consumer preferences, demands and its tastes should also be considered for the cultivation, for maximizing benefits.

SUGGESTIONS

- All of the zucchini genotypes can be cultivated commercially using both organic and inorganic source of nutrients.
- Zucchini cultivation is viable and economic for the cultivation on mid hill region provide that they should be protected from extreme rainfall and moisture stress.
- Slesha1214 genotype can be selected for cultivation among these evaluated genotypes considering its high yield.
- It is better to mulch the soil around the plants
- Plant protection measures should be implemented efficiently in order to control plant diseases and manage insect pest like: Aphids, Whitefly, Red pumpkin beetle, and vectors of plant viruses.
- Seeds, fertilizers, and other inputs should be well accessible and sufficient to the farmers for the cultivation and for optimal production and returns.

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EFFECT OF CANOPY TEMPERATURE AT FLOWERING STAGE ON DROUGHT TOLERANCE AND GRAIN YIELD OF RICE GENOTYPES

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ABSTRACT

Temperature change with concomitant change in canopy temperature influences crop growth and productivity. A two-years (2017 and 2018) experiment was carried on forty rice genotypes in alpha lattice design with three replications at Regional Agricultural Research Station, Tarahara. Canopy temperature was measured at flowering by infra-ray thermometer. The rice genotypes having canopy temperature found same or up to 1-degree higher than air temperature were drought tolerance and higher yield attributing traits and grain yield whereas higher canopy temperature genotypes were drought susceptible and lower yield attributing traits and grain yield.

Keywords: canopy, temperature, genotypes, yield

INTRODUCTION

Food security is threatened by global warming, which is also seen as a significant obstacle to meeting the demands of an expanding population in the twenty-first century. The recent increase in global warming has exposed a number of crops to higher temperatures, which has in turn significantly increased yields due to a variety of variables. According to earlier studies, global warming may considerably reduce the production of cereal crops. For instance, a 1°C increase in nighttime air temperature could result in a 10% drop in rice yield (Peng *et al*., 2004). Globally, the mean surface air temperature has risen by 0.74°C over the past 100 years and is expected to do so again by the end of the century. The stage most vulnerable to high-temperature stress has been identified as flowering, and reproductive outcomes have been causally connected to the ambient temperatures present during anthesis i.e., flower opening (Jagadish *et al*., 2007). A number of heat stress-sensitive processes, including anther dehiscence, pollination (Jagadish *et al*., 2010), pollen germination, and pollen tube growth occur during the roughly 45 minutes that rice flowers are open. Normally, fertilization is finished between 1.5 and 4 hours after anthesis (Cho, 1956). The response of biomass production is the primary predictor of yield fluctuations at temperatures below the maximum for rice. It has also been noted that biomass has a varying reaction to seasonal increases in air temperature; when the temperature rose from 25 to 27°C, the biomass fell by 16%. (Baker and Allen, 1993). When the temperature was raised from 25 to 31°C, there was no discernible difference in the biomass; however, when the temperature was raised from 25 to 28°C, the biomass grew by 13–16%. (Ohe *et al*., 2007).

One of the most important components of source strength is leaf photosynthesis. The photosynthetic rate is typically determined by the supply of carbon dioxide (CO_2) to the chloroplasts as well as the demand for CO_2 inside the chloroplasts. The CO_2 supply is controlled by the diffusion of CO_2 from the atmosphere through stomata. Stomatal conductance is one of the elements affecting the supply of CO_2 (Takai *et al*. 2013). It can be used as a measure of photosynthetic capacity and yield and is crucial for leaf photosynthesis and high yield potential in current crops. The rate of gas exchange is typically used to assess gas exchange rate (GSR), but this approach is time-consuming and labor-intensive, making it unsuitable for use in genetic analyses and breeding programs (Takai *et al*. 2010). The rate of evaporation or transpiration from the leaf is a key factor in determining leaf temperature; when stomata open and the evaporation rate rises, the temperature of the leaf decreases (Furbank *et al*. 2009). As a result, the temperature of leaves can be used to measure GSR and transpiration (Jones 2004). In addition to leaf temperature, canopy temperature depression (CTD), the difference in temperature between the canopy and the air, has been employed as a crop water status indicator and a GSR indicator (Fischer *et al*. 1998).

Rapid and non-destructive temperature measurements on the leaf or canopy can be made with infrared thermometers based on infrared thermometry and thermography (Jones 2004). According to O'Toole *et al*. (1984), the Crop Water Stress Index, which is based on infrared thermometry of canopy temperatures, is an effective way to measure water stress that is neither disruptive nor harmful. Plants stressed by a root-reducing treatment showed decreased photosynthesis, transpiration, and GS in their canopies, and infrared imaging demonstrated an inverse shift in canopy surface temperature. Infrared thermometry was previously used in investigations to locate a quantitative trait locus (QTL) for leaf temperature in rice under drought stress (Babu *et al*., 2003).

As the environment is always changing, it is important to take into account the dynamic nature of leaf temperatures in a study on leaf temperature because a wide variety of plant and environmental factors affect leaf or canopy temperature (Jones 2004). Jones (2004) stated that while improving measurements made in the field, resolution and sensitivity to climatic variables, thermal dynamics, spectral characteristics, the sun and view angle should be taken into account. By measuring leaf temperatures in conjunction with suitable reference temperatures, such as control plants or wet-and-dry reference surfaces, it may be possible to lessen the impact of environmental influences (Leinonen *et al*. 2006). Takai *et al*. (2010) suggested for accurate estimations of leaf or canopy temperature, using the canopy temperature differential (CTd), which is the variation in canopy temperature from a control plant. In this study, we know canopy temperature that exhibit high and low canopy temperatures in the field effect on drought tolerance and grain yield.

MATERIALS AND METHODS

Irrigated and reproductive water stress trail were conducted at Regional Agriculture Research Station (RARS), Tarahara during rainy seasons of 2017 to 2018. Total fourty genotypes in Advanced Yield Trial 100 to 120 day’s maturity were tested. Experiment was layout in Alpha lattice design with two replications. Twenty-five days old seedlings were transplanted with two to three seedlings per hill with 20 cm spacing between hills and between rows. Irrigation was applied at transplanting to until harvest for control condition. For Reproductive Stress (RS) experiments were four weeks late planted than control trials so as to synchronize the occurrence of drought stress at reproductive stage of the crop. The water from experiments was drained off 4 weeks (28 days) after transplanting to induce RS. Fertilizer applied @ 100:40:30 kg/ ha of N: P2O5 :K2O. Nitrogen was applied as urea (46% N) on two occasions (1/2 each at transplanting as a basal and at 30 days after transplanting), while the P2O5 and K2O were applied once as a basal application in form of Di- ammonium phosphate (DAP) (46% P and 18% N) and of Murate of Potash (60% K2O), respectively. Observations were recorded 3 time by infra ray thermometer from heading to flowering stage at day time (1-3 pm). Air temperature were recorded every 15 min interval. The data were fed into computer and statistically

analyzed using STAR Computer program. Likewise, tolerance index (STI) was calculated using the following formula:
(https://www.frontiersin.org/articles/10.3389/fpls.2016.01276/full"1992):
STI= $(Yp*Ys)/(Xp)^2$;

where Ys = grain yield of a test genotype under drought-stressed condition; Yp = grain yield of a test genotype under non-stressed condition, and Xp = mean yield of test genotypes under non-stressed condition.

RESULTS AND DISCUSSION

Canopy temperature differ than air temperature

In control trial, the canopy temperature found higher than air temperature in both years. Likewise, canopy temperature found same or up to 1-degree higher than air temperature found in stress tolerance genotypes whereas more than 2-degree higher canopy temperature found in stress susceptible genotypes at reproductive stress experiment (Figure 1). Genotypes IR 16L 1591, IR 16L 1661, IR 16L 1737, IR 16L 1755, IR 16L 1792, IR 16L 1606, IR 16L 1743, IR 16L 1601, Sukhkha dhan 6 and IR 74371-70-1-1 had lower canopy temperature whereas IR 16L 1801, IR 16L 1860, IR 16L 1619, IR 16L 1668, IR 16L 1815 and Sabitri had higher canopy temperature in reproductive stress condition.

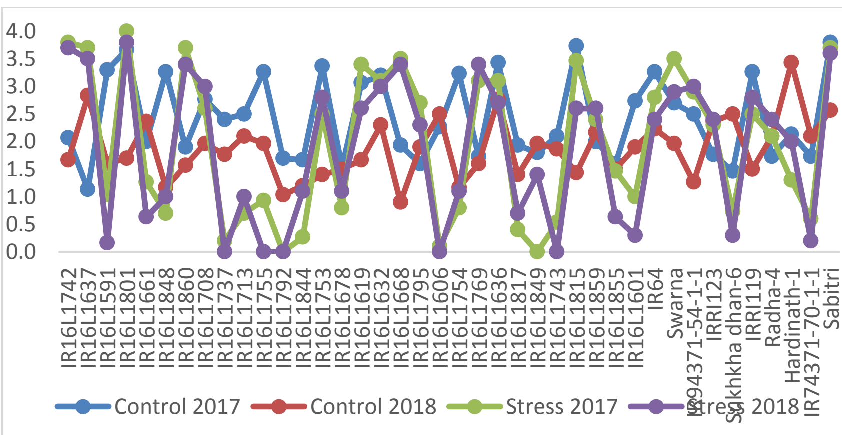

Figure 1. Difference of rice canopy temperature to air temperature in control and reproductive stress experiment during 2017 and 2018

Yield and yield attributes

Traits such as days to 50% flowering, plant height, panicle length, grain yield, straw yield and harvest index were found significant among genotypes in both year but tiller/m^2 and 1000 grain weight was found significant in 2017 and non-

Table 1. Performance of tested genotypes in Advance Yield Trial (AYT) 100-120 Control during 2017 at RARS, Tarahara

Genotypes	Days to flowering	Plant Height (cm)	Panicle length (cm)	Tiller/ m2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	HI
IR16L1742	93	101	23	221	4547	6247	22.7	0.42
IR16L1637	91	109	23	244	4541	5940	23.3	0.43
IR16L1591	88	111	23	230	4915	6277	23.3	0.44
IR16L1801	86	111	23	238	4972	6722	23.7	0.43
IR16L1661	88	106	23	261	4962	6494	22.7	0.43
IR16L1848	91	110	23	279	4670	6123	21.7	0.43
IR16L1860	91	113	23	254	4897	5716	23.0	0.46
IR16L1708	90	118	22	242	5082	6563	22.9	0.44
IR16L1737	90	121	23	190	5547	7296	24.3	0.43
IR16L1713	91	116	24	207	5724	7515	23.8	0.43
IR16L1755	89	111	24	226	5905	7158	23.6	0.45
IR16L1792	87	108	22	274	6293	6970	22.4	0.47
IR16L1844	87	109	22	263	5930	7618	21.7	0.44
IR16L1753	87	108	22	219	5448	8219	21.3	0.40
IR16L1678	87	105	23	223	4915	8372	21.9	0.37
IR16L1619	87	104	23	236	4818	7217	22.2	0.40
IR16L1632	87	105	24	271	4967	6356	22.3	0.44
IR16L1668	88	110	24	267	4936	5647	20.9	0.47
IR16L1795	88	108	24	457	4528	5850	20.4	0.44
IR16L1606	88	109	22	414	4637	6224	23.0	0.43
IR16L1754	88	110	23	418	4539	6695	25.4	0.40
IR16L1769	88	114	22	216	5097	7290	25.9	0.41
IR16L1636	88	119	23	286	4961	7401	25.0	0.40
IR16L1817	87	114	22	287	4785	6989	24.9	0.41
IR16L1849	87	112	23	298	4566	6484	24.7	0.41
IR16L1743	86	108	23	292	4490	6217	23.6	0.42
IR16L1815	86	106	22	287	4807	7089	23.3	0.40
IR16L1859	85	103	22	312	5024	7351	23.0	0.41
IR16L1855	87	106	22	302	5440	7886	25.3	0.41
IR16L1601	89	111	23	299	5241	7287	26.0	0.42
IR64	90	111	22	287	4777	6767	29.1	0.41
Swarna	91	105	20	251	4457	5687	26.2	0.44
IR94371-54-1-1	91	106	20	256	4534	5424	25.4	0.46
IRRI123	92	108	22	250	4773	5489	22.7	0.47
Sukhkha dhan-6	91	109	23	280	4666	5588	23.3	0.46
IRRI119	89	105	23	286	4654	5672	23.9	0.45
Radha-4	88	107	22	264	5037	6266	24.4	0.45
Hardinath-1	87	108	22	246	4940	6776	25.7	0.42

IR74371-70-1-1	87	105	21	261	5179	7758	25.8	0.40
Sabitri	87	101	21	273	5337	9214	25.8	0.37
F test	**	**	**	**NS**	**	**	*	**
LSD (0.05)	**7.82**	**11.62**	**2.40**	**0.00**	**1388.6**	**1888.97**	**2.22**	**0.07**
CV %	**2.51**	**6.01**	**6.37**	**25.94**	**12.93**	**17.39**	**12.72**	**7.38**

Table 2. Performance of tested genotypes in Advance Yield Trial (AYT) 100-120 Control during 2018 at RARS, Tarahara

Genotypes	Days to flowering	Plant Height (cm)	Panicle length (cm)	Tiller/m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 gr. wt. (g)	Harvest index
IR16L1742	89	96	25	238	4889	5838	24.1	0.46
IR16L1637	87	104	25	262	4883	5551	24.8	0.47
IR16L1591	84	106	25	247	5285	5866	24.8	0.47
IR16L1801	82	106	25	256	5346	6282	25.2	0.46
IR16L1661	84	101	25	281	5336	6069	24.1	0.47
IR16L1848	87	105	25	300	5022	5722	23.1	0.47
IR16L1860	87	108	25	273	5266	5342	24.5	0.49
IR16L1708	86	112	24	260	5465	6134	24.4	0.47
IR16L1737	86	115	25	204	5965	6819	25.9	0.47
IR16L1713	87	110	26	223	6155	7023	25.3	0.47
IR16L1755	85	106	26	243	6349	6690	25.1	0.49
IR16L1792	83	103	24	295	6767	6514	23.8	0.51
IR16L1844	83	104	24	283	6376	7120	23.1	0.48
IR16L1753	83	103	24	236	5858	7681	22.7	0.43
IR16L1678	83	100	25	240	5285	7824	23.3	0.4
IR16L1619	83	99	25	254	5181	6745	23.6	0.44
IR16L1632	83	100	26	291	5341	5940	23.7	0.48
IR16L1668	84	105	26	287	5308	5278	22.2	0.5
IR16L1795	84	103	26	491	4869	5467	21.7	0.47
IR16L1606	84	104	24	445	4986	5817	24.5	0.46
IR16L1754	84	105	25	449	4881	6257	27	0.44
IR16L1769	84	109	24	232	5481	6813	27.5	0.45
IR16L1636	84	113	25	307	5334	6917	26.6	0.44
IR16L1817	83	109	24	309	5145	6532	26.5	0.44
IR16L1849	83	107	25	320	4910	6060	26.3	0.45
IR16L1743	82	103	25	314	4828	5810	25.1	0.45
IR16L1815	82	101	24	309	5169	6625	24.8	0.44
IR16L1859	81	98	24	335	5402	6870	24.5	0.44
IR16L1855	83	101	24	325	5849	7370	26.9	0.44
IR16L1601	85	106	25	322	5636	6810	27.7	0.46
IR64	86	106	24	309	5137	6324	31	0.45
Swarna	87	100	22	270	4793	5315	27.9	0.48
IR94371-54-1-1	87	101	22	275	4875	5069	27	0.49
IRRI123	88	103	24	269	5132	5130	24.1	0.5
Sukhkha dhan-6	87	104	25	301	5017	5222	24.8	0.49
IRRI119	85	100	25	307	5004	5301	25.4	0.49
Radha-4	84	102	24	284	5416	5856	26	0.48
Hardinath-1	83	103	24	265	5312	6333	27.3	0.46

IR74371-70-1-1	83	100	23	281	5569	7250	27.4	0.43
Sabitri	83	96	23	294	5739	8611	27.4	0.41
F test	**	**	**	**NS**	**	**	**NS**	**
LSD (0.05)	**7.45**	**11.07**	**2.29**		**1322.5**	**1799.02**		**0.07**
CV %	**2.64**	**6.33**	**6.71**	**27.3**	**13.61**	**18.31**	**13.39**	**7.77**

Table 3. Performance of testing genotypes in Advance Yield Trial (AYT) 100-120 Reproductive Stress during 2017 at RARS, Tarahara

Genotypes	Days to flowering	Plant Height (cm)	Panicle length (cm)	Tiller/m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
IR16L1742	88	98	27	204	1429	4268	20.8	0.25
IR16L1637	84	107	24	172	1878	3836	22.4	0.33
IR16L1591	87	107	22	164	2983	3268	19.6	0.48
IR16L1801	91	102	24	199	1082	4529	21.7	0.19
IR16L1661	85	99	21	170	3308	4000	19.7	0.45
IR16L1848	89	97	23	214	2756	3492	19.4	0.44
IR16L1860	87	100	24	184	1350	3118	19.2	0.30
IR16L1708	86	112	23	157	1498	3405	23.7	0.31
IR16L1737	85	102	23	219	2801	3730	22.6	0.43
IR16L1713	87	99	24	195	2952	4047	22.0	0.42
IR16L1755	88	120	23	183	2638	4118	28.0	0.39
IR16L1792	88	98	23	188	2250	4255	22.4	0.35
IR16L1844	88	90	23	200	2805	4204	22.1	0.40
IR16L1753	89	95	22	189	1325	4573	23.6	0.22
IR16L1678	88	107	23	186	2716	3391	20.7	0.44
IR16L1619	88	90	22	178	1567	3512	20.6	0.31
IR16L1632	88	97	24	189	1420	3047	20.4	0.32
IR16L1668	87	100	23	228	1554	4021	21.0	0.28
IR16L1795	89	105	21	205	1626	3582	25.1	0.31
IR16L1606	88	89	25	213	3236	4542	23.6	0.42
IR16L1754	86	99	23	249	2920	4047	23.1	0.42
IR16L1769	86	103	23	146	1243	2967	22.3	0.30
IR16L1636	82	89	21	181	2081	2475	23.0	0.46
IR16L1817	90	91	22	239	3182	3656	21.3	0.47
IR16L1849	89	98	23	192	2939	3422	20.9	0.46
IR16L1743	87	105	25	206	3087	4144	23.3	0.43
IR16L1815	91	93	20	233	1579	3783	21.7	0.29
IR16L1859	91	98	20	201	1292	4733	19.6	0.21
IR16L1855	93	92	21	155	2545	4904	24.0	0.34
IR16L1601	86	112	24	196	2640	4051	21.7	0.39
IR64	89	100	22	188	1368	3502	21.9	0.28
Swarna	105	101	20	206	0	3288	0.0	0.00
IR94371-54-1-1	87	110	23	182	2755	3553	21.2	0.44
IRRI123	90	95	24	148	1588	4195	22.7	0.27
Sukhkha dhan-6	87	109	24	206	2981	4733	21.5	0.39
IRRI119	113	95	22	270	0	2613	0.0	0.00
Radha-4	92	102	23	203	2487	4630	22.2	0.35
Hardinath-1	82	104	24	160	2402	2957	21.6	0.45
IR74371-70-1-1	85	112	23	166	3251	3415	21.1	0.49

Sabitri	105	95	20	236	0	4583	0.0	0.00
F test	**	**	**	**	**	**	*	**
LSD (0.05)	**9.03**	**17.41**	**3.73**	**126.26**	**966.84**	**1510.45**	**2.36**	**0.10**
CV %	**3.55**	**6.09**	**5.06**	**20.15**	**17.10**	**15.91**	**19.07**	**8.82**

Table 4. Performance of testing genotypes in Advance Yield Trial (AYT) 100-120 Reproductive Stress during 2018 at RARS, Tarahara

Genotypes	Days to flowering	Plant Height (cm)	Panicle length (cm)	Tiller/m2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
IR16L1742	84	93	29	219	1630	4844	22.1	0.25
IR16L1637	80	102	26	185	1780	4354	23.8	0.29
IR16L1591	83	102	24	176	2885	3709	20.9	0.44
IR16L1801	87	97	26	214	1584	5140	23.1	0.24
IR16L1661	81	94	23	183	3310	4540	21.0	0.42
IR16L1848	85	92	25	230	2758	3963	20.6	0.41
IR16L1860	83	95	26	198	1532	3538	20.4	0.30
IR16L1708	82	107	25	169	1500	3865	25.2	0.28
IR16L1737	81	97	25	235	2803	4233	24.0	0.40
IR16L1713	83	94	26	210	2955	4594	23.4	0.39
IR16L1755	84	114	25	197	2640	4673	29.8	0.36
IR16L1792	84	93	25	202	2251	4829	23.8	0.32
IR16L1844	84	86	25	215	2807	4772	23.5	0.37
IR16L1753	85	90	24	203	1527	5190	25.1	0.23
IR16L1678	84	102	25	200	2718	3849	22.0	0.41
IR16L1619	84	86	24	191	1569	3986	21.9	0.28
IR16L1632	84	92	26	203	1422	3458	21.7	0.29
IR16L1668	83	95	25	245	1556	4563	22.3	0.25
IR16L1795	85	100	23	220	1628	4066	26.7	0.29
IR16L1606	84	85	27	229	3238	5155	25.1	0.39
IR16L1754	82	94	25	268	2922	4594	24.6	0.39
IR16L1769	82	98	25	157	1244	3367	23.7	0.27
IR16L1636	78	85	23	195	2082	2809	24.5	0.43
IR16L1817	86	87	24	257	3184	4149	22.7	0.43
IR16L1849	85	93	25	206	2941	3884	22.2	0.43
IR16L1743	83	100	27	221	3089	4704	24.8	0.40
IR16L1815	87	89	22	251	1380	4294	23.1	0.24
IR16L1859	87	93	22	216	1303	5372	20.8	0.20
IR16L1855	89	88	23	167	2547	5565	25.5	0.31
IR16L1601	82	107	26	211	2642	4598	23.1	0.36
IR64	85	95	24	202	1570	3975	23.3	0.28
Swarna	100	96	22	221	0	3732	0	0.00
IR94371-54-1-1	83	105	25	196	2757	4032	22.5	0.41
IRRI123	86	90	26	159	1790	4761	24.1	0.27
Sukhkha dhan-6	83	104	26	221	2983	5372	22.9	0.36
IRRI119	108	90	24	290	0	2965	0	0.00
Radha-4	88	97	25	218	2489	5255	23.6	0.32
Hardinath-1	78	99	26	172	2404	3356	23.0	0.42

IR74371-70-1-1	81	107	25	179	3253	3876	22.4	0.46
Sabitri	100	90	22	254	0	5201	0	0
F test	**	**	**	*	**	**	ns	**
LSD (0.05)	9.5	18.33	3.93	132.9	1165.09	1429.58		0.1
CV %	3.38	5.8	4.82	19.19	16.29	15.15	18.16	8.4

significant in 2018. Genotypes IR16L1859 flowered earlier whereas IR16L1742 had late flowering (Table 1 and 2). Likewise, genotype IR16L1742 had dwarf plant and IR16L1737 had taller plant. Similarly, IR16L1792, IR16L1844, IR16L1755 and IR16L1713 produced higher grain yield. The highest straw producing genotypes were Sabitri, IR16L1678, IR16L1753, IR16L1855, IR74371-70-1-1, IR16L1844 and IR16L1713.

REPRODUCTIVE STRESS

Traits such as days to 50% flowering, plant height, panicle length, grain yield, straw yield and harvest index were found significant among genotypes in both year but 1000 grain weight found significant in 2017 and non-significant in 2018. Check variety Hardinath 1 flowered earlier and genotypes IRRI 119 had late flowering (Table 3 and 4). Likewise, genotypes IR16L1636 had dwarf plant and genotype IR16L1755 had taller plant. Similarly, among tested genotypes; IR16L1661, IR74371-70-1-1, IR16L1606, IR16L1817 and IR16L1743 were found promising that produced higher grain yield in severe drought condition where check varieties Sabari, IRRI 119 and Swarna unable to grain formation. Similarly, highest straw yields producing genotypes were IR16L1855, Sukhkha dhan-6 and IR16L1859. Genotypes IR74371-70-1-1 had harvest index. Same as genotype IR16L1860 had fine grain than other.

Relationship of canopy temperature with stress tolerance index

The stress tolerance index (STI) was found higher (more than 50) when the canopy temperature is less than 2 degrees higher than air temperature and lower STI in more than 2-degree higher canopy temperature than air temperature on reproductive drought stress condition. The linear regression coefficient slope is negative (-0.1217) and correlation coefficient is 0.706. Therefore, there is an inverse relationship between canopy temperature and stress tolerance index.

DISCUSSION

In control trail, water supply was sufficient, so the plant transpires more in higher temperature for maintaining plant physiological activities. Higher transpiration means higher canopy temperature due to water vapors present in leaf surface (Farooq *et al*., 2009). Whereas in water shortage condition, plant close stomata for reducing transpiration and maintain the water level in plant body. Stomatal closure is a key factor to control the transpiration during drought stress in rice. Under drought stress, rice plants close their stomata, and hence there is a negative correlation between stomatal conductance and drought stress (An et al., 2019). In other hand, Genotypes unable to close stomata caused more transpiration and suffer from water stress. More water loss from plant, increased concentrations of solutes may become toxic, thereby affecting the functioning of some enzymes, including those required for photosynthetic machinery (Hoekstra et al., 2001).

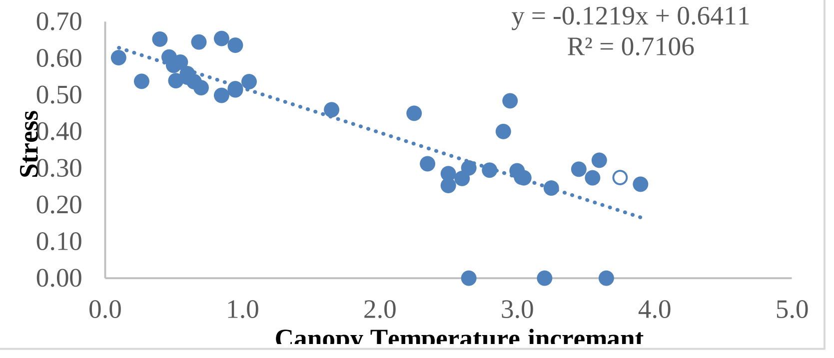

Figure 2. Regression line showing relationship between canopy temperature and stress tolerance index

CONCLUSION

Genotypes IR16L1755, IR16L1737, IR16L1591, IR16L1713, IR16L1743, IR74371-70-1-1 and IR16L1817 found drought tolerant. Likewise, Rice genotypes having canopy temperature found same or up to 1-degree higher than air temperature were drought tolerance.

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YIELD STABILITY AND GENOTYPE X ENVIRONMENT INTERACTION OF LENTIL

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ABSTRACT

Plant breeders choose the best genotype through GE interactions while assessing variety in various environments. The objective of this study was to evaluate the genotype by environment interaction using the additive main effects and multiplicative interaction model for a yield of lentil genotypes. The study was carried out for two consecutive years, 2017 and 2018 at four locations, Banke, Chitwan, Surkhet, and Doti districts. The experiments were laid out in a randomized complete block design with three replications. The result of the combined analysis of variance of the yield of 15 lentil genotypes showed that there were highly significant differences among the environments, genotypes and GE interaction. The 33 +33=66 % of the total yield variation was explained by the environment, 8.9 % by a difference among the genotypes and 25.5 % by GE interaction. The yield ranged from 1217 kg/ha to 824 kg/ha. The mean yield of seven genotypes ILL10061, ILL10065, ILL10853, ILL10856, ILL9924, NR-2001-71-3 and RL-55 produced more than the average yield of check variety Sagun 1066 kg/ha. The genotypes with high stability (NR-2001-71-3) and the highest mean yield (ILL10065) could be recommended for further inclusion in the breeding program.

Keywords: AMMI; Genotypes; Lentil; Stability, Yield

INTRODUCTION

The major pulse crop in Nepal is lentil, which accounting for 62.64% of the area and 64.35% of the production of all pulses (Darai et al. 2017). Nepal is the world's fifth-largest producer of lentils, after Canada, India, Australia, and Turkey (FAO, 2019). In Nepal, there were fourteen improved lentil varieties have been released for farmer's cultivation. To official variety release Coordinated Varietal Trail (CVT) was evaluated in multi-environments. Genotype-environment (GE) interaction is necessary to choose the best genotypes for the tested environments (Annicchiarico, 2002; Kang, 1998; Karimizadeh et al., 2012a; Yan et al., 2007).

GE interaction refers to the different ranking of genotypes across environments and may complement the selection process and recommendation of a genotype for a target environment (Bocianowski et al. 2019, Ebdon and Gauch, 2002. Cross-over GE interactions hinder the selection process of breeders (Gauch, 2006). A genotype's performance might vary from one environment to another, and genotypes that perform better in one environment might not be better in another (GE)) (Makumbi et al. 2015; Baker 1988; Beyene et al., 2011). Currently, the most popular analytical approach for analyzing and estimating GE interaction in multi-environmental trials is the additive main effects and multiplicative interaction (AMMI) model (Zhang et al., 1998; Gauch 2013; Veenstra et al., 2019). This reduces the correlation between phenotypes and genotypes, complicating breeding and selection of superior cultivars (Makumbi et al. 2015). The objective of the trial was to evaluate the lentil genotypes for higher yield and identify the most stable genotypes for the variety release.

MATERIALS AND METHODS

A total of 15 lentil genotypes were evaluated at four locations in the mid and west parts of Nepal. The trial was conducted in the winter season in four locations Rampur, Khajura, Surkhet and Doti for two consecutive years 2017 and 2018. The experiment was carried out in a Randomized Block Design in 4 m2 plot size with three replications. Trial sets were prepared after seeds were treated with Bavistin@2.5 g/kg. Pre-emergence herbicide i.e Pendamethaline 5ml/liter of water followed by one hand weeding after 25-30 days after sowing used for weed management.

Description of the Study Sites of G x E interaction trial was at Khajura, Banke $81^{0}37$" East longitude and $28^{0}06$" North latitude and an altitude of 181 meters above mean sea level (masl), Rampur, Chitwan $84^{0}19$" E and $27^{0}40$" N and an altitude of 228 masl, Surkhet $81^{0}47$" E and $28^{0}3$" N and an altitude of 580 masl and Doti at the $81^{0}47$"E and $29^{0}15$''N and as well altitude 600 masl.

Statistical analysis: Recorded data from all four locations were analyzed by using R-stat. Duncan's Multiple Range Test (DMRT) was used for mean arrangement. The AMMI model was created from the main effects of genotypes, environments and the IPCA scores. The AMMI model method was employed to investigate the grain yield. The biplot was drawn by placing the overall mean on the X-axis and the respective score (IPCA1) on Y-axis. The AMMI analysis first fits additive effects for genotypes and environments by the usual additive analysis of variance procedure and then fits multiplicative effects for GE interaction by principal component analysis (PCA). The AMMI model equation following (Zobel et al., 1988) is the response of the genotypes to different environments.

$$Y_{ij} = \mu + G_i + E_j + n\Sigma\, \lambda_k\, \alpha_{ik}\, \gamma_{jk} + \epsilon_{ij}$$

Where, Y_{ij} is the yield of the i^{th} genotype in the j^{th} environment; μ is the grand mean; G_i and E_j are the genotype and the environment deviations from the grand mean, respectively; λ_k is the Eigenvalue of the PCA axis k; α_{ik} and γ_{jk} are the genotype and environment principal component scores for axis k; n is the number of PCA axes considered and ϵ_{ij} is the residual term which includes the experimental error.

The additive part of the AMMI model (μ, G_i and E_i) was estimated from an analysis of variance and the multiplicative part (λ_k, α_{ik}, and γ_{jk}) was from the principal component analysis. The interaction between any genotype and environment was estimated by multiplying the score for the interaction principal component axis (IPCA) of a genotype by an environment IPCA score (Van et al., 1993). The greater the IPCA (Interaction Principal Component Axis) scores, either negative or positive, indicated the specific adaptation of a genotype to a certain environments.

The AMMI model 1 biplot was generated from the main effect and first multiplicative axis term (IPCA-I) of both genotypes and environments. The abscissa shows the main effects and the ordinate shows the IPCA1 scores that capture interaction effects. The greater the IPCA scores, either negative or positive, the more specifically adapted a genotype to a certain environment. The more the IPCA scores tend towards zero, the more stable the genotype is over all the environments (Crossa, 1990).

Genotypes or environments appearing almost on a perpendicular line have similar means and those falling almost on a horizontal line have similar interaction patterns.

AMMI-based stability indices: This function computes the following AMMI-based stability indexes: ASV, AMMI stability value (Purchase et al., 2000); SIPC, sums of the absolute value of the IPCA scores (Sneller et al. 1997); EV, averages of the squared eigenvector values (Bose et al., 2014); and Za, the absolute value of the relative contribution of IPCAs to the interaction (Sneller et al., 1997), and WAAS, a weighted average of absolute scores (Zali et al., 2012).

The ASV index is calculated as follows:

$$ASV_i = \left[\left[\frac{r\lambda_1^2}{r\lambda_2^2} \times \left(\lambda_1^{0.5} a_{i1} t_{j1}\right)\right]^2 + \left(\lambda_2^{0.5} a_{i2} t_{j2}\right)\right]^2$$

Where r is the number of replications included in the analysis,

The SIPC index is calculated as follows:

$$\mathrm{SIPC_i} = \sum_{\mathrm{k=1}}^{\mathrm{p}} \left|\lambda_{\mathrm{k}}^{0.5} \mathrm{a_{ik}}\right|$$

Where P is the number of IPCA retained via F-tests.

The EV index is calculated as follows:

$$\mathrm{EV_i} = \sum_{\mathrm{k=1}}^{\mathrm{p}} a_{ik}^2 / P$$

The ZA index is calculated as follows

$$\mathrm{Za_i} = \sum_{\mathrm{k=1}}^{\mathrm{p}} \theta_k a_{ik}^2$$

Where θ_k is the percentage sum of squares explained by the kth IPCA

$$WAAS_i = \sum_{k=1}^{p} \left|IPCA_{ik} \times EP_k\right| / \sum_{k=1}^{p} EP_k$$

Where WAASi is the weighted average of absolute scores of the *i*th genotype; PCAik is the score of the *i*th genotype in the *k*th IPCA; and EPk is the explained variance of the *k*th IPCA for *k = 1,2,..,p*, considering *p* the number of significant PCAs.

Five simultaneous selection indexes (ssi) are also computed by summation of the ranks of the ASV, SIPC, EV and Za indexes and the ranks of the mean yields (Sneller et al., 1997) which results in ssiASV, ssiSIPC, ssiEV, ssiZa, and ssiWAAS, respectively.

Yield stability index (YSI): The YSI was computed by the following formula as suggested by (Crossa, 1990):

YSI = RASV+RY

Where RASV is the rank of AMMI stability value and RY is the rank of mean grain yield of genotypes across environments. YSI incorporates both mean yield and stability in a single criterion. Low values of the parameter show desirable genotypes with high mean yield and stability.

RESULTS AND DISCUSSION

Combined AMMI analysis of Variance: Additive Main Effects and Multiplicative Interaction (AMMI) which combines Analysis of Variance (ANOVA) and Principal Component Analysis (PCAs) in the analysis of GE, has proven to be a powerful tool in the identification of patterns of interaction (Olivoto et al., 2019). A combined analysis of variance for grain yield revealed that 15 lentil genotypes in 4 environments showed highly significant differences among the environments and GE interaction. Sum squares for environments and replication as environments illustrated 33 % each of the total and these factors had the highest effect on the yield. The difference between genotypes represented 8.9 %. The first principal component of interaction (IPCA1) showed highly significant out of three principal components The grain yield varied from (241 kg/ha) by RL-44 at Surkhet to (1706 kg/ha) by ILL ILL10065 in Khajura condition. The maximum average yield was recorded in the Khajura condition (1389 kg/ha) however minimum average yield (722 kg/ha) was recorded in the Doti condition. The highest yield across the four locations was produced by the genotype ILL10065 (1217 kg/ha) followed by ILL10856 (1196 kg/ha) (Table 2). of interaction (Table 1). Many studies on the other crops that showed the significant difference in G x E interactions, (Veenstra et al., 2019) in pea, (Krualee et al., 2012) in wheat, (Verma, 2020) in field pea genotypes reported significant differences among the environments, genotypes and GE interactions.

Stability only is not a suitable selection criterion as stable genotypes may not be high yielders, simultaneous use of yield and stability in a single measure is essential (Ersullo L.J. 2016; Kang 1993). The Simultaneous selection index also referred to as genotype stability index (GSI) or yield stability index (YSI) (Farshadfar et al., 2008) was computed by adding the ranks of stability measure and the average yield of genotypes.

Table 1. AMMI analysis of variance over four environments for yield

Source	Df	Sum sq	Mean sq	F-statistic	Variability explained (%)
ENV	3	6735750	2245250	1.31**	33.0
REP (ENV)	4	6845799	1711450	30.92***	33.0
GEN	14	1850886	132206	2.39**	8.9
GEN:ENV	42	5286922	125879	2.27***	25.1
IPCA1	16	4535498	283469	5.12***	83.7
IPCA2	14	575392	41099	0.74	11.5
IPCA3	12	176031	14669	0.27	3.3
Residuals	56	3099714	55352	0.27	
Total	161	29105991	180783		

Table 2. Grain yield performance of 15 lentil genotype at 4 environments

S. N.	Genotypes	Doti	Khajura	Rampur	Surkhet	Mean Yield
1	ILL10045	659	1051	886	1229	956cde
2	ILL10061	780	1396	1024	1412	1153abc
3	ILL10065	763	1706	960	1440	1217a
4	ILL10853	774	1476	977	1219	1111abc
5	ILL10856	826	1649	928	1383	1196ab
6	ILL2437	681	1639	910	879	1027abcde
7	ILL6458	736	1283	1089	1386	1124abc
8	ILL8010	743	1276	819	1075	978bcde
9	ILL9924	695	1412	1094	1318	1130abc
10	NR-2001-71-3	741	1488	1041	1157	1107abc
11	RL-44	688	1311	1213	241	863de
12	RL-45	551	1313	1181	256	825e
13	RL-55	685	1293	915	1467	1090abcd
14	RL-67	624	1240	1180	251	824e
15	Sagun	881	1298	840	1247	1066abcd
	Mean	722	1389	1004	1064	1045

The observed G x E interactions in the AMMI model has been segregated among the first and second IPCA. Interaction Principal Component Axes) accounting for 83.7 % and 11.47 % respectively, together explaining 95.17 of the total variation.

Stability analysis: The genotypes having higher IPCA scores, either positive or negative are more specifically adapted to specific environments and those with lower IPCA scores designate a more stable genotype in all tested environments (Farshadfar et al., 2011). Similarly, genotypes with larger IPCA1 such as RL44 (19.8%), followed by RL-45 and RL-67 same value (18.6%) were the more responsive and contributed largely to the interaction component and may be considered as certain adapted genotypes in contrast NR-2001-71-3 (0.9), ILL10853 and ILL8010 were the least contribution to the interaction component as they are with smaller IPCA1 and mapped near to the bi-plot origin indicating that wider adaptability or stability (Table 3). The ASV distance is the distance from the coordinate point to the origin in a two-dimensional scatter diagram of an IPCA score against IPCA2 scores in the AMMI model (Baraki et al., 2014). ASV revealed that genotypes NR-2001-71-3, ILL10853 and ILL6458 had lower measures that showed stable performance while RL-44 showed the least stable performance. IPCA value of lentil genotypes was negative.

Table 3. Measures of stability of lentil genotypes as per AMMI analysis

Genotype	GY	IPCA1	IPCA2	IPCA3	ASV	YSI	rASV	rYSI	EV	ZA	SIPC	WAASB
ILL10045	956	7.0	10.0	1.5	56.0	23	11	12	0.032	0.16	7.0	3.56
ILL10061	1153	7.0	2.7	-1.6	55.0	13	10	3	0.032	0.15	7.0	5.34
ILL10065	1217	6.9	-9.8	-3.7	55.0	10	9	1	0.031	0.15	6.9	7.11
ILL10853	1111	3.0	-2.4	0.8	24.1	8	2	6	0.006	0.07	3.0	2.81
ILL10856	1196	6.1	-8.3	1.4	49.1	9	7	2	0.025	0.14	6.1	6.26
ILL2437	1027	-3.9	-12.5	0.5	33.1	14	4	10	0.010	0.09	3.9	3.2
ILL6458	1124	6.3	7.7	-4.3	50.3	13	8	5	0.027	0.14	6.3	5.01
ILL8010	978	3.1	0.2	7.2	24.5	14	3	11	0.006	0.07	3.1	1.3
ILL9924	1130	4.3	2.5	-6.9	33.8	9	5	4	0.012	0.09	4.3	3.64
NR-2001-71-3	1107	0.9	-2.0	-2.1	7.7	8	1	7	0.001	0.02	0.9	1.79
RL-44	863	-19.8	2.2	2.2	156.4	28	15	13	0.261	0.44	19.8	13.04
RL-45	825	-18.6	0.5	-3.8	146.8	27	13	14	0.230	0.41	18.6	12.9
RL-55	1090	10.4	3.6	-2.8	82.1	20	12	8	0.072	0.23	10.4	6.54
RL-67	824	-18.6	3.6	0.5	146.9	29	14	15	0.230	0.41	18.6	13.08
Sagun	1066	5.9	2.0	11.2	46.6	15	6	9	0.023	0.13	5.9	3.91

The minimum value of EV showed by NR-2001-71-3 followed by ILL8010 and ILL10853 however, the maximum value was recorded by the genotype RL-44. The lower value of SIPC was recorded in NR-2001-71-3 followed by ILL10853 and ILL8010 as the most stable genotypes; however, genotype RL 44 is the lowest stable genotype. ZA value showed the minor values NR-2001-71-3, NR-2001-71-3 and ILL10853 have higher stability, whereas RL-44 with least stability. The stable nature of genotypes such as ILL6458, NR-2001-71-3 and

ILL6458 was confirmed with the lowest WAASB value for considered locations (Krualee et al., 2012). The yield range in the yield stability index indicated that the genotypes ILL10065 produced the highest yield followed by ILL10856 and ILL10061 and the check as good variation had been observed from 824 to 1217 kg/ha. According to AMMI selections of genotypes for the testing environments (Table 4), the highest yielding genotype ILL10065 and ILL10856 were recommended for 3 environments. Similarly, ILL10061 for Doti and Surkhet, ILL10853 for Doti and Khajura, ILL6458 for Rampur and Surkhet, Sagun for Doti, genotypes ILL2437 and NR-2001-71-3 for Khajura, RL-44, RL-45, RL-67 and ILL9924 for Rampur and RL-55 for Surkhet.

Table 4. The first five AMMI selections of genotypes for the testing environments

Environment	Selected genotypes per locations				
	1	2	3	4	5
Doti	Sagun	ILL10856	ILL10061	ILL10853	ILL10065
Khajura	ILL10065	ILL10856	ILL2437	NR-2001-71-3	ILL10853
Rampur	RL-44	RL-45	RL-67	ILL9924	ILL6458
Surkhet	RL-55	ILL10065	ILL10061	ILL6458	ILL10856

Biplots are graphs where both genotypes and environments are represented on the same axes so that interrelationships can be visualized.

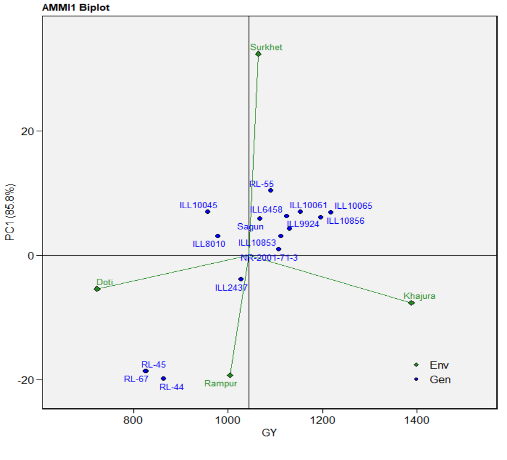

Figure 1. Biplot of the first component axis AMMI1 versus grain yield

The AMMI biplots were created by the use of IPCA components and mean grain yield. In the AMMI1 biplot, genotypes found in the same quadrants show similar adaptations similarly environments also influence genotypes when they are grouped under the same quadrants. In the present study, RL55, ILL6458, ILL10061, ILL10065, ILL9924, ILL10856, ILL10853, NR-2001-71-3, and Sagun gave a higher grain yield than the mean value (Figure 1). This showed that these genotypes are less affected by GE interaction. The small green arrow in Figure 2 represents the "mean environment", which is an environment, built on the coordinate means for all environments in the analysis. The green line in Figure 2 with the arrow passing through the origin represents the "mean-environment axis" and the direction in which the arrows point represents a higher mean yield for the genotypes. The second axis represents stability; genotypes that are closer to the origin are more stable (Purchase J.L. 1997; Yan W, 2011). Genotype NR 2001-71-3, by ILL 10853, ILL10856 and ILL 10065 were showed more stable with higher yield however RL-67, RL-57 and RL-45 were less stable with lower yield.

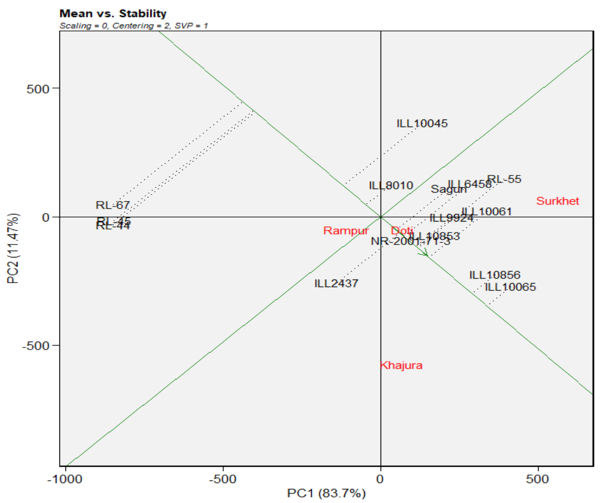

Figure 2. The mean vs. stability view of GGE biplot based on principal components.

In Figure 3, the center of the concentric circles is where an ideal genotype (high mean yield and the most stable one).

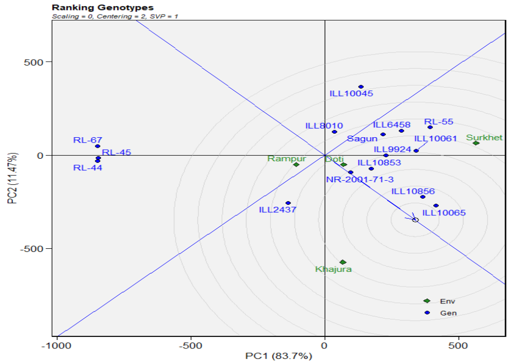

Figure 3. GGE-biplot based on genotype focused scaling for comparison of the genotypes with the ideal genotype. Ranking of genotypes

Therefore, genotype ILL10065 following to genotypes ILL10856 were closest to the concentric center. Also, genotypes NR-2001-71-3 and ILL10853 were stable and different from other genotypes and RL-67, RL-57 and RL-45 were apparently inferior.

CONCLUSION

The mean yield of 7 genotypes ILL10061, ILL10065, ILL10853, ILL10856, ILL9924, NR-2001-71-3 and RL-55 produced more than the average yield of Sagun 1066 kg/ha. The AMMI model and yield would be useful as compared to measures that consider either the AMMI or yield of genotypes only. Based on the measures ASV, EV, ZA, SIPC and WAASB, genotype NR-2001-71-3 is the most stable genotype followed by ILL10853 and ILL8010 are the recommendable across environment.

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INFLUENCE OF TIME OF POTASSIUM APPLICATION ON YIELD AND YIELD RELATED TRAITS OF HYBRID RICE VARIETIES

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ABSTRACT

Effect of time of potash application on the yield and yield components of hybrid rice varieties was studied at Directorate of Agricultural Research, Province 1, Tarahara during Rainy season of two years i.e., 2019 and 2020. The four time of potassium application (45 kg P at basal (Farmer practice), 30kg P at basal+15 kg P at PI stage, 60 kg P at basal and 45kg P at basal+ 15 kg P at PI) and five hybrid varieties (Hardinath Hybrid 1, Hardinath Hybrid 3, MRP 5433, MRP 5566 and MRP 5569) were tested in split plot design with three replications. Nitrogen and phosphorus fertilizers were applied at the rate of 100:60 NP kg/ha. Total phosphorus half Nitrogen were applied during final land preparation. The remaining half N was top dressed into two splits at tillering and panicle initiation stage of crop. All the other cultural practices were followed as per the requirement. The results showed genetic differences and interaction effect of genotypes with potassium management on days to 80% maturing, panicle length, grain yield, straw yield, 1000 grain weight and harvest index. Increasing the potassium and split dose found increase maturity time and panicle length. Similarly, potassium application on 45 kg at basal and 15 kg at PI stage gave higher grain yield, straw yield and 1000 grain weight. Similarly, split application increased harvest index than whole dose at basal. In case of varieties, MRP 5569 produced higher yield among varieties on all potassium application and not affected by potassium application methods. However, other 4 varieties (Hardinath Hybrid 1, Hardinath Hybrid 3, MRP 5433 and MRP 5566) produced significantly higher yield on 45 kg at basal and 15 kg at PI stage.

Key words: Potassium, hybrid rice, yield and yield traits.

INTRODUCTION

Rice is cultivated in three distinct agro-ecological regions viz., Terai, mid hill and high hill with respective shares of 68, 28, and 4%. (MoALD, 2020). In Nepal, rice consumption per person is 138 kg, and it accounts for 16% of the country's agricultural GDP and 52% of all grain consumption (Yadav and Chaudhary, 2017). In terms of global rice yield and production, Nepal comes in at number 64. Although on par with India (3.7 t ha) and Pakistan (3.5 t ha), Nepal's rice sub-sector productivity (3.5 t ha) is less than that of its neighbors Bangladesh (4.4 t ha) and China (6.7 t ha). Between 1960 and 2017, Nepal's rice output increased annually at a rate of 1.14%, which is significantly lower than that of its neighbors, including India (2.5%), Bangladesh (3%) and China (4.2%), as well as the global average of 4.5% (FAOSTAT, 2019).

An ineffective nutrient management method may result in nutrient imbalance in the soil, which will negatively impact crop yield. The use of nitrogen (N) and phosphorus (P) fertilizers has steadily increased as a result of the introduction of high-yielding crop types and hybrids during the green revolution and the gradual intensification of agriculture. The neglect of potassium (K) fertilizer caused the soil's potassium reserves to be depleted and crops to become deficient in K, which is now a limiting dietary component for growing rice output (Yang *et al*., 2003). Rice is the plant food that absorbs potassium the most readily, which is an important macronutrient for plant growth and reproduction (Fageria *et al*., 2011). It plays a significant role in plants and activates plant enzymes, maintains cell turgor, improves photosynthesis, decreases respiration, aids in the transport of sugars and starches, aids in nitrogen uptake, improves crop quality, strengthens straw, and increases disease resistance against pests and diseases in addition to assisting the plant in withstanding stress. The establishment, growth, and production of crops are constrained by potassium deficiency (Rengel and Damon, 2008). According to Liu *et al.* (2009), modern high-yielding rice varieties extract a significantly higher amount of K than phosphorus or even nitrogen. For maximum commercial output in the Indo-Gangetic Plains (IGP), high-yielding rice cultivars needed fertilizer K ranging from 75 to 101 kg ha-1 (Tiwari *et al.*, 2006). The right potassium doses and treatment methods at the right time of crop growth are crucial. The timing of fertilizer application has a significant impact on how well crops respond to fertilizer. Understanding the fate of applied nutrients and their impact on crop production is essential for developing strategies to increase the availability and efficiency of nutrients. An excellent opportunity to improve K use efficiency is provided by increased crop yield achieved by increasing the rate, timing, and management of K fertilizers. This experiment was carried out with the aim of identify appropriate potassium dose and time in association with suitable genotypes in eastern terai environment.

MATERIALS AND METHODS

A field experiment during rainy season of year 2019 and 2020 were carried out at research farm of Directorate of Agricultural Research, Tarahara to find the optimum level of potassium and its proper time of application with respect to yield of rice. The experimental site was situated in the Eastern terai region of Nepal. That was at an altitude of 136 meters above the mean sea level. Climate is characterized by sub-tropical, hot desiccating summer, cold winter, and moderate rainfall. The mean weekly average maximum temperatures varied from 28.8 to 34 °C and minimum 9.5 to 26.8 °C. Total rainfall during cropping period was 750 mm.

Treatments comprised of four levels of potassium application i.e. 45 kg/ha at basal (FP), 30 kg/ha at basal + 15 kg/ha at PI, 60 kg/ha at basal and 45 kg at basal + 15 kg at PI and five hybrid varieties i.e., Hardinath hybrid 1, Hardinath hybrid 3, MRP 5433, MRP 5566 and MRP 5569. The treatments were replicated thrice under split plot design (SPD) with a net plot size of 5 m × 2 m. For transplanting of rice, 21 days old seedling was transplanted in a well puddled plot at a density of 1-2 seedlings per hill with spacing 20 cm × 20 cm. The recommended dose of fertilizer @ 150:50 kg ha-1 of NP was applied using Urea, DAP and the level and time of potassium fertilizer application was followed as per the treatment details by using MOP.

RESULTS AND DISCUSSION

There were genetic differences and interaction effect of genotypes with potassium management on days to 80% maturing, panicle length, grain yield, straw yield, 1000 grain weight and harvest index. Increasing the potassium and split dose found increase maturity time and panicle length (Table 1). Likewise, 60 kg at basal increase plant height and tiller number. Similarly, potassium application on 45 kg at basal and 15 kg at PI stage gave higher grain yield, straw yield and 1000 grain weight. Similarly, split application increased harvest index than whole dose at basal. In case of varieties, Hardinath Hybrid 1 and MRP 5566 produced significantly higher yield. In case of interaction of potassium and varieties Hardinath Hybrid 1 and MRP 5569 gave higher grain yield on 45 kg at basal and 15 kg at PI stage (Table 2). The results showed genetic differences and interaction effect of genotypes with potassium management on days to 80%

maturing, panicle length, grain yield, straw yield, 1000 grain weight and harvest index. Increasing the potassium and split dose found increase maturity time and panicle length (Table 3). Likewise, 60 kg at basal increase plant height and tiller number. Similarly, potassium application on 45 kg at basal and 15 kg at PI stage gave higher grain yield, straw yield and 1000 grain weight.

Table 1. Response of potassium management on hybrid rice varieties at DoAR, Tarahara during 2019

Potassium Dose	Days to Maturity	Plant height (cm)	Panicle length (cm)	Tiller/ m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
45 kg at basal	126	108	25	210	5898	6574	21	0.47
30 kg at basal and 15 kg PI stage	125	102	25	209	6116	6726	22	0.48
60 kg at basal	126	104	26	215	6207	7095	23	0.47
45 kg at basal and 15 kg at PI stage	127	100	27	214	6583	7186	24	0.48
F Test	*	**NS**	*	**NS**	*	*	**	**
LSD (0.05)	**1.67**		**1.52**		**680.58**	**588.23**	**1.78**	**0.05**
Varieties								
Hardinath Hybrid 1	127	111	28	224	6196	7210	25	0.46
Hardinath Hybrid 3	115	93	25	197	5946	6431	23	0.48
MRP 5433	131	102	24	214	5756	6794	17	0.46
MRP 5566	130	108	27	207	6360	7176	22	0.47
MRP 5569	129	103	25	219	6748	6865	25	0.50
F Test	**	**	**	**NS**	**	**	**	**
LSD (0.05)	**2.63**	**7.02**	**1.68**		**704.53**	**660.81**	**1.89**	**0.06**
CV	**1.37**	**8.13**	**4.41**	**13.31**	**7.82**	**9.98**	**7.73**	**5.93**

Similarly, split application increased harvest invest than whole dose at basal. In case of varieties, Hardinath Hybrid 1 and MRP 5566 produced significantly higher yield. In case of interaction of potassium and varieties Hardinath Hybrid 1 and MRP 5569 gave higher grain yield on 45 kg at basal and 15 kg at PI stage (Table 4).

Combined analysis: There were genetic differences and interaction effect of genotypes with potassium management on days to 80% maturing, panicle length, grain yield, 1000 grain weight and harvest index. Increasing the potassium and split dose found increase maturity time and panicle length (Table 5). Likewise, 60 kg at basal increase plant height and tiller number.

Table 2. Interaction of Potassium application and hybrid rice varieties at DoAR, Tarahara during 2019

Potassium Dose	Varieties	Days to Maturity	Plant Height (cm)	Panicle length (cm)	Tiller /m2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
45 kg at basal	Hardinath Hybrid 1	127	124	27	214	5621	6331	24	0.47
	Hardinath Hybrid 3	115	95	25	210	5695	5877	21	0.49
	MRP 5433	130	104	22	226	6192	7088	16	0.47
	MRP 5566	130	106	26	209	5550	7063	20	0.44
	MRP 5569	127	111	24	193	6434	6513	24	0.50
	Hardinath Hybrid 1	123	109	29	230	5986	7096	24	0.46
	Hardinath Hybrid 3	115	93	24	196	5068	5329	21	0.49
	MRP 5433	131	101	22	176	5822	6608	17	0.47
	MRP 5566	130	108	26	223	7170	7873	22	0.48
	MRP 5569	128	100	25	220	6533	6723	25	0.49
	Hardinath Hybrid 1	128	105	26	241	6260	7531	26	0.45
	Hardinath Hybrid 3	115	94	25	184	6297	7160	25	0.47
	MRP 5433	131	108	25	234	5098	6608	18	0.44
	MRP 5566	129	109	27	204	6313	6846	23	0.48
	MRP 5569	129	101	25	212	7066	7329	24	0.49
	Hardinath Hybrid 1	128	107	29	210	6916	7883	26	0.47
	Hardinath Hybrid 3	114	90	27	198	6724	7358	25	0.48
	MRP 5433	131	96	28	221	5912	6873	18	0.46
	MRP 5566	130	107	27	190	6406	6923	24	0.48
	MRP 5569	131	100	26	250	6959	6894	25	0.50

Similarly, potassium application on 45 kg at basal and 15 kg at PI stage gave higher grain yield, straw yield and 1000 grain weight. Similarly, split application increased harvest index than whole dose at basal. In case of varieties, Hardinath Hybrid 1 and MRP 5566 produced significantly higher yield. In case of interaction of potassium and varieties Hardinath Hybrid 1 and MRP 5569 gave higher grain yield on 45 kg at basal and 15 kg at PI stage (Table 1).

Table 3. Response of potassium management on hybrid rice varieties at DoAR, Tarahara during 2020

Potassium Dose	Days to Maturity	Plant height (cm)	Panicle length (cm)	Tiller/m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
45 kg at basal	124	99	24	202	6209	8844	20	0.42
30 kg at basal and 15 kg PI stage	125	99	24	152	6217	8603	20	0.42
60 kg at basal	125	99	24	176	7071	8667	21	0.45
45 kg at basal and 15 kg at PI stage	125	99	25	164	7448	7837	21	0.49
F Test	*	**NS**	*	**NS**	**	**NS**	**	**
LSD (0.05)	**1.04**		**1.52**		**674.21**		**0.45**	**0.02**
Varieties								
Hardinath Hybrid 1	123	100	26	175	6454	8893	22	0.42
Hardinath Hybrid 3	113	82	22	154	5709	6380	22	0.47
MRP 5433	134	105	24	176	6932	8667	16	0.44
MRP 5566	127	110	26	167	7134	9528	21	0.43
MRP 5569	127	97	24	195	7451	8972	22	0.45
F Test	**	**	**	**	**	**	**	**
LSD (0.05)	**1.48**	**3.95**	**0.94**	**22.75**	**571.37**	**733.54**	**0.63**	**0.02**
CV	**1.44**	**4.81**	**4.66**	**15.77**	**10.2**	**10.39**	**3.74**	**7.02**

Table 4. Interaction of Potassium application and hybrid rice varieties at DoAR Tarahara during 2020

Potassium Dose	Varieties	Days to Maturity	Plant Height (cm)	Panicle length (cm)	Tiller /m2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
45 kg at basal	Hardinath Hybrid 1	120	98	25	208	5555	8944	21	0.38

	Hardinath Hybrid 3	113	85	22	184	5426	5889	21	0.48
	MRP 5433	133	106	23	197	6796	9500	15	0.42
	MRP 5566	126	112	26	206	6410	10500	21	0.38
	MRP 5569	126	94	25	216	6856	9389	22	0.42
	Hardinath Hybrid 1	125	101	27	159	5625	9072	21	0.38
	Hardinath Hybrid 3	113	79	20	112	5423	6444	21	0.46
	MRP 5433	134	106	25	170	6855	8722	15	0.44
	MRP 5566	128	107	26	147	6540	10000	21	0.40
	MRP 5569	128	99	24	170	6641	8778	22	0.43
	Hardinath Hybrid 1	123	101	26	179	7167	9056	22	0.44
	Hardinath Hybrid 3	112	77	22	157	5960	6833	22	0.47
	MRP 5433	133	103	24	181	6909	8278	16	0.45
	MRP 5566	127	113	26	165	7496	9722	22	0.44
	MRP 5569	127	101	24	199	7823	9445	23	0.45
	Hardinath Hybrid 1	123	101	27	156	7470	8500	22	0.47
	Hardinath Hybrid 3	112	87	23	165	6029	6352	22	0.49
	MRP 5433	135	105	25	157	7167	8167	15	0.47
	MRP 5566	128	106	26	151	8091	7889	21	0.51
	MRP 5569	128	96	24	193	8484	8278	23	0.51

Table 5. Response of potassium management on lowland hybrid rice varieties at DoAR, Tarahara

Treatments	Days to Maturity	Plant height (cm)	Panicle length (cm)	Tiller/ m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
Potassium Dose								
45 kg at basal	125	103	25	206	5881	7607	21	0.44
30 kg at basal and 15 kg PI stage								
60 kg at basal	125	102	25	196	6720	7907	22	0.46
45 kg at basal and 15 kg at PI stage	126	100	26	189	7044	7533	22	0.48
F Test	**	**NS**	*	**NS**	*	**NS**	**	**
LSD (0.05)	**1.36**		**1.52**		**677.40**	**294.12**	**1.12**	**0.04**
Varieties								
Hardinath Hybrid 1	125	106	27	200	6325	8052	23	0.44
Hardinath Hybrid 3	114	88	23	176	5828	6405	22	0.48
MRP 5433	132	104	24	195	6344	7730	16	0.45
MRP 5566	129	109	26	187	6747	8352	22	0.45

MRP 5569	128	100	25	207	7100	7919	24	0.48
F Test	**	**	**	**	**	**	**	**
LSD (0.05)	**2.06**	**5.49**	**1.31**	**11.38**	**637.95**	**697.18**	**1.26**	**0.04**
CV	**1.41**	**6.47**	**4.54**	**14.54**	**9.01**	**10.19**	**5.74**	**6.48**

Table 6. Interaction of Potassium application and hybrid rice varieties at DoAR, Tarahara

Potassium Dose	Varieties	Days to maturity	Plant height (cm)	Panicle length (cm)	Tiller /m^2	Grain yield (kg/ha)	Straw yield (kg/ha)	1000 grain wt. (g)	Harvest index
45 kg at basal	Hardinath Hybrid 1	124	111	26	211	5588	7638	23	0.43
	Hardinath Hybrid 3	114	90	24	197	5247	5609	21	0.48
	MRP 5433	132	105	23	212	6173	8282	18	0.43
	MRP 5566	128	109	26	207	5754	8554	19	0.41
	MRP 5569	127	102	24	205	6645	7951	23	0.46
	Hardinath Hybrid 1	124	105	28	194	5805	8084	23	0.42
	Hardinath Hybrid 3	114	86	22	154	5559	6161	21	0.47
	MRP 5433	133	104	23	173	6339	7665	16	0.46
	MRP 5566	129	108	26	185	6855	8936	21	0.44
	MRP 5569	128	100	25	195	6587	7750	24	0.46
	Hardinath Hybrid 1	126	103	26	210	6714	8293	24	0.45
	Hardinath Hybrid 3	114	86	24	171	6129	6997	23	0.47
	MRP 5433	132	105	24	208	6411	7576	17	0.46
	MRP 5566	128	111	26	185	6905	8284	22	0.46
	MRP 5569	128	101	25	206	7445	8387	23	0.47
	Hardinath Hybrid 1	126	104	28	183	7193	8192	24	0.47
	Hardinath Hybrid 3	113	89	25	182	6376	6855	23	0.48
	MRP 5433	133	101	26	189	6680	7627	16	0.47
	MRP 5566	129	107	26	170	7249	7406	22	0.49
	MRP 5569	129	98	25	222	7721	7586	24	0.50

DISCUSSION

The split potassium application improved photosynthetic activities and increased dry matter production by efficiently regulating the opening and shutting of stomata. In later phases of crop growth, increasing potassium levels and its splitting were significantly superior to the advised potassium dose when applied as a basal application. According to Meena *et al*. (2003), higher potassium levels had a substantial impact on the buildup of dry matter. The findings of Abdel *et* *al*. (2004), Bahmaniar and Ranjbar (2007) and Banerjee *et al*. (2018) were all taken into consideration while determining the outcome of this experiment. Rice growth and the distribution of the total biomass are directly impacted by the exogenous administration of K (Samejima *et al*., 2005). The dry matter yield and K content of the straw are also the key determinants of K absorption. More biomass is produced per unit of nutrient uptake by efficient plants, especially when nutritional stress circumstances are present (Yang *et al*., 2003).

CONCLUSION

The results showed genetic differences and interaction effect of genotypes with the potassium split application on panicle length, grain yield, test weight and harvest index. Split application of potassium 30 kg at basal and 15 kg at panicle initiation stage is better for hybrid rice cultivation.

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ASSESSMENT OF SOIL ORGANIC CARBON IN THE TERAI ARC LANDSCAPE (TAL) REGION

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ABSTRACT

Soils have been playing a vital role in carbon sequestration but their rate is varying place to place and from time to time. Nepal, with altitudes ranging from 59m to 8848.86m, has different physiographic regions. Different vegetation is found in this different physiographic region and carbon stock varies in various regions. Thus, this study was objectively carried out to assess and compare the soil carbon content in TAL regions of Nepal. Ten sample plots were selected for each district of the TAL region for the soil sample collection. Sampling Sites were selected from the permanent sample plots of FRA. The stratified random sampling method was used for soil sample collection as developed by DFRS for the National Inventory of SOC. Altogether 70 plots were selected from the TAL region of Nepal. The soil samples were collected from 0-10 cm, 10-20 cm, and 20-30 cm depth below ground. Organic carbon content was determined by the Walkley and Black method. SOC Stock was slightly higher in Bara district in the selected Terai region. Bulk density was comparatively higher in the Kanchanpur district Terai region. SOC % and BD showed positive and negative relationships with total SOC stock (t/ha) respectively in all districts. Hence, the soil of forests has the potential to sequester carbon, and such records of carbon stock play a vital role in the REDD+ mechanism.

Keywords: *Soil Organic Carbon, Carbon sequestration, TAL*

INTRODUCTION

Soils are considered to be viable carbon (C) sinks in the atmosphere, with the potential to play a significant role in climate change mitigation (Lal, 2004). Soil organic carbon (SOC) accounts for around 62 percent of the world's 2500 Pentagram (Pg; 1 Pg = 1015 g) soil carbon stock (Lal,2004). Soils have a unique potential to sequester and store large amounts of carbon (C). They are estimated to contain two to three times the amount of carbon stored in the atmosphere and plants combined (Chhabra, Abha. 2013, Lehmann, Johannes & Kleber, Markus. 2015). Soil organic matter (SOM) is an important component of soil fertility and functioning, and it's commonly used to evaluate soil quality since it affects plant nutrition (Cambardella & Elliott, 1992; Franzluebbers, 2002; Kay & VandenBygaart, 2002. Carbon is stored in the ocean, atmosphere, soil, and forests and exchanged between them (Peng et al. 2008; Pan et al. 2011). Soil Organic Carbon is formed from plants, microorganisms, leaves, and wood, which are typically present in the initial meter of soil. Temperature, rainfall, vegetation, soil management, and changes in land use are only a few of the many factors and processes that influence variations in soil organic carbon. Through a variety of techniques, increasing soil organic carbon can enhance soil health, increase agricultural productivity, increase food security, and lessen the need for pesticides. Numerous studies show that raising soil organic carbon can boost crop output. According to several studies, the total amount of soil organic carbon on earth is estimated to be around 2,350 gigatons. For the farming community and the fight against climate change, the soil's capacity to store carbon is a beneficial tactic (Prasad et al. 2020). Carbon (C) sequestration in soil is the accumulation and storage of atmospheric CO_2 in the pedosphere in a way that enhances its mean residence time (MRT) and minimizes re-emission sinks. (Lal, R. (2008). Carbon Sequestration is widely regarded as a cost-effective and efficient tool to alleviate climate change issues. One of the major sources and sinks of greenhouse gasses (GHGs) responsible for climate change and global warming is soil. Through soil respiration and root respiration, it contributes around 20% to overall carbon dioxide emissions, 12% to methane emissions, and 60% to anthropogenic nitrous oxide emissions. (Jakhar et al. 2017). The global carbon cycle may be affected by climate change, which would alter ecosystem structure and function. The very low organic matter concentration (1.0% in tropical soils) will drop even further, and climate change may have an impact on the quality. The global drop in SOC brought on by changes in land use, including deforestation, shifting cultivation, and arable agriculture, has significantly aided in the rise of atmospheric CO_2 levels. Soils have the ability to store more carbon than they now do as a result of the historical depletion of SOC levels (Lal et al., 1998). Lately, climate change is skyrocketing and its effect has been a major threat to vegetation, and all types of ecosystems. The findings of this study will pave the way for future carbon credit claims under various REDD+ schemes. Forests influence climate and climate change processes by changing the concentration of atmospheric carbon (Pandey et. al. 2011; Brown and Gaston 1996). The link between CO_2 and climate warming is detected through the impact of a greenhouse. Various physiographic areas of Nepal possess different soil types, altitudes, and temperatures. Research on carbon stocking on above and underground biomass has been done. However, there is an information gap in evaluating the soil carbon in the TAL regions of Nepal. Only a few types of research have been done on soil, and SOC in various regions has not yet been assessed. As a result, this study was carried out objectively to compare the SOC stock in different places in the TAL area and its trend according to soil depth.

MATERIALS AND METHODS

The study area of this research is Terai Arc Landscape (TAL). It is a 4.95 million hectares trans boundary conservation project that links 11 trans boundary protected areas in Nepal and India. It extends from Rautahat district in the east to Kanchanpur district in the west, comprising 15 districts, including part of Arghakhanchi district in southern Nepal. The study was conducted in seven different districts of the TAL region. Most soils are alluvial deposits. Mainly tropical deciduous riverine and tropical evergreen hardwood forests with dominant Sal are found.

Sites were selected from the permanent sample plots of FRA. Sample plots from 7 different districts of Terai region were selected for the Soil sample collection and SOC stock estimation. Soil samples were collected from four soil pits dug in each cardinal direction, 21 m away from the CCSP center, soil pits were dug within a 2 m x 2 m area to collect undisturbed soil samples. Soil samples were taken from three separate layers i.e., 0-10cm, 10-20cm, and 20-30cm, from each pit of sample plots. Separate plastic bags were used to collect the samples for each layer. The fresh mass of the sample was determined with an accuracy of 1 g. The samples were brought to DFRS Soil Laboratory and kept separately to facilitate the assessment of the within-site variability of soil organic carbon (SOC). The relative volume occupied by stones in the soil was estimated ocularly by observing the soil pit walls by using the FAO Guidelines (FAO, 2006).

The required information for the research was gathered from journals, research articles, and published and unpublished case studies.

Soil bulk density was determined using the known volume's core sampling method (Blake and Hartge, 1986). The samples were collected using core samplers without disturbing the natural structure. Before the bulk density determination, soil samples were Oven dried (at 105 0C) for moisture correction. Bulk density was calculated by using the following formula;

Bulk density (g.cm-3) = (Oven dry weight of soil in 'g') / (Volume of the soil in 'cm3 ')Where, Volume of the soil = Volume of core – Volume of the stone

The collected soil samples will be analyzed in the laboratory for the Soil Organic Carbon test using the **Walkley-Black chromic acid wet oxidation method.**

This method is based on the oxidation of organic matter by potassium dichromate (K2Cr2O7) and sulfuric acid mixture, followed by titration of the excessive dichromate by a ferrous ammonium sulfate ($(NH_4)_2Fe(SO_4)_2 \cdot 6H_2O$).

Following is the reaction that shows the titration process by Walkley- Black (1934) in detail:

The Soil Organic Carbon content percent was calculated as per the following:

Carbon (%) = 3.951⁄g [1 -T/S]

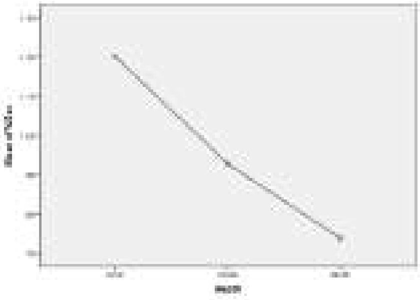
Where, g = Weight of sample in gram,
T = Volume of ferrous solution consumed in sample titration (ml),
S = Volume of ferrous solution consumed in blank titration (ml).
Total soil organic carbon stock was then calculated (Chhabra et al., 2003)
SOC = ρ x d x %C
Whereas SOC = soil organic carbon stock per unit area (ton ha-1),
ρ = soil bulk density (Kg/m3), d = soil depth (m)
%C = carbon concentration (%)

The data from field and laboratory analysis were analyzed using MS-Excel, Arc-GIS 10.5, and SPSS software as required. One-way ANOVA was used to test the significance of the SOC in the TAL Regions of Nepal.

RESULTS AND DISCUSSION

Soil bulk density: For all forests, soil depths increased soil bulk density (BD). Minimum BD (1.21 gm/cc) was found at upper soil depth (0-10cm) and

Maximum BD (1.41 gm/cc) at lowermost (20-30cm) with average BD (1.39 gm/cc) at 10-20cm depth of TMH forest of TAL region.



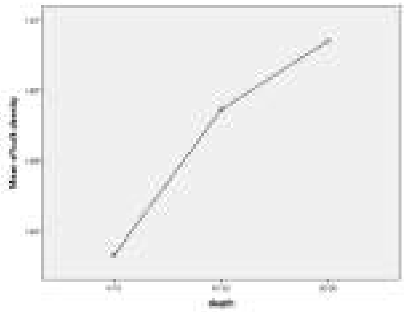
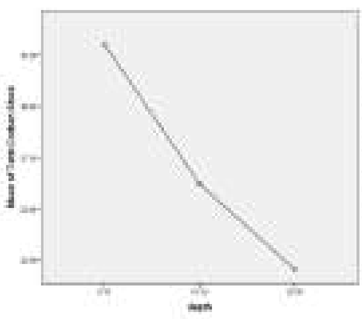


Figure 1. Bulk density of TMH forest **Figure 2. SOC % of TMH forest**

Soc % : Average C % of TMH forest was highest (1.20%) in uppermost depth (0-10cm), 0.93% in 10- 20cm and 0.74% in 20-30cm. The result shows that C % is decreasing with an increase in soil depth.

Total carbon content: According to the above result, the Average SOC of TMH forest in the Terai Arc Landscape region was decreasing with the increase in the depth of soil. It was 16.32 t/ha in 0-10cm, 13.21 t/ha in 10-20cm and 10.68 t/ha in 20-30cm.

District with highest SOC of TAL Region: Amongst 7 districts of the TAL region, SOC of the TMH forest of Bara district was highest. The average Bulk density at the uppermost soil depth (0-10cm) was 2.15gm/cc, at 10-20 was 2.23 gm/cc, and 2.25 gm/cc at the lowermost soil depth (20-30cm). SOC percentage was found to be highest (1.51%) at topsoil depth (0-10) followed by 1.07% at 10-20cm and 0.9 % at 20-30cm. Average SOC stock at 0-10cm was highest (33.30 t/ha),(26.19 t/ha) at 10-20cm and lowest (22.00t/ha) at 20- 30cm.



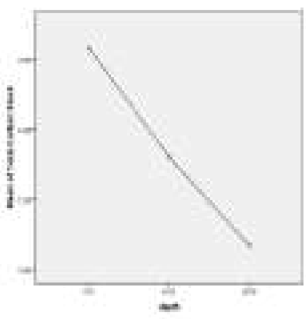


Figure 3. Total SOC of TMH forest **Figure 4. Mean of Total Carbon Stock**

Table 1. Soil parameter of Bara District

Soil depth (cm)	Average Bulk density	Average SOC%	Average Total SOC
0-10	2.15	1.51	33.31
10-20	2.23	1.07	26.19
20-30	2.25	0.9	22.00

District with lowest SOC of Terai Region: Similarly, the TMH forest of Kanchanpur district had the lowest SOC among the seven TAL districts. Average BD was 1.16, 1.17 and 1.15 at 0-10cm, 10-20cm and 20-30cm respectively. Average SOC % was 1.20, 0.90 and 0.65 at 0-10cm, 10-20cm and 20-30cm respectively. SOC stock was found to be decreasing with increasing depths.

Table 2. Soil parameter of Kanchanpur District

Soil depth (cm)	Average Bulk density	Average SOC%	Average Total SOC
0-10	1.16	1.20	13.79
10-20	1.17	0.90	10.22
0-30	1.15	0.65	6.90

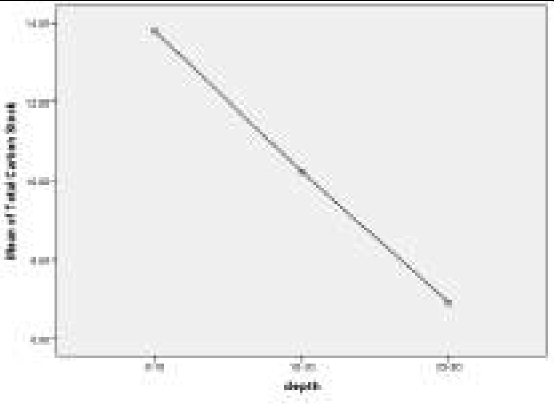


Figure 5. Mean of Total Carbon Stock of Kanchanpur district

ANOVA test for total SOC stock between TAL districts showed that there is a significant difference with a p-value of 0.08. Similarly, there was a significant difference between SOC concentrations at a 5% level of significance, for which the alternative hypothesis is accepted, being a p-value less than 0.05. However, there was no significant difference in BD with a p-value of 0.841 at a 5% level of significance.

DISCUSSION

Several variables, including climate, parent material (or soil type), vegetation cover, and land management, must be considered to understand and derive accurate estimates of SOC stock levels. (Gray, J. M., Bishop, T. F., & Wilson, B. R.,2015) With increasing soil depth, the BD gradually increased. The topsoil layer had lower BD compared to the other soil depths, suggesting that the soil was better for plant growth, which might be ascribed to the greater SOC content in the top layer of soil. But as the soil depth increased, it was noticed that the BD had reduced from top to bottom. (M.Sharma & G. Sharma,2020) Higher BD was found in the Bara district which is the indicator of healthier soil than in other TAL districts.

Table 3. Anova Table

Parameters		Sum of Squares	Df	Mean Square	F	Sig.
Bulk density	Between Groups	.136	2	.068	.174	.841
	Within Groups	81.179	207	.392		
	Total	81.315	209			
	Between Groups	7.589	2	3.794	13.140	.000
	Within Groups	59.777	207	.289		
	Total	67.366	209			
	Between Groups	1119.764	2	559.882	4.881	.008
	Within Groups	23742.365	207	114.697		
	Total	24862.129	209			

Because of the natural compaction, higher Bd was noticed in the soil with increasing depth. Soil BD increases with increasing soil depth due to decreasing

SOM content, less aggregation, fewer roots, and other soil living organisms, and soil compaction. According to Pradhan et al., the organic matter content of soil decreases with increasing soil depth, resulting in decreased soil porosity and compaction.

ANOVA test showed that there was a significant difference in the mean SOC stock with a p-value of 0.08 between all the selected TAL regions at a 5% level of significance. The greater SOC concentration in the top layer might be attributed to the quick decomposition of forest litter. It is essential to preserve soil fertility at its peak point since soils with high levels of SOC stock often imply high fertility. This calls for cautious land use and management approaches. In contrast to other depths, a higher SOC stock was found in the topsoil. Forest SOC is influenced by a variety of biotic and abiotic variables, including microclimate, faunal diversity, land use, land management, and agriculture (Shrestha & Singh 2008). (Khanal, 2008), (Ale, 2010), (Maharjan, 2010), (Ranjitkar, 2010), (Sharma, 2010), (Basnet, 2011), and all other relevant studies corroborate the significant decrease in soil carbon with the increase in soil depth (Dutta et al. 2011). It might be due to less dissolved organic content (DOC) leaching and hence less accumulation at lower depths. The study shows that Kanchanpur district had the lowest SOC stock (10.36 t/ha) and the Bara district had the largest SOC stock (27.07 t/ha) in the selected TAL area. This variation in the same regions might be attributed to microclimate influences (Haden et al., 2019).

CONCLUSION

SOC Stock was highest, and BD was lowest in the Bara district among all the selected study sites while Kanchanpur had lowest SOC Stock and highest Bulk Density. Bulk Density was increasing with an increase in depth in all the districts. SOC % and total SOC stock (t/ha) was decreasing with increase in depth in all the study sites. SOC % and BD had positive and negative effects respectively on SOC stock (t/ha) in all the districts.

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ASSESSMENT OF RESOURCE POOR GROUNDNUT FARMERS' ACCESS TO FORMAL CREDIT AT KADUNA STATE, NIGERIA

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ABSTRACT

This research work focused on assessment of resource poor groundnut farmers' access to formal credit, Kaduna State, Nigeria. Multi-stage method of sampling was employed. One hundred (100) groundnut producers were sampled and selected. Primary data used for this research were obtained from well-designed and also well-structured questionnaire. Econometrics and statistical tools were used for data analysis. The results show that the mean age of resource poor groundnut producers was 44 years. Averagely, resource poor groundnut producers had 5 years' experience in groundnut farming and they had 1.1 hectares of planted groundnut farms. The sources of credit facilities to resource poor groundnut producers include: formal (44%) and informal sources (56%). They had little or no access to formal credit facilities. The mean amount of money obtained from formal sources was 350,000 Naira. The statistically and significantly regressors influencing output of groundnut production include: farm size, seed input, fertilizer input, labour input, and chemical input. The statistically and significantly socio-economic predictors influencing technical inefficiency of resource poor groundnut producers include: age, marital status, gender, educational level, experience in farming and size of households. The *mean technical efficiency score was 44%, while maximum technical efficiency score was 82%. The statistically and significant regressors influencing access to formal credit facilities by resource poor groundnut producers were age, farm size, household size, gender education level, access to extension services, and membership of cooperative organizations. The major constraints encountered by resource poor groundnut producers include: lack of collaterals, high interest rate, cumbersome administrative procedures, short repayment period, and long distant to financial institutions. The policy recommendations offered include: government should introduce policies that will make farmers easy access to formal credit facilities at low interest rate preferably at single digits, farmers should form cooperatives organizations for easy access to formal credit, acquire the needed farm implements, and quality seeds. More efforts should be intensified by extension officers in educating farmers to increase productivity.*

Keywords: Groundnut Farmers, Resource Poor, Access to Formal Credit, Kaduna, Nigeria

INTRODUCTION

Agricultural credit can be defined as all advances and loans granted to farmers for service and finance activities of agricultural production such as crop production, fisheries, animal production, forestry, and the distribution and marketing of agricultural produce resulting from these activities (Alabi *et al*, 2016).About two-third of Nigerians are poor and 80% of them are farmers living in the rural areas, and they are characterized by low income, large family size, lack of formal education, lack of access to credit, and use of crude implements (Ibrahim and Aliero, 2012). Rural dwellers in sub-Saharan Africa constitutes 75% of work force in agriculture and 80% of them are food producers. Availability of credit to resource poor farmers is important for increased agricultural productivity and agricultural development of sub-Saharan countries. Access to credit is crucial for farmers to finance activities of capital-intensive agricultural industry such as investment in machineries, buildings, equipment, farmlands, farm inputs, breeding livestock and other assets structure of most farms (Nimoh *et al*., 2013). Access to credit enables farmers increased use of improved high yielding seeds, plant protection measures and fertilizers which lead to higher output per unit of land and labour, and encourage farmers to adopt labour-saving technologies resulting in increased income and improved well-being of farmers (Ammani, 2012). Agricultural credit services are provided by informal and formal institutions. Informal institutions include: family, friends, savings and credit associations, formal institutions include: commercial banks, bank of agriculture, agricultural credit guarantee scheme fund. The problems faced by farmers in accessing credit from financial institutions include: high interest rate, collaterals, high risk of farming, and high cost of service delivery (ADB, 2001). Access problem to financial services by resource poor farmers in one factors that limit their benefit from credit facilities. Agricultural credit is needed by small, medium and large scale farmers to increase farm income. Large scale farmers had access to formal credit than small scale farmers because the large scale farmers possess collaterals security and assets. Smallscale farmers also had limited access to informal sources because the informal credit markets are characterized by personal nature of contracts. Smallholder farmers' easy and timely access to credit enables them to diversify their farming activities, adopt new technologies and expand their farm activities. An efficient credit market enables proper input use by smallholder farmers, because most smallholder farmers purchased their inputs in cash or from dealers on a credit-in- kind basis leading to increase dependence of farming households on credit markets. An efficient credit market also provides the opportunity of smallholder farmers to meet consumption requirements resulting in improvement in their livelihood (Saqib *et al.,* 2018). Credit is a significant factor for the development of rural sector (Isitor and Nkamigbo, 2019). Access to credit by poor rural populace can eradicate poverty, increase income, improve the well-being of resource poor farmers, and enhance agricultural productivity (Lawal and Ette, 2006).

Groundnut (*Arachis hypogeal*) is a major cash and food crop grown in sub-Saharan Africa (Opany et *al.,* 2022). It ranks 13th as the most important food crop in the world. It ranks 4th as the most important source of vegetables in the world (Ekunwe *et al*., 2013). In Nigeria, Groundnut production in 2018 and 2019 were 4,600,00metric tonnes and 4,500,050 metric tonnnes respectively (FAO, 2020). Developing countries including Nigeria accounted for 90% of world groundnut export. Groundnut is rich in lipids, vitamins, carbohydrates, and proteins. Groundnut is also rich in calcium, potassium, magnesium, and phosphorous. Groundnut contains easily digestible protein (25%), high quality edible oil (50%), and carbohydrates (20%) (Onuwa *et al*., 2020; Girei *et al*., 2013). Groundnut solvents and oil are used in fabrics, dyes, vanishes, paints, leather dressings, lubricating oil, cosmetics, medicines, plastics, furniture, soap, insecticides, nitro-glycerin, and polish. Groundnut provides income, food and nutrition security. Groundnut production is mainly undertaken by resource poor or smallholder farmers using traditional methods employing low yield variety of seeds giving low yield per hectare. Groundnut is a leguminous crop that fixes nitrogen into the soil. The vegetative cover of groundnut prevents rain and wind from eroding the soil. Groundnut by products following oil extraction include:

the cake, haulm and shell. The shell is used for fuel by some local factories or they are spread on the field as soil amendment. The shell can also be used as bulk in livestock rations or in making chipboard for use in joinery in wooden products. The haulm is used to feed livestock, the cake is an essential vitamin and protein source in chicken feed (Ibrahim *et al*., 2012). Groundnut is consumed directly due to its high food value, it plays an important role in the diets of rural populace particularly children because of its high contents of protein and carbohydrate (Aboki *et al*., 2018). Confectionary products like sauce, snacks nut, peanut butter, flour, and cookies are made from high quality nuts of the crop (Ibrahim *et al*., 2013). Groundnut is an excellent cash crop for domestic markets as well as for foreign trade in many developing and developed countries (Taphee *et al*., 2015).
This research work focused on assessment of resource poor groundnut farmers' access to formal credit at Abuja, Nigeria.

METHODOLOGY

This research study was conducted in Kaduna State, Nigeria. Kaduna State occupies between Longitudes 06^{0} $15^{|}$ and 08^{0} $50^{|}$ East and Latitudes 09^{0} $02^{|}$ and 09^{0} $02^{|}$North of the equator. The State has land area totaling 4.5 million hectares. The state vegetation is divided into two (2), the Southern guinea savanna and Northern guinea savanna. There are two (2) seasons in Kaduna State. The seasons are: wet and dry seasons, the dry season is between October to March, and the wet season starts from April to October, in between the wet and dry seasons is the brief Harmattan period which span from November to February. The mean or average rainfall is about 1,482mm, the temperature of Kaduna State ranges from 35^{0}C to 36^{0}C, which can be as low as 10^{0}C to 23^{0}C during the Harmattan period. The population of Kaduna as at 2021 was 8.9 million people. They are involved in agricultural activities. Crops grown include: groundnut, tomatoes, okra, pepper, maize, ginger, sorghum, rice, yam, cassava, and millet. Animal reared include: cattle, goats, sheep, rabbit, and poultry. Multi-stage method of sampling was employed. One hundred (100) groundnut producers were selected. Data obtained from tomato producers were of primary sources and the data were collected using well-designed and also well-structured questionnaire. The questionnaire was administered to groundnut producers using well trained enumerators. Data were analyzed using the following statistical and econometrics tools:

Descriptive Statistics: The measures of central tendency will be employed to have a summary statistics of socio-economic profiles of resource poor groundnut producers. This involves the use of mean, percentages, frequency distributions to summarize socio-economic characteristics such as age, household size, farming experiences, farm size, marital status, and gender of groundnut producers as stated specifically in objective one (i), and to determine the sources of credit by resource poor groundnut farmers as stated specifically in objective two (ii).

Stochastic Production Frontier Function Model

According to Alabi *et al*. (2022), the stochastic production frontier model is stated thus:

$Y_i = f(X_i, \beta_i)e^{v_i - u_i}$……………………………….(1)

$l_nY = \beta_0 + \beta_1 l_n X_1 + \beta_2 l_n X_2 + \beta_3 l_n X_3 + \beta_4 l_n X_4 + \beta_5 l_n X_5 + V_i - U_i$…..(2)

where,

Y_i = Output of Groundnut (kg)

X_i = Vectors of Factor Inputs

β_i = Vectors of Parameters

V_i = Random Variations in Groundnut Output

U_i= Error Term due to Technical Inefficiency

X_1 = Farm Size in hectares

X_2 = Seed-Input in kg

X_3 = Fertilizer-Input in kg

X_4 = Labour-Input in mandays

X_5 = Chemical-Input in litre

$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \ldots\ldots\ldots\ldots\ldots\ldots.$ (3)

where,

Z_1 = Age in years

Z_2 = Marital Status (as Dummy, 1, married; 0, otherwise)

Z_3 = Gender (as Dummy, 1, male; 0, otherwise)

Z_4 = Educational Level Attained (Likert, 0, non-formal; 1, primary; 2, secondary; 3, tertiary)

Z_5 = Experience in Farming in years

Z_6 = Size of Household in number

α_0 = Constant Term

$\alpha_1 - \alpha_6$ = Parameters to be Estimated

U_i= Error Term due to Technical Inefficiency

This will be used specifically to achieve objective three (iii).

Probit Dichotomous Regression Model: The dichotomous response model is defined as follows:

$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \alpha_3 X_3 + \alpha_4 X_4 + \alpha_5 X_5 + \alpha_6 X_6 + \alpha_7 X_7 + U_i$…………(7)

$Y =$
$\text{Dichotomous Response Model (1, Access to Formal Credit; 0, Otherwise)},$
$X_1 = \text{Age of Groundnut Farmers in Years},$
$X_2 = \text{Farm Size in Hectares},$
$X_3 = \text{Household Size in Units}$
$X_4 = \text{Gender (Dummy, 1, Male; 0, Otherwise)}$
$X_5 =$
$\text{Education Level (Likert, 0, Non} -$
$\text{Formal; 1, Primary; 2, Secondary; 3, Tertiary)}$
$X_6 = \text{Access to Extension Services (Dummy, 1, Access; 0, Otherwise)}$
$X_7 =$
$\text{Membership of Cooperative Organizations (Dummy, 1, Member; 0, Otherwise)}$
$U_i = \text{Error Term},$
$\alpha_1 - \alpha_7 = \text{Regression Coefficients},$
$\alpha_0 = \text{Constant Term},$
This was used specifically to achieve objective four (iv).

Principal Component Analysis: The problems facing groundnut farmers was subjected to principal component analysis. This was used specifically to achieve objective five (v).

RESULTS AND DISCUSSION

Socio-economic profiles of groundnut producers

The summary statistics of socio-economic profiles of groundnut producers are presented in

The mean age of groundnut farmer was 44 years (Table 1). This signifies that the groundnut producers were energetic, active, and resourceful in their youthful age. They can easily adopt innovations or new farming techniques on groundnut production. Access to credit facilities is crucial for resource poor groundnut farmers in adopting improved farm technologies. The mean experience in groundnut farming was 5 years. Experience is necessary for groundnut producers for planning, management, decision making and increased production. Experience is necessary for groundnut producers for efficient use of scarce resources and the ability to take risk associated with adoption of innovation for increase groundnut production. Averagely, groundnut producers had 7 people per households, the reason behind large family size could be due to the dependence on family as source of labour for groundnut production. In sub-Saharan African countries, Nigeria inclusive, family labour is the most important component of labour in resource poor or smallholder farmers' production. The mean value in educational level was 8 years. This is an indication that groundnut farmers had formal education, education of groundnut farmers is an incentive for effective communications and adoption of new farm technologies. Educated groundnut farmers will likely be receptive to new and improved innovations that could lead to increase output in groundnut production. Averagely, resource poor groundnut farmers had 1.1 hectares of cultivated farm land. The farm size is less than 5 hectares of farm land, by implication the groundnut producers were predominantly smallholder farmers.

Table 1. Summary statistics of socio-economic profiles of groundnut producers

Variables	Mean Values
Age in Years	44
Experience in Farming in Years	05
Farm Size in Hectares	1.1
Household Size in Number of People	7
Educational Level Attained in Years	8
Access to Credit (Dummy)	Yes
Membership of Cooperatives (Dummy)	Yes

Source: Field Survey (2021)

The groundnut producers had little or no access to credit facilities, they use their personal savings to farm or obtained credit facilities through friends and relatives. They belong to one member of cooperative organizations or the other, this could assist them to obtained formal credit from financial institutions, of bulk purchase their farm inputs or jointly sell their agricultural produce.

Sources and amount of credit facilities accessed by resource poor groundnut producers

Sources of credit facilities by resource poor groundnut producers include: formal (44%), and informal (56%) as shown in Table 2. The informal sources include: personal savings, money lenders, farmers' associations, relatives and friends. Formal sources include commercial banks and financial and public institutions. Averagely, resource poor groundnut producers obtained 350,000 Naira from formal sources, while 129,558 Naira was obtained from informal sources respectively.

Table 2. Sources and amount of credit accessed by resource poor groundnut producers

Sources	Frequency	Percentage	Mean Amount (₦)
Formal	44	44.00	350,000
Informal	56	56.00	129,558

Source: Field Survey (2021)

Factors influencing output or technical efficiency (te) of groundnut production

The predictors influencing output of groundnut produced by resource poor farmers were presented in the TE component of Table 3. In the TE component, all the predictors had positive regression coefficients, farm size and labour-input are statistically and significant predictors influencing output of groundnut produced at (P < 0.01). Seed – input, fertilizer-input and chemical-input were statistically significant predictors influencing output of groundnut produced (P < 0.05). A 1% increase in farm size keeping all other predictors fixed will lead to 18.12% increase in output of groundnut production. Also, a 1% increase in the use of chemical-input in groundnut farming will lead to 67.18% increase in output of groundnut production. The return to scale is the summation of elasticity of production. The regression coefficients are the elasticity of production in the TE component. The return to scale was calculated at 1.551, which means increasing return to scale. A unit increase in the predictor in the TE component keeping other predictors constant will lead to more than proportionate increase in the output of groundnut production of resource poor farmers. The variance ratio was estimated at 0.7220, this suggests that 72.20% of variations in the output of groundnut production were explained by regressors included in the model. The total variance of 1.700 and Likelihood ratio test of 316.71 were statistically significant at (P < 0.01), this is an indication that the model is of good fit.

Factors influencing technical inefficiency (tin) among resource poor groundnut producers

The predictors included in the TIn component were age, marital status, gender, educational level, experience in farming, and size of households. All the predictors had negative coefficients; this is an indication that all the predictors included in the model decrease TIn among the resource poor groundnut producers. Educational level and size of households were predictors statistically and significantly decreasing TIn of resource poor groundnut producers at (P < 0.01). Also, ages, marital status, gender, were predictors statistically and significantly decreasing TIn of resource poor groundnut producers at (P < 0.05). Experience in farming was statistically significant regressor decreasing TIn of resource poor groundnut producers at P < 0.10.

Technical Efficiency (TE) scores among resource poor groundnut producers

Table 4 shows the frequency distribution of resource poor groundnut producers at the different levels of efficiency. Majority (45%) of resource poor groundnut producers were between 41 to 60% efficiency levels, this implies that most farmers were averagely technically efficient. The mean TE was 44% leaving a gap of 56% for improvement. In addition, the least TE score was 08% while the best performing groundnut farm had the maximum TE of 82.0%.If the average resource poor groundnut producers were to achieve the level of TE like most of its efficient counterparts, then the average groundnut producers could make 46.34% cost savings. The calculated value for the most technically inefficient resource poor groundnut producers revealed a cost savings of 90.24%.

Table 3. Maximum Likelihood (MLE) results of the stochastic frontier production model

Variables	Parameters	Coefficient	Standard Error	t-Value
Technical Efficiency (TE)				
Constant	β_0	5.879680***	0.59920	9.81239
Farm Size	β_1	0.181275***	0.04388	4.1310
Seed-Input	β_2	0.361302**	0.12072	2.9927
Fertilizer-Input	β_3	0.155433**	0.06757	2.3001
Labour Input	β_4	0.181409***	0.04927	3.6816
Chemical-Input	β_5	0.671823**	0.30111	2.2311
Return to Scale (RTS)		**1.551**		
Inefficiency Component(TIn)				
Constant	α_0	0.560*	0.2580	2.17
Age	α_1	-0.190**	0.0753	-2.52
Marital Status	α_2	-0.122**	0.0467	-2.61
Gender	α_3	-0.210**	0.0890	-2.50
Educational Level	α_4	-0.401***	0.1077	-3.72
Experience in Farming	α_5	-0.112*	0.0446	-2.51
Size of Households	α_6	-0.205***	0.0556	-3.69
Diagnostic Statistics				
Total Variance	σ^2	1.7001***		
Variance Ratio	γ	0.7220		
Log-Likelihood		461.32		
Likelihood Ratio Test		316.71		

Source: Data Analysis (2021)
*Significant at $(P < 0.10)$.,**Significant at $(P < 0.05)$; ***Significant at $(P < 0.01)$.

Factors influencing resource poor groundnut producers access to formal credit facilities

The regressors under consideration influencing resource poor groundnut producers access to formal credit facilities include age, farm size, household size, gender, educational level, access to extension services, and membership of cooperative organizations (Table 5). All the predictors included in the dichotomous Probit regression model had positive regression coefficients. Access to extension services by resource poor groundnut producers was statistically significant at (P < 0.01). A 1% increase in access to extension services by resource poor groundnut producers will lead to 27.05% probability of increase in the output of groundnut production. Age, farm size, household size, gender, educational level, and membership of cooperative organizations were statistically significant regressors influencing resource poor groundnut producer's access to formal credit at (P < 0.05).

Table 4. Summary statistics of Technical Efficiency (TE) scores

Efficiency Score	Frequency	Percentage
0.00 – 0.20	17	17.00
0.21 – 0.40	22	22.00
0.41 – 0.60	45	45.00
0.61 – 0.80	09	09.00
0.81 – 1.00	07	07.00
Mean	0.44	
Standard Deviation	0.2192	
Minimum	0.08	
Maximum	0.82	

Source: Field Survey (2021)

A 1% increase in hectares of planted groundnut farms will lead to 16.20% probability of increase in groundnut production by resource poor farmers. The maximum likelihood estimates revealed that the Log Likelihood value was -43.81071, the Chi square value was 16.59 which were statistically significant at $(P < 0.01)$.

Table 5. Maximum Likelihood (MLE) estimates of the probit dichotomous regression model

Variables	Coefficients	Standard Error	Z-Score	Marginal Effects
Age (X_1)	0.00427**	0.001636	2.61	0.01402
Farm Size (X_2)	0.05162**	0.020484	2.52	0.16201
Household Size (X_3)	0.07154**	0.026205	2.73	0.23052
Gender (X_4)	0.21460*	0.106766	2.01	0.08012
Education Level (X_5)	0.03603**	0.016915	2.13	0.01348
Access to Extension Services(X_6)	0.30719***	0.084859	3.62	0.27053
Membership of Cooperative Organizations (X_7)	0.50102**	0.198817	2.52	0.14308
Constant	0.29062*	0.144587	2.01	0.30521
Log Likelihood	-43.81071			
LR Chi^2	16.59			
Prob > Chi^2	0.00013			
Pseudo R^2	0.6702			

Source: Field Survey (2021)

**-Significant at 10% probability level, **-Significant at 5% probability level*
****-Significant at 1% probability level*

The Pseudo R square was 0.6702, this signify that 67.02% of variations in access to formal loan facilities by resource poor groundnut producers were explained by the regressors included in the Probit dichotomous response model.

Constraints encountered by resource poor groundnut producers

The problems encountered by resource poor groundnut producers were subjected to analysis of principal component model (Table 6). Five (5) constraints facing resource poor groundnut producers with Eigen values greater than 1 were retained by the analysis. Lack of collaterals with Eigen value of 1.903 was ranked 1st and this explained about 22.01% of all constrained retained by the model. High interest rate with Eigen-value of 1.821 was ranked 2nd and this explained 14.01% of all constraints included in the model.

Table 6: Principal component model of constraints encountered by resource poor groundnut producers

Constraints	Eigen-Value	Difference	Proportion	Cumulative
Lack of Collaterals	1.903	0.902	0.2201	0.2201
High Interest Rate	1.821	0.850	0.1401	0.3602
Cumbersome Administrative Procedures	1.732	0.531	0.1102	0.4709
Short Repayment Period	1.501	0.423	0.1089	0.5793
Long Distant to Financial Institutions	1.541	0.390	0.1045	0.6838
Bartlett Test of Sphericity				
Chi Square	792.01***			
KMO	0.7621			
Rho	1.00000			

Source: Computed from Data Analysis (2021) ***Significant at 1% Probability Level

Cumbersome administrative procedure was ranked 3rd with Eigen-value of 1.732 and this explained 11.02% of all problems included in the analysis. All problems retained by the analysis explained 68.38% of all constraints encountered by the resource poor groundnut producers. The chi-square value of 792.01 was statistically significant at ($P < 0.01$). This signifies that the principal component model is of good fit.

CONCLUSION AND RECOMMENDATIONS

This study has established that resource poor groundnut producers had little or no access to formal credit facilities. The sources of credit facilities include: formal and informal sources. The maximum amount of credit accessed from formal sources was 350,000 Naira. The groundnut producers are active, energetic, resourceful in their youthful age. The family sizes are large, and they had formal education with enough experience in groundnut farming. The resource poor groundnut producers belong to cooperative organizations. The statistical and significant regressors influencing output of groundnut produced include farm size, seed input, fertilizer input, labour input, and chemical input. The statistically and significant regressors influencing technical inefficiency of resource poor groundnut producers include: age, marital status, gender, educational level, experience in farming, and size of households. The average technical efficiency score was 44%, while the maximum technical efficiency score was 82%. The statistical and significant predictors influencing access to formal credit by resource poor groundnut producers were age, farm size, household size, gender, educational level, access to extension services, and membership of cooperative organizations. The problems encountered by resource poor groundnut producers include: lack of collaterals, high interest rate, cumbersome administrative procedures, short repayment period, and long distant to financial institutions. The following policy recommendations were offered:

(i) Policies to provide resource poor farmers with easy access to formal credit at low interest rate preferably at single digits should be introduced.
(ii) Farmers should be encouraged to organize themselves into groups, cooperatives so that they can easily obtain formal credit, needed farm implements, and quality seeds.
(iii) All efforts should be intensified on the part of extension officers in educating the farmers so as to increase productivity.
(iv) Use of improved varieties of groundnut seeds and mechanized labour should be encouraged.

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FACTORS AFFECTING AND PEOPLE'S PERCEPTION ON YARSAGUMBA (*OPHIOCORDYCEPS SINENSIS)* COLLECTION AT THULIVERI MUNICIPALITY, DOLPA DISTRICT

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ABSTRACT

A study was conducted in Thuliveri Municipality, Dolpa district about the factors affecting and people's perception on Yarsagumba collection. The study was conducted for 4 months and sample size of 70 respondents was selected using a simple random sampling technique. Respondents were interviewed with pre-structured questionnaire. Descriptive statistics and indexing were used to analyze the data. The average age of the respondents was found to be 40.72 years with an average family size of 6.21 members. Three different categories of Yarsagumba were collected and their value differs with the quality. On average people harvested 124.55 units of Yarsagumba in the year 2022. The average income and expenditure during collection are NRs. 76654.29 and NRs. 33132.14 respectively. Beside the Yarsagumba collection, the major occupation of the respondents was agriculture. From the study, the benefit cost ratio index was found to be 2.35 which show that the collection process is beneficial. The 80% of respondents were unknown of the medicinal value of Yarsagumba. The extreme climatic condition was a major risk factor followed by the theft of Yarsagumba while collecting Yarsagumba. Overgrazing was the major problem for declining of Yarsagumba in recent years followed by climatic change and excessive harvesting of Yarsagumba. Respnsible stakeholders and local government should take responsibility for making guidelines, rules, and regulations for the collection and marketing of Yarsagumba. Awareness should be given to collectors regarding the information on climate change, pollution effect, market information and sustainable harvesting of Yarsagumba.

Key words: Yarsagumba, Livelihood, Profitability Index, Climate Change

INTRODUCTION

Yarsagumba (*Ophiocordyceps sinensis*) is one of the most effective medicinal mushrooms in the world (McKenna, 2008). It is named in Atreya Samhita as Bhu-Sanjibani about three thousand years ago and discussed its usage to heal complex kidney and syphilis problems (Shrestha 2010, Shrestha *et al*. 2010). Yarsagumba (literally translated as summer plant winter worm in English) thrives in the Himalayan ranges, between 3000 and 5000 meter above sea level in Nepal, India, China, and Bhutan (Balfour-Browne 1955, Shrestha 2011a).

In Nepal, it is variously pronounced in local dialects such as Yer tsa gunbu, Yartsa gunbu, Yarsha gumba, Yarsagomba, Yarcha gumbu, Yarcha gumba, Yarchagunbu, Yarcha and so on (Shrestha 2010, Shrestha *et al*. 2020, Shrestha 2011b). Jingani, Jivan Buti, Kira Chhyau, Kira Jhar, Saram Buti, and Saram Buti Jadi are some of the local names of Yarsagumba in Nepal (Shrestha *et al* 2010, Shrestha 2011b). It is commonly recognized as a Chinese caterpillar fungus, Cordyceps mushroom, or Vegetable Wasp Plant Worm in English (Shrestha *et al*., 2010). It is also known as Dong Chong Xia Cao or Chong Cao in China, Tochu-Kaso in Japan, and Dhongchunghacho in Korea (Amatya 2008, Shrestha *et al*. 2010, Shrestha 2011b).

Yarsagumba has a unique life cycle that is influenced by host insect availability, soil characteristics, and precipitation. In August, the fungal spores infect moth larvae in the soil and develops inside them under the snow over the winter, producing fusiform hyphae that divide via budding and finally fill the body cavity of the host larvae. In the early spring, the fungus appears above ground as a cylindrical stroma (Yang *et al* 1989; Zeng *et al* 2006; Stone 2008).

Yarsagumba is indeed very essential to the socio-economic life of indigenous people in the Himalayan region (Shrestha *et al*., 2014; Pant *et al*. 2014). According to the revenue records from 11 districts, the yarsagumba trade in Nepal was worth an estimated USD 4.7 million (NRB,2015). Yarsagumba also generates 41% of the revenue collected from the non-timber forest products sector and which serves as financial assistance to support social welfare programs such as village electricity and local school maintenance (Thapa *et al*.). Moreover, the poorest households in Dolpa, Nepal, were relying on yarsagumba for up to 72% of their total income (Shrestha & Bawa, 2014).

Yarsagumba is one of the most important and valuable medicinal herbs found in high mountain range, between 3500 and 5500 meters from the sea. Government officials have given little or no attention to the efficient utilization of resources. Yarsagumba receives a lot of attention in the media, but there hasn't been comprehensive research of it. Yarsagumba is one of the high value medicinal plant species found in the Himalayan region of Nepal which is important in the upliftment of livelihood of rural people. Though the number of people involved in Yarsagumba collection is increasing, the growth and production of Yarsagumba are low in comparison to previous years. This study is aimed at comprehending the current status of Yarsagumba in the wild, its role in income generation, and also how Yarsagumba has affected the economy and livelihood of people in Thulibheri Municipality of Dolpa district.

MATERIALS AND METHODS

Study area: The study area of this research is the Thulibheri Municipality which is located in Dolpa, the largest and mountainous district of Nepal. It encompasses 5.36% of the country's total area and is positioned at 28°43'N to 29°43'N latitude and 82°23'E to 83°41'E longitude. The elevation ranges from 1,525 to 7,625 m (5,003 to 25,016 ft.). This study area was selected because Dolpa is one of the largest contributors in Yarsagumba collection and Thulibheri Municipality has many pastures for Yarsagumba collection in comparison to other places.

Sample size: Simple random sampling was used to select and collect information from the respondents. Information from a total of 70 respondents was collected from Thuliveri Municipality. Sampling was made as inclusive as possible by including respondents from different ethnic groups, age groups, and economic status. Further information was obtained from the municipality and ward office.

Data collection: Data was collected by using both primary sources and secondary sources. Primary data were collected by directly visiting the respondents in the study area.

Primary data: A well-structured questionnaire was developed to cover the study objectives. Field survey was conducted to collect the required information of households like age, ethnicity, gender, education status, occupation, land holding, annual income, collection trend of Yarsagumba, duration to reach collection site, risks while collecting Yarsagumba, reasons for declining of Yarsagumba and effect of climate change on it.

Secondary data: Secondary information related to the study was collected through review of different articles, books, publications, and reports. Mainly secondary information was collected from the Ministry of Agriculture and Livestock Development (MoALD), the Central Bureau of Statistics (CBS), and the Ministry of Forests and Environment (MoFE).

Data analysis: The collected information from the household survey was entered into the Microsoft Excel. Further analysis was done using IBM SPSS Statistics 20 and Microsoft Excel. Arcgis 10.4 was used to make the map of the study area.

Descriptive statistics: Descriptive statistics like mean, standard deviation, frequency, percentage, and range were used to analyze the data. The obtained result was expressed in pie charts, bar diagram and table. Data on age, gender, ethnicity, education, occupation and income were analyzed using descriptive statistics.

Indexing : The risks associated with Yarsagumba collection were ranked by the respondents in a prioritization scale ranging from one to five; one for the top priority followed by two, three, four and five for less successive priority. The index value was calculated using following formula:

$I_p = (\sum S_i F_i)/N$

where,

I_p = index value
$\sum$ = summation
S_i = scale value of i^{th} intensity
F_i = frequency of i^{th} intensity
N = total number of respondents

The risks were also ranked by the respondents using a scale of one for an extreme barrier, two for a high barrier, three for a moderate barrier, four a for slight barrier, and five for no barrier.

RESULTS AND DISCUSSION

Duration to reach collection site: Since the collection site is far away from their house, we have classified time to reach collection site into four catagories (Table 1). Out of 70 respondents, the majority of respondents (52.8%) took about 6 hours to reach collection site of Yarsagumba. Similarly, 22 (31.3%) took 6-12 hours (Table 1).

Collection trend: The figure 1 explains about the trend of collection of Yarsagumba in the recent years. Out of 70 respondents, 58 of them suggested that there was a decrease in the number of Yarsagumba, while 3 of them reported as an increase in its number and 9 of them reported to be same.

Table 1. Duration to reach the collection site

Categories (In hours)	Frequency	Percentage
0-6	37	52.8
6-12	22	31.3
12-18	2	2.9
18 above	9	12.9

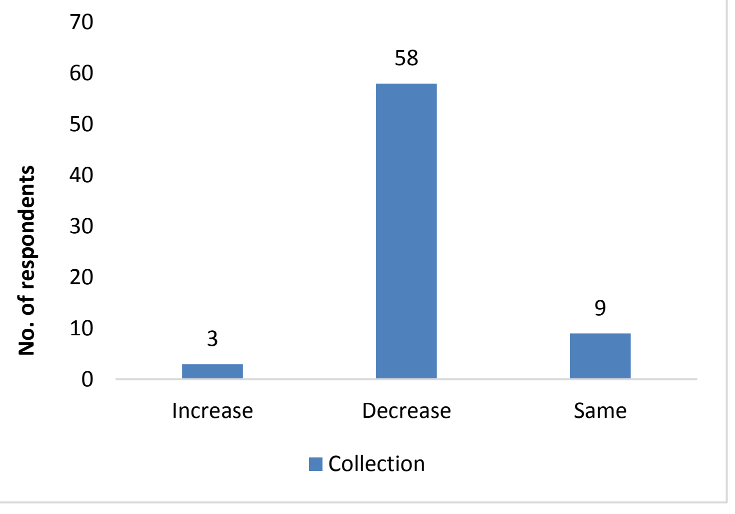

Figure 1. Collection trend of Yarsagumba in recent years

The above figure 1 also shows that the average annual collection of Yarsagumba is also decreasing every year due to various reasons. Average collection of Yarsagumba is dropping from 475 pieces in 2010 to 186 pieces in 2014 (Pant *et al*., 2014). This could be due to degradation of Yarsagumba sites, overgrazing, climate change etc

Respondent's knowledge on Medicinal value of Yarsagumba: From the above pie chart (Figure 2), about 80% of the respondents didn't know about the medicinal uses of Yarsagumba and only 20% of respondents knew about its medicinal value. Most of them collect Yarsagumba only for selling purposes while some of them use as medicine. The uses of Yarsagumba are acknowledged by local and outside collectors in the Dolpa district. They have been using it for the past 20 years. Usually, they used it as a tonic and a sexual stimulant. It is also used locally to treat diarrhea, headaches, coughs, rheumatism, and liver illness. Individuals have their own understanding on the application of Yarsagumba to various diseases (Devkota, 2006).

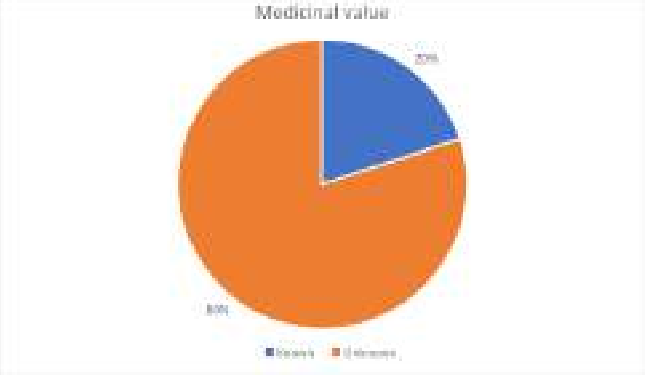

Figure 2. Respondent's knowledge on medicinal value of Yarsagumba

Economics of Yarsagumba collection

Categories of Yarsagumba with its value: The price of Yarsagumba mainly depends on its biological and morphological quality. The economic valuation of the Yarsagumba depends upon its fruiting stage. The Yarsagumba with the very firm larva and no sporulation had the highest market value whereas the one with a soft larva had the lowest. According to the compactness and sporulation phase, the price of Yarsagumba has been grouped into 3 classes.
Class A - Yarsagumba which has a thick size, very firm larva and no sporulation

Class B - Yarsagumba with the starting of sporulation
Class C - Yarsagumba which has a small size and soft larva (Winkler, 2008)

The price fluctuates according to the demand and supply in the local and international markets and other various reasons too. From this study, it is found that average price for a piece of class A yarsagumba was NPR 842.14 and for class B was NPR. 452.86. Similarly, for class C Yarsagumba average price per piece was NPR.122.86 (Table 2).

ANOVA test for differences in price value between different classes of Yarsagumba showed that there is a significant difference at a 5% level of significance for which the alternative hypothesis is being accepted, being a p-value less than 0.05.

Table 2. Categories of Yarsagumba with its value (in NPR)

Categories	Collected Units	Price per unit (NPR)	Income (NPR)
Class A	52.64	842.14	44007.86
Class B	68.04	452.86	31830
Class C	4.74	122.86	816.43

Income from Yarsagumba: The average income per person in a season from collecting all three categories of Yarsagumba was NPR. 76654.29.

Expenditure during Yarsagumba collection: In general, the average expense for an individual in harvesting Yarsagumba was found to be NPR.33132.14. The Average total expenses in food and clothes were NPR. 21764.28 and NPR. 4352.71 respectively. Besides that, other expenses like, transportation cost was about NPR. 2102.41 in average and for health it was about NPR. 1915.71. The above table showed that other miscellaneous expenses were about NPR. 3021.29 in average. Other miscellaneous expenses include expenses in communication and irregular expenses while buying tents and equipment used in collection of Yarsagumba.

Table 3. Expenditure during Yarsagumba Collection (NRs / head)

Categories	NPR
Food	21764.28
Clothing	4325.71
Health	1915.71
Transportation	2102.14
Others	3024.29
Total expenditure	**33132.14**

Profitability index: Profitability index is an indicator which is used in cost-benefit analysis that helps to summarize the overall value for money. It is a simple method to know the ratio at which return is obtained with respect to cost invested and it simply gives an idea about improvement of cost incurred during the production by return from products. The average income from Yarsagumba collection was NPR.76654.29 whereas average expenditure was NPR. 33132.14 (table 10). The cost benefits ratio of Yarsagumba collection enterprise was found to be 2.35 which show that collection of Yarsagumba is a profitable off farm activity and beneficial work. Similar findings were reported by (Karki et al., 2019) in API Nampa conservation area, Darchula with benefit-cost ratio of 5.13. This may be due different time, collection site, market, and other various reasons.

Livelihoods status: Out of 70 respondents, 53 (75.71%) reported that education was easily accessible to them (table 11). Similarly, electricity and water were also available for them. But 42 (60%) reported that they were deprived of proper health facility. From this study, it was found that 50 (71.43%) were out of reach from communication services and 38 (54.28%) had easy access for drinking water, but still 32 (45.72%) were deprived of drinking water. Respondents reported that royalties collected from Yarsagumba collection was used to pay for electricity, health and drinking water. Local collectors claimed that during Nepal's insurgency, the insurgents had complete control over trade and royalty collection from traders and harvesters.

Table 4. Profitability status of Yarsagumba collection

Categories	NPR
Income	76654.29
Expenses	33132.14
Profitability index	2.35

Table 5. Livelihood status in study area

Category	Available	Unavailable	Total
Education	53(75.71%)	17(24.29%)	70(100%)
Electricity	41(58.57%)	29(41.43%)	70(100%)
Health	28(40%)	42(60%)	70(100%)
Water	38(54.28%)	32(45.72%)	70(100%)
Communication	20(28.57%)	50(71.43%)	70(100%)

As a "revolution tax" that harvesters had to pay anyhow, they used to collect 500 NPR for each person. Since 2007, Local Community Forest User Groups have been collecting royalty/entry charge from each collector in order to protect the resources that remain within the laws, regulations, and supervision of district forest office (DFO) of Dolpa.

Risk and status of Yarsagumba collection

Collection trend in the last 5 years: The figure 6 shows that, the average collection of Yarsagumba per individual per season during last five years. One unit equals to one piece of Yarsagumba. Average annual collection of Yarsagumba in 2018 was 449.16 per individual per season. It decreased to 364.58 units in 2019. In the year 2020 the average collection of Yarsagumba per individual per season was 13.79 pieces. In 2021, that was only 37.7 pieces per individual.

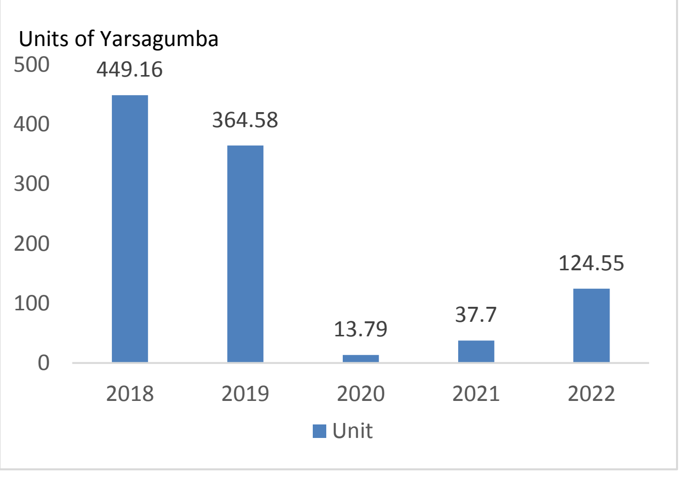

Figure 3. Collection trend per individual in the last 5 years

Yarsagumba was collected by an individual per season. But coming to year 2022, the average collection was up to 124.55 pieces. Collector reported that due to pandemic of Covid 19 in 2019 and 2020 they were restricted from collecting Yarsagumba, but locals near collection site collected Yarsagumba in low amount. However, in 2022 collection was affected due to local election as there was no security committee for controlling the collection of Yarsagumba.

Reasons for decline in Yarsagumba: The study showed that people knew about the Yarsagumba and their harvesting period but majority of them did not know about the concept of climate change and impact of climate change in availability of Yarsagumba. Out of total respondents, 39% of them suggested that the reason for the decline of Yarsagumba was overgrazing (Figure 4).

While 24% of the respondents suggested that the climate change could be the main reason for the declination of Yarsagumba (Fig. 4). Other reasons given by the respondents were anthropogenic pollution (17%) and excessive harvesting (20%). Kelly (2018) reported that the combined stresses of climate change and overexploitation for traditional medicine represent a threat to the sustainability of the caterpillar fungus both economically and ecologically.

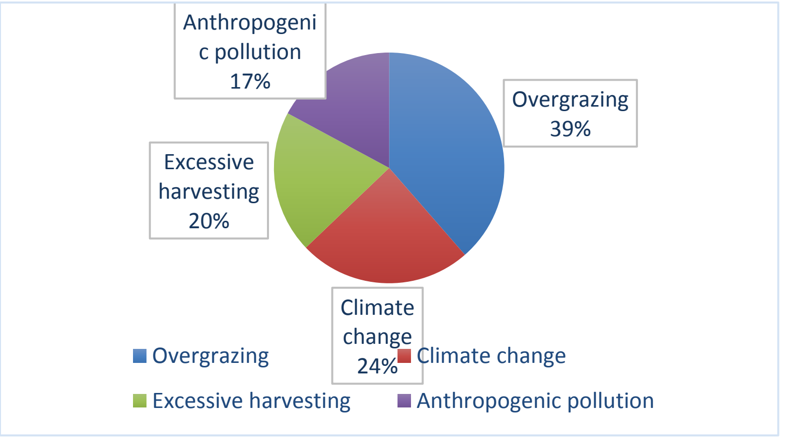

Figure 4. Reasons for decline in Yarsagumba

Risk while collecting Yarsagumba: There are many risks while collecting yarsagumba. The risks were classified as extreme climatic condition, transportation, theft of Yarsagumba, injury, topography and death, and the respondents were asked to rank them from major risks to minor risks.

Respondents of the study area ranked extreme climatic condition as the major risk for yarsagumba collection followed by theft of Yarsagumba. Other risks while collecting Yarsagumba are transportation, injury, topography, and death in descending order. Devkota (2006) reported that the risks are ranging from monetary value such as theft, even life-threatening cases, gang fights etc. to geographic hardships, unavailability of food, low oxygen at collection sites, steep slopes etc.

Table 6. Risks associated with Yarsagumba collection

Risks	Index value	Rank
Extreme climatic conditions	2.12	1
Theft	2.36	2
Transportation	2.92	3
Injury	3.08	4
Topography	3.12	5
Death	3.96	6

Climate change effect on Yarsagumba: The study shows that the majority of the respondents 38(54.29%) were unaware of any information on climate change whereas 32(45.71) were aware of climate change (Fig. 8). Also, the study reveals that 29(41.43%) respondents believe that climate change has some effect on Yarsagumba availability whereas 41(58.57) respondents did not believe climate change has no any effect on the availability of yarsagumba. Collectors in Dolpa, Nepal who reported climate change as decreasing winter snow (66%), earlier spring snowmelt (52%), and warming (38%) as causes of decreasing production in Yarsagumba (Shrestha and Bawa, 2015).

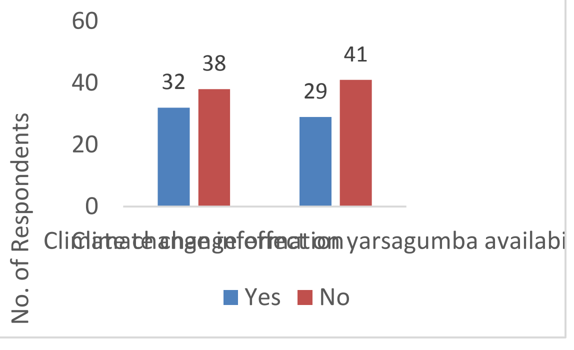

Figure 5. Climate change effect on Yarsagumba

CONCLUSION

This study is focused on assessing factors affecting and people perception on Yarsagumba collection in Thuliveri, Municipality of Dolpa district. Yarsagumba is playing an important role in the economy and livelihood, fulfilling the daily needs of people from their personal effort without national planning and local governing bodies' inputs. Similarly, the use of royalties collected by Local Community Forest User Groups from Yarsagumba collector in electricity, drinking water, education, and health is helping in the upliftment of the socio-economic class. Yarsagumba is not a cultivable crop, and it is harvested from the wild there is question of sustainability due to overgrazing and over exploitations. As a result, the amount of Yarsagumba is decreasing annually. Overgrazing, climate change, excessive harvesting, and anthropogenic pollution are some of the reasons for declining of Yarsagumba as reported by the collector. Extreme climatic conditions, chances of theft, and injury are major risks while collecting yarsagumba.

SUGGESTIONS

Information obtained from this study can be used by the policymakers, organizations, local government, and researchers to promote Yarsagumba. Some of the suggestions are listed below.

- There should be a local government plan for securing suitable harvest plans with conservation planning of habitat and biodiversity relating to Yarsagumba growth in the wild.
- Awareness should be given to collectors regarding the information on the life cycle, habits, and habitat of Yarsagumba, climate change, and pollution effect on declining Yarsagumba.
- Some areas should be protected and research on life cycles, morphological diversities, species variants, and substrate about Yarsagumba growing should be done.
- Minimizing risk hazards, and threats to life, controlling overgrazing, insurance policy for Yarsagumba collectors by local government, taxing system and revenue generation and recording by local government should be done.

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ASSESSING DISEASE SEVERITY OF ALTERNARIA LEAF SPOT OF CAULIFLOWER UNDER DIFFERENT LEVELS OF NITROGEN

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ABSTRACT

Yield and productivity of cauliflower are declining due to various biotic and abiotic stresses. Among all, heavy losses are incited yearly by Alternaria brassicicola on the cauliflower. On the horticulture farm of Lamjung campus in Sundarbazar, Nepal, a study was conducted to see how varying nitrogen concentrations affected the severity of Alternaria leaf spot disease in cauliflower. The experimental field was laid out in randomized complete block design with four replications and five different levels of nitrogen as treatments (100, 150, 200, 250 and 300) kg ha^{-1}. Disease scoring was done using 0-9 scale on individual plant at 5 days intervals and mean area under disease progress curve (AUDPC) was calculated. Further plant height, curd weight and curd diameter were also recorded. Different nitrogen levels had a significant effect on AUDPC. Maximum mean AUDPC (75.94) was observed on plants receiving nitrogen level of 300kg ha^{-1} while minimum AUDPC (29.17) was observed on 150kg ha^{-1}. Similarly, difference in plant height was observed between the levels of nitrogen. The highest and lowest plant height was recorded on plants receiving nitrogen level of 300 kg ha^{-1} and 100 kg ha^{-1} respectively. Difference on other tested yield parameters viz. curd weight and curd diameter were found non-significant. The result indicated that 150 kg ha^{-1} nitrogen level was effective over other levels in reducing disease severity.

KEY WORDS: AUDPC; Biotic stress; Disease severity; Nitrogen.

INTRODUCTION

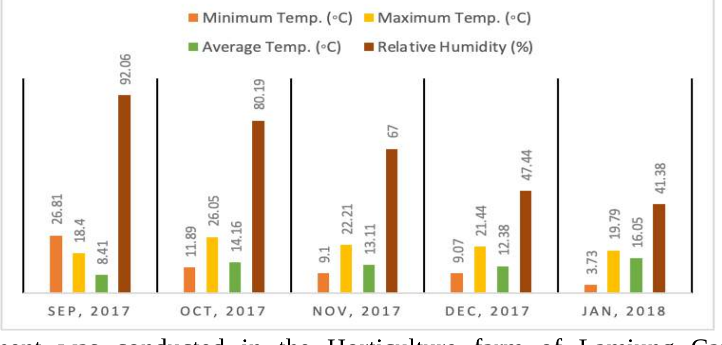
Cauliflower (*Brassica Oleracea* var. *botrytis*), a winter-season crop of Brassicaceae family is also recognized as the "Queen of winter vegetables". It is an herbaceous annual crop for vegetable purpose and a biennial crop for seed production. Globally, cauliflower is cultivated on 1,357,462 ha area with the total annual production of 25,206,752 tons (FAOSTAT, 2017). Among vegetable crops, cauliflower is ranked 1st in terms of both cultivated area (34,967 ha) and productivity of 15.7 mt/ha (MoAD, 2016). On the farmer's field, there is a significant difference between the potential yield and the actual yield. Both biotic and abiotic factors constrain plant growth and output (Seki *et al.,* 2003). Abiotic stress can cause 50% of the yield losses contributing significant economic losses (Vij and Tyagi, 2007). Abiotic stress may occur as a result of their sensitivity to environmental conditions like as temperature, rainfall, relative humidity, leaf wetness duration, and nutritional status. Cauliflower frequently encounters alternaria leaf spot, one of the most significant biotic stresses. *Alternaria* species that are pathogenic to cruciferous crops include *A. alternata*, *A. brassicae*, *A. brassicicola*, and *A. raphani*. The primary pathogen of the oil-producing *Brassica* plant, *Alternaria brassicae*, is more prevalent on vegetable crops than the other three (Jung *et al.,* 2002; Kolte 2018; Tewari, 1991; Verma and Saharan, 1994, Woudenberg *et al*., 2013). These diseases can attack Brassicaceae crops at several growth stages, including the seedling, vegetative, and reproductive stages (Valkonen and Koponen, 1990; Blagojević *et al.,* 2020). *A. brassicicola* is reportedly more common and dangerous compared to other species (Sabry *et al*., 2015). The necrotrophic pathogen, *A. brassicicola* is characterized by its ability to grow either saprophytically on the dead plants or necrotrophically on a living host. Despite the fact that mating genes have been discovered in *A. brassicicola* genome, this fungus has no known sexual stage (Dang *et al*., 2015). Alternaria blight in Nepal has been reported to cause average yield losses of between 32 and 57 percent (Shrestha *et al*., 2005). When it comes to the pathogen's infection structures and disease symptoms in crucifers, the incubation temperature and relative air humidity are crucial factors (Bassey and Gabrielson, 1983). Alternaria leaf spot is caused by fungi that overwinter in damaged plant residues as well as on wild perennial hosts. On older leaves, little necrotic patches with concentric rings and occasionally a yellow halo first appear as disease symptoms. Alternaria infections are the primary cause of both qualitative and quantitative yield reductions (Singh, 2015; Kumar *et al.,* 2014).

Due to its critical role in plant growth and impact on crop quality and production, nitrogen is the most significant nutrient for plants (Gastal and Lemaire, 2002; Li *et al.*, 2003; Lea and Azevedo, 2006; Leghari *et al.*, 2016). Numerous physiological and metabolic processes involve nitrogen. The majority of plant species consume nitrogen in a variety of forms, including nitrate (NO3-) and ammonium (NH4+). Plant illnesses can develop as a result of nitrogen's effects on physiological processes in plants, such as enzyme activity, water balance, photosynthetic rate, respiration rate, and signaling pathways. Various forms of nitrogen might influence metabolic pathogen adaptation and signals governing virulence factor stimulation, hence affecting disease tolerance (Sharma, 2020). The use of inorganic nitrogenous fertilizers boosts host plant development while also increasing susceptibility to foliar diseases (Develash and Sugha, 1997). Additionally, high nitrogen content in the plant prevents the development of lignin and phenolic chemicals (fungistatic), which diminish disease resistance (dos Santos *et al.*, 2009). Additionally, nitrogen increases the levels of amino acids and amines in the apoplast, which seem to have an even higher effect on conidia germination than sugars, promoting the spread of fungi (Marschner, 2011; Simon *et al.*, 2020).Use of balanced fertilizers is essential for the treatment of Alternaria leaf spot on cauliflower. The objective of this study was to establish the optimal nitrogen dose for reducing Alternaria leaf spot disease and boosting cauliflower yield.

MATERIALS AND METHODS

Experimental site and meteorological information

The lab work was conducted at the laboratory of Plant Pathology while field



experiment was conducted in the Horticulture farm of Lamjung Campus, Institute of Agriculture and Animal Science (IAAS), Sundarbazar, Lamjung

Figure 1. Meteorological data during the research study (Source: Nasa Power https://power.larc.nasa.gov/data-access-viewer)

located at the coordinates 28º8'41.43" N latitude, 84º24'43.25"E longitude and lies 630.02 meter above sea level. The experiment was conducted during September 2017 to January 2018. It has humid and subtropical climate, sandy loam soil with average annual rainfall of 2800 mm (DTMP Report, 2013).

Collection, isolation, purification, and maintenance of the pathogen cultures

From fields of Sundarbazar, Lamjung, cauliflower leaves of typical indications of Alternaria leaf spot were collected in paper bags. Samples were surface sterilized with 0.5% sodium hypochlorite solution for 2 minutes, washed three times with sterilized distilled water, and then cleaned with tap water. The surplus water was then drained from the samples by drying them between two layers of sterile filter paper. Using a sterilized scalpel and adjacent healthy tissues, the dried, sterilized spotted leaf tissues were sliced into little pieces and put on simple agar medium in 9 cm petri plates. Dishes with the inoculum were incubated at 28°C for 24 hours (Reuben, 2021).

The expanding colonies outermost hyphal tips were transferred to plates with potato dextrose agar (PDA) medium, where they were cultured at 28 °C **(**Meah et al., 2017**)**. Pure cultures were obtained for each of the isolated fungi using hyphal tip technique. The purified fungi were identified according to their morphological characters using the description given by Ellis 1968, Ellis 1971, Ellis 1993 and Holliday, 1980. As implied, conidia are typically found in chains of up to 20 or more, occasionally branched, acropleurogenous, emerging from tiny pores in the conidiophore wall, straight, nearly cylindrical, typically tapering slightly towards the apex or obclavate. The apical cell is roughly rectangular or shaped like a truncated cone; it is occasionally well developed but always short and thick, with 1-11, typically less than 6, transverse septa that are frequently constricted at the septa; it is smooth and light to dark olivaceous brown in color. The basal cell is spherical and often has little or no beak.

Experimental design and field set up: In the year 2017/18, the experiment was conducted using a single factorial Randomized complete block design (RCBD) with four replications and five treatments. Kathmandu Local, which is a popular variety in this area and susceptible to Alternaria leaf spot was used. Different dose of nitrogen viz. 100kg ha^{-1}, 150kg ha^{-1}, 200 kg ha^{-1}, 250kg ha^{-1} and 300kg ha^{-1} were used as treatments. Nursery bed was prepared in September 2017 while seedlings were transplanted in October 2017. The size of each unit plot was 2.4m×1.8 m. The total number of plots were 20. Each plot contained 16 plants with a row to row spacing of 60 cm and a plant to plant spacing of 45 cm.

Gap between two consecutive replication and consecutive treatment was maintained 50 cm and 25 cm respectively. Full doses of P and K were given, whereas 50% of the required amount of nitrogen was given as a basal dose and the remaining N was given in two split doses at equal intervals 30 and 60 days later. 12.96 kg well rotten farmyard manure was applied per plot at the time of field preparation. Irrigation and other intercultural tasks were carried out in accordance with accepted horticultural techniques.

Inoculum preparation and inoculation: The pure culture of *A. brassicicola* was then multiplied in the petri plates of PDA (Potato Dextrose Agar), incubated at 25ºC under 12/12 hours of alternating dark/light conditions for 7-10 days. 50 ml sterile water was used to flood the developed cultures. To dislodge fungal growth from the medium surface, the growth (mycelia mates and spores) was gently brushed away with a smooth brush. Prepared suspension was kept in sterilized flasks. To remove mycelium fragments and big particles, the obtained spore and mycelium suspensions were blended together and filtered through sterilized cheesecloth. Obtained fungal suspensions were adjusted to 10^5 spores/ml using sterilized water with the aid of haemocytometer. Droplets of tween 20 (0.5 ml/L) were finally added. Inoculum was sprayed on healthy cauliflower transplants until run off when the plants were 40 days old (Kohl et al., 2010, Valvi et al., 2019).

Treatment details: The treatment details were as presented in Table 1.

Table 1. Treatment details for the assessment of disease severity of Alternaria leaf spot in cauliflower under different nitrogen doses during 2017/18

Treatments	Treatment details
T1	100 kg Nitrogen ha^{-1}
T2	150 kg Nitrogen ha^{-1}
T3	200 kg Nitrogen ha^{-1}
T4	250 kg Nitrogen ha^{-1}
T5	300 kg Nitrogen ha^{-1}

Assessment of disease reaction and scoring: The indications of Alternaria leaf spot occurred after the 49th day after transplanting. Four plants from each treatment's net plot were chosen to record the observations. Disease severity of leaves was determined at five days interval using 0-9 scale described by **(**Sharma *et al*., 2004**)** as shown in Table (2) which is based on the number and size of flecks with lesions as well as dead patches formed on infected leaves of each plant.

Assessment of area under disease progress curve (AUDPC): AUDPC delineates the information on the rate of disease increment in fields and the cumulative amount of disease across a season for an overall estimate of disease progress.

Table 2. Cabbage leaf spot disease scale used for determination of the severity in the field

Scale	Disease severity groups	Disease severity descriptions
0	Control	Healthy, no apparent disease
1	No. of flecks	>5 pinpoint lesions (flecks).
2		6 to 10 flecks.
3		11 to 15 flecks.
4	Flecks and Lesions	<15 flecks or few large concentric- ring lesions.
5		Moderate flecking or few large lesions.
6		Heavy flecking or moderate larger lesions.
7	Flecks, lesions and tissue collapse	Heavy flecking or many large lesions with mild tissue collapse.
8		Heavy flecking or many large lesions with moderate tissue collapse.
9		Heavy flecking or many large lesions with extensive tissue collapse.

Based on the progression of symptoms, the scale can be divided into four primary groups of severity. ***0)*** *healthy plants* ***1-3)*** *grades of leaf flecking* ***4-6)*** *grades of leaf flecking and no. of large concentric lesions* ***7-9)*** *heavy flecking, lesions and the area of tissue collapse.*

Thus, it is the quantitative assessment of disease intensity over time. Using disease severity data from each recording, the area under the disease progress curve (AUDPC) was determined. The AUDPC was calculated using the formula given by Campbell and Madden, 1990.

$$\boldsymbol{AUDPC} = \sum_{i=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2}\right)(t_{i+1} - t_i)$$

Where ‘y’ is the percentage of disease severity at each reading,‘t’ is the time of each reading, and ‘n’ is the number of readings.

Assessment of yield and yield attributing traits

The growth metric measured was plant height, while the yield parameters were curd weight and curd diameter.

Statistical analysis

The data obtained from the experiment was entered and processing was carried out using Microsoft Office Excel 2010. Analysis of variance (ANOVA), post hoc test using Least Significant Difference (LSD) and Duncan's Multiple Range Test (DMRT) at 5% significance level was done using SPSS version 16.0.

RESULTS AND DISCUSSION

Effect of nitrogen levels on disease severity and AUDPC

Disease severity increased as the cauliflower approached towards maturity and was generally greatest on the lower leaves. Different nitrogen levels had a significant effect ($p < 0.01$) on AUDPC. Among the five levels of nitrogen tested, the AUDPC value was highest (75.94) on plants receiving nitrogen level of 300kg ha^{-1} which was statistically at par with plants receiving nitrogen level of 250 kg ha^{-1}. However, plants receiving nitrogen level of 150 kg ha^{-1} recorded lowest AUDPC value (29.17) which was found statistically at par with plants receiving nitrogen level of 100 kg ha^{-1} (Table 3). This result is in accordance with the findings of Khatun *et al.* (2011) and Dasgupta *et al.* (1991). Singh *et al.* (1992) also reported similar result in Alternaria leaf spot of mustard where the severity of leaf spot increased along with the increase in level of nitrogen. Sridhar (1972) revealed that the application of excessive level of nitrogen alters the biochemical components of host tissue thus increasing the susceptibility of the plants to disease. Wu *et al.* (2014) also suggested that increase in nitrogen supply causes changes in the canopy structure, lower phenol levels, and higher crop density, all of which may create a favorable microclimate for pathogen development.

Table 3. Assessment of disease severity of Alternaria leaf spot in cauliflower under different nitrogen levels during 2017/18 at Lamjung campus, IAAS

S.N.	Treatment			AUDPC
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	
1.	100	120	80	34.17^{c}
2.	150	120	80	29.17^{c}
3.	200	120	80	42.50^{b}
4.	250	120	80	72.81^{a}
5.	300	120	80	75.94^{a}
LSD (≤ 0.05)				6.750
SEm (±)				4.381
CV (%)				8.6
F-test				**

*AUDPC: Area Under Disease Progression Curve, CV: Coefficient of Variation, LSD: Least Significant Difference, SEM (±) indicates standard error of mean. Means followed by the same letters in a column are not significantly different by DMRT at 1% level of significance and **: significant at 1% level.*

Effect of different levels of nitrogen on plant height: Different nitrogen levels had a significant effect ($p<0.05$) on plant height (Table 4). The maximum plant height (69.05cm) was recorded in plants receiving nitrogen level of 300kg ha^{-1} while the minimum plant height (59.86cm) was observed with nitrogen level of 100kg ha^{-1} at harvest. This result is in accordance with Khurana *et al.* (1990) who carried out an experiment to study different levels of nitrogen (0, 90,120,150 kg ha^{-1}) on cauliflower growth and revealed that 150 kg ha^{-1} nitrogen level showed significant increase in plant height (41.3cm). Similar findings were obtained by Moniruzzaman *et al.* (2007) who noted that the application of nitrogen at higher level (200 kg ha^{-1}) gave tallest plant height compared to the lower level (100 kg ha^{-1}) in broccoli. Similar result was obtained by Jadhao *et al.* (1999) in radish. Yildrin *et al.* (2007) reported that soil nitrogen fertilization increased the plant height of broccoli. This could be because nitrogen is an essential nutrient for plants, as it is involved in physiological and enzymatic processes. Nitrogen accelerates amino acid synthesis because it is a component of protein and chlorophyll molecules, resulting in development of plant height (Anas *et al.*, 2020).

Effect of different levels of nitrogen on curd weight: Statistical analysis of the data indicates that different levels of nitrogen had no significant effect on curd weight (Table 4). However, the trend shows that the highest curd weight (0.34kg) was observed in plants treated with 200kg ha^{-1} nitrogen level and lowest curd weight was observed in plants treated with 300 kg ha^{-1} nitrogen level. The trend shows there was increase in curd weight continuously with the increase of nitrogen level from 100 kg ha^{-1} to 200 kg ha^{-1}. Furthermore, with the increase of nitrogen level from 200 kg ha^{-1} to 300 kg ha^{-1}, curd weight decreased continuously. The lower curd weight with the increase in level of nitrogen suggests the effect of disease severity in curd weight. The experimental findings were in consonance with the findings of Nkoa *et al.* (2001) who mentioned that excess nitrogen in cole crops may result in lower yield. This could be due to an increase in the susceptibility of plants to disease at higher nitrogen levels. This result is also close with the findings of Sharma *et al.* (1994) who noted more disease infection with higher nitrogen application which subsequently lower the yield. The amount of nitrogen fertilizer applied can influence the plant resistance to pathogens (Sandhu, 1985).

This result is in agreement with the experiment of Jian (1990) who found the average weight of Chinese cabbage increased as nitrogen fertilization increased from 0 to 150 kg ha^{-1}, but increasing nitrogen fertilization to 180 kg ha^{-1} resulted in a weight decrease.

Effect of different levels of nitrogen on curd diameter

Statistical analysis of the data indicates that different levels of nitrogen had no significant differences on curd diameter (Table 4). However, the trend shows that the highest curd diameter (17.05cm) was observed in plants receiving nitrogen level of 200 kg ha^{-1} while the lowest curd diameter (15.47 cm) was observed in plants receiving nitrogen level of 300 kg ha^{-1}. The result obtained shows that there is increase in curd diameter with the increase in nitrogen level from 100 kg ha^{-1} to 200 kg ha^{-1}. Furthermore, with the increase in nitrogen level from 200 kg ha^{-1} to 300 kg ha^{-1}, curd weight decreases continuously. The lower curd weight with the increase in nitrogen level suggests the effect of disease severity in curd weight. The finding of the present investigation is in conformity with the result that the nitrogen level greater than 120 kg ha^{-1} did not significantly increase the yield and yield attributes in mustard as reported by (Singh *et al.*, 2003). It might be due to the reason that excess nitrogen can delay maturity, thus extending the time available for infection and disease development resulting in yield loss. High nitrogen creates a favorable environment on host for infection by the pathogen.

Table 4. Effect of different levels of nitrogen on plant height, curd weight and curd diameter of cauliflower at Lamjung Campus, Nepal during Sep 2017- Jan 2018

S.N.	Treatment			Growth and yield attributing parameters		
	N (kg ha^{-1})	P (kg ha^{-1})	K (kg ha^{-1})	Plant height (cm)	Curd weight (kg)	Curd diameter (cm)
1.	100	120	80	59.86^{b}	0.30	15.78
2.	150	120	80	62.49^{ab}	0.31	16.37
3.	200	120	80	66.23^{ab}	0.34	17.05
4.	250	120	80	68.65^{a}	0.29	15.57
5.	300	120	80	69.05^{a}	0.27	15.47
LSD (≤ 0.05)				6.116	0.19	4.71
SEm (±)				3.970	0.12	3.06
CV (%)				6.1%	40.9%	19.1
F-test				0.027*	NS	NS

*Means followed by the same letters in a column are not significantly different by DMRT at 5% level of significance, *: significant at 5% level and NS=non-significant*

CONCLUSION

Based on the findings, it can be inferred that a nitrogen level of 150 kg ha^{-1} was more effective than other nitrogen levels at reducing the severity of Alternaria leaf spot in cauliflower. The use of optimal fertilizer in disease-prone areas aids in the control of this cosmopolitan fungus while also promoting healthy plant growth and development. The relationship between host nutrition and disease development can be used to improve current agricultural practices in order to reduce disease severity. As a result, disease prevention and management should be based on a combination of appropriate agricultural management methods and nitrogen levels.

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VALUE CHAIN ANALYSIS OF LENTIL PRODUCTION IN SARLAHI DISTRICT

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ABSTRACT

Lentils production can significantly improve the livelihood and nutrition of rural farmers. Despite the tremendous opportunity it represents, its potential has not been fully developed due to lack of prioritization. This study entitled "Value chain analysis of lentil production in Sarlahi district was conducted from October to December,2022 in 2 municipalities namely Lalbandi and Balara of Sarlahi. Primary and secondary data were collected from 100 respondents including producers, different actors and enablers as well as government and non-government publications. The objectives of the study were to 1) highlight the economic significance of lentil production, and 2) prioritize the major constraints and opportunities in lentil production. Study shows that Sarlahi district contributes 30.44 percent of the total lentil production in Nepal. An average yield of lentil was 1,240 kg per hacter per season in Sarlahi district. The cost of production of lentil was found to be NRs 23,415 per hacter. On an average, the return from lentil production was NRs 37,200 per ha per season. Net profit gained by the farmer was NRs 13,785. The farm gate price of lentil was found to be NRs. 30 per kg. Cost of production, up to harvesting, of lentil was NRS 18.88 per Kg and transportation cost was found to be NRs 35 from farm to the collector so the average total cost of lentil production was NRs. 20.18 per kg. The study showed that profit margin to wholesaler was higher than that of the other actors. followed by producer and retailers (52.03 percent, 26.82 percent, 21.14 percent respectively.). The lentil value chain does not seem to be strong enough due to poor vertical and horizontal linkages, market distortion and unhealthy competition among traders.

Keywords: Lentil, Value Chain, Value share, Cost, Profit Margin

INTRODCTION

Lentil (Lens culinaris) is mainly grown in the lowland Terai region of Nepal in rotation with cereals based on the availability of residual soil moisture after the harvesting of rice. It is generally planted in mid-October to November and harvested in March and April. Lentil is a short bushy annual legume with small purse like pods containing 1 or 2 lens-shaped seeds. Lentils were among the earliest domesticated plants about 10,000 years ago in the Near East (Cubero et al. 2009). Lentils play an important role in livelihood, food, and nutritional security. They are low in fat, low in sodium, cholesterol free, high in protein, and are an excellent source of both soluble and insoluble fiber, complex carbohydrates, vitamins and minerals. Lentil is also an important nitrogen fixing crop. Lentil is the highest pulse in terms of both production areas and production quantity that covers more than 60percent of the total pulses produced in Nepal. It is also the largest exported item among agricultural commodities from Nepal with a share of about 2.3 percent of total national exports and about 3.1 percent of the total world export (ITC, 2010). Nepal is currently listed among the top 10 exporters and was 5th in 2009 and 2010 in terms of quantity and value in US dollar exported. Lentils from Nepal are receiving US $1,364 per metric ton (MT) which is high compared to the lentils from other countries. The Nepal Trade Integration Strategy (NTIS) has prioritized lentil as one of the 19 commodities with export potential in Nepal. Despite a high export potential, there are many constraints that are limiting the production and export of lentils. The major constraints to increase lentil production at farm levels are the lack of improved seeds, production technologies, micro-nutrients, chemical fertilizers, insecticide/pesticide management, and micro-irrigation. Also constraining export growth are proper linkages with international buyers, compatible policies, information gaps, and quality standards and certification.

MATERIALS AND METHODS

The study was conducted from October to December, 2022 in 2 municipalities of Sarlahi Districts Lalbandi and Balara with the randomly selected 100 respondents including input suppliers, producers, wholesalers, retailers, and consumers from Sarlahi. The study consisted of following procedures such as: Selection of the study sites, survey of the study sites, preparation of the sampling frame, sample design, sources of information, data collection techniques, analysis of the data and their interpretation.

Data collected from field survey was coded first and entered into the computer. Both qualitative and quantitative techniques were used for the data analysis. Descriptive statistics like Mean, percentage and frequency was used to describe socioeconomic, value chain actors and activities and marketing of tomato produced under IPM technique. Data entry and analysis was done by using

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computer software package ''Microsoft Excel 2007'. Analyzed data was then presented in Tables, graphs and pie chart as per the requirement. The price of lentil at value chain levels and commodity quantities are presented in a range because they fluctuate over time, even within a week. Additionally, there is a price difference between different regions (i.e. Eastern versus Western) because of transfer costs. Therefore, data might not precisely capture the trend or pattern to reflect market dynamics. The data is validated to the extent possible with different sources.

Total Cost

Total cost refers to the sum of total variable cost and fixed cost incurred to produce final product (Bist ,2010). All cost incurred to fixed factors such as land tax, electricity charge, salary of the permanent labor, fitting materials, farm construction, and depreciations were considered as fixed cost. Likewise, monetary value incurred to all variable factors such as wages of hired labor, seedling, fertilizers, organic manures and pesticides etc. was considered as variable cost

Total Cost = Total variable cost + total fixed cost
Total variable cost = ∑ (Variable inputs × Price)
Total fixed cost = ∑ (Fixed inputs × Price)
Total Cost = Total variable cost + total fixed cost
Total variable cost = ∑ (Variable inputs × Price)
Total fixed cost = ∑ (Fixed inputs × Price)
Total Cost = Total variable cost + total fixed cost
Total variable cost = ∑ (Variable inputs × Price)
Total fixed cost = ∑ (Fixed inputs × Price)

Price

The value of any commodities or services in monetary term is called price (Joshi, 2001). Prices reflect value or can be adjusted to do so (Gittinger, 1982). Three points of prices such as farm gate price, wholesale price and retail price were calculated in this study. The monetary value that received by gerbera producer when he/she sold his/her product is referred as farm gate price, that the wholesaler received is referred as whole sale price and that the retailers received referred as retail price.

The value of any commodities or services in monetary term is called price (Joshi, 2001). Prices reflect value or can be adjusted to do so (Gittinger, 1982). Three points of prices such as farm gate price, wholesale price and retail price were calculated in this study. The monetary value that received by lentil producer when he/she sold his/her product is referred as farm gate price, that the wholesaler received is referred as whole sale price and that the retailers received referred as retail price.

Gross Return

Gross return is the total value of the final product which was calculated based on the direct use value of the final product at the local level (Bist, 2013). It was calculated by using following formula:

Gross return= Price × Total quantity marketed

Value share

Value shared by different value chain actors in Nepalese Rupees (NRs) per stick was calculated. Share on the value was categorized into three categories namely; profit percentage of total cost, profit percentage of sales price and share in total benefit. These economic parameters were calculated by using following formulae (PACT, 2014):

Profit percentage of total cost = total cost incurred by respective actors / net profit gained by respective actors.

Profit percentage of sales price = net profit received by respective actors / price received by respective actors

Share in total benefit = net profit gained by respective actors / total profit received by value added activities

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Share in total benefit = Net profit gained by respective actors / total profit received by value added activities

RESULTS AND DISCUSSION

Value chain Actors

There are many actors in lentil value chain which play different roles in product marketing from input supply to production, collection, processing/milling, wholesaling, retailing and ultimately to the consumers.

Input suppliers

In lentil value chain, agro-vets, agricultural tool dealers, fertilizer dealers and financial institutions are the major input suppliers. They supply inputs and also provide technical advice to farmers on application methods. There are 200 agro-vets, 32 fertilizers dealers and 29 financial institutions in the district. Producers Farmers are the producers of lentil in the district. They get inputs required for rice production from local level input suppliers. About 20 percent of lentil produced is used in home consumption, 55 percent is sold to small scale collectors and remaining 25 percent is sold to large scale collectors.

Collectors (small scale/large scale)

Most of the small scale collectors are also primary producers. Around 350 small scale collectors from different VDCs are involved in collection of lentil from villages. They are mostly involved in collection, drying, winnowing and storage. Of the total amount they collect, about 50 percent of lentil is sold to large scale collectors, 25 percent to millers and about 25 percent lentil to to small mill holders. There are about 120 large scale collectors who collect lentil from small scale collectors and sometimes also from primary producers. They sell their lentils to large millers

Wholesalers

In the district, about 150 wholesaler's lentil are found. They buy lentil from large millers and sell it to retailers within the district and outside markets.

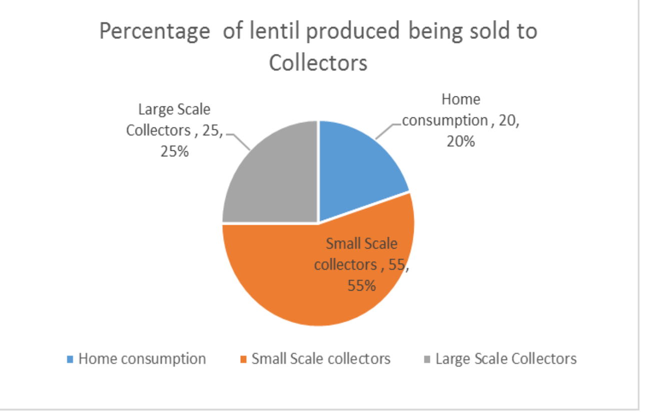

Figure 1. Pie-chart showing the percentage of lentil being sold to collectors in Sarlahi district

Retailers

In the district, about 1000 retailers of lentil are found. Retailing shops buy lentil from wholesalers and sell it to consumers. The functions of retailers are weighing and retailing.

Value chain analysis

Cost of production

Cost of production includes all the cost of inputs, machineries and labours used from land preparation to harvesting of lentil. The cost of production was found NRs 23415. Net profit gain by the farmer was NRs 13785.

Table 1. Benefit cost analysis of Lentil Production by a farmer

Fixed cost per ha/season				
Cost item	Unit	Quantity	Rate (NRS)	Amount (NRS)
Land Tax	NRS/ha	1.00	0.85	0.85
Variable cost per ha /season				
Labor	Unit			
Male	Number	15	300	4500
Female	Number	15	300	4500
Total Cost of hired labor	**NRs**	**30**	**300**	**9000**
Seed(>85% Germination)	**Weight, Kg**	**20**	**30**	**600**
Fertilizer	Killograms	Unit	Rate	Amount

Nitrogen	Killograms	20	18	360
Phosphorus	Killograms	40	32	1280
Pottash	Killograms	20	20	400
Rhizobium	litre	1	400	400
Sugar solution	litre	1	200	200
Multivitamin	Bottle	1	300	300
Total cost of fertilizer	**NRs**			**2940**
Manual weeding 2 times	**person**	**10**	**300**	**6000**
Organic Manure**				
FYM	Tones	5	300	1500
Total Cost of Organic matter				**1500**
Pesticides**				
Diethene M 45	Packet	1	375	375
Total cost of pesticieds				**375**
Harvesting (manual labour)	**Number**	**10**	**300**	**3000**
Sub total (B)				23415
Total Cost: (C)= (A+B)				23415
Income (D)		Unit	rate	Amount, NRs
Total Production of Lentil		1240 Kg	30	37200
Net profit: D-(A+B)	37200-23415			13785

Return from lentil production

It was found that on an average yield of lentil was 1240 kg per hacter per season on Sarlahi district. Out of total lentil production in Nepal Salahi district contributes 30.44 percent of lentil production. The return from lentil was on average NRs 37200 per ha per season. The farm gate price of lentil was found to be NRs. 30 per kg.

Table 2. Area and Production of lentil in Nepal during different economic year

Economic Year	Area (Ha)	Production (Metric tons)
2074/75 (2017/18)	198,605	249,491
2075/76 (2018/19)	208,766	251,185
2076/77 (2019/20)	212,876	262,835

Table 3. Area, production and yield of Lentil in Sarlahi districts 2076/77 (2019/20)

Particulars	**Quantity**
Area of Lentil Production	6,460 Ha
Quantity of Lentil Produced	8,009 Metric tons
Yield of Lenil	1.24 metric tons per ha

Value added activities and share in value addition activities by lentil production

The study showed that Land preparation, field sanitation, disease pest management, maturity judgment was the major activities carried out by producers to create and add value on lentil across the study site. This indicates that good agricultural practice has great role to add value in lentil.

Table 4. Table showing the shares of producers, wholesalers and retailers

Partiulars	Producers	Wholesalers	Retailers	Total
Cost of Production in NRs	18.88			18.88
Loss at farm in NRs	0.15			0.15
Storage loss in NRs	0.1		0.25	0.35
Transportation loss in NRs	0.5		0.16	0.66
Transportation cost in NRs	0.35	0.35	0.35	1.05
Packaging in NRs	0.2	0.1	0.7	1
Storage cost in NRs		0.5	0.8	1.3
Buying cost in NRs		30	50	
Total Cost in NRs	20.18	30.95	52.26	
Sales Price in NRs	30	50	60	
Profit in NRs	9.82	19.05	7.74	36.61
Profit Percent of the cost	48.6620416	61.5508885	14.8105626	
profit percent of the sales	32.7333333	38.1	12.9	
shares in total benefit in percentage	26.8232723	52.0349631	21.1417645	100 (Percent)

Value addition in lentil: Cost of production, up to harvesting, of lentil was NRS 18.88 per Kg. Transportation cost was found NRS 35 from farm to the collector. On average total cost of lentil production was NRs. 20.18. The study showed that profit margin to wholesaler was higher than that of the other actors in the value chain of lentil. Share in total benefit was found higher to the wholesaler followed by producer and retailers (52.03%, 26.82%, and 21.14 %, respectively).

Share and supporting organizations: A number of public and private organizations are providing support for the promotion of lentil in Sarlahi district. Most of the organizations are focusing their support to increase the productivity and production of lentil at farm level. The following are the major service providing organizations:

Governmental and non-governmental organizations

DADO, NARC, local NGOs and cooperatives are the major service providers in Sarlahi district. They support the value chain actors in different aspects such as technology dissemination, infrastructure development, electricity, policy and marketing. Farmers complain that technical and other supports are inadequate. Furthermore, there is lack of coordination and collaboration among service providing organizations for consolidated efforts to promote rice in a value chain approach. Financial institutions: There are more than 9 financial institutions providing services in Sarlahi district. Financial institutions provide loan to farmers and traders involved in rice business. The interest rate ranges from 12 to 24 percent per year.

Value chain map

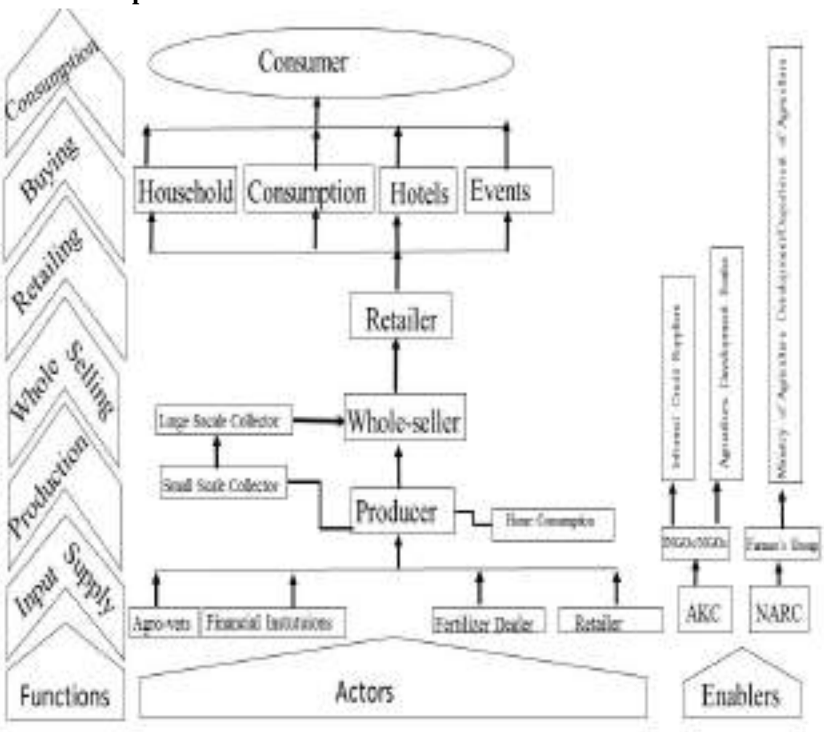

Figure 2. Value chain map of lentil production

Major constraints, opportunities and potential interventions: Major constraints and opportunities in lentil value chain were identifies through FGDs and stakeholders workshop. In the district, several issues were found in lentil value chain. Major constraints and opportunities were categorized into seven major aspects. Some of the major constraints were high cost of production, less number of collection centers and storage facilities in villages, unorganized farmers for the business, lack of market information system, and short-term loan with early pay-back system. There are also opportunities to improve the performance of lentil business by strengthening the value chain. Based on the constraints and opportunities, potential interventions were identified in consultation with key stakeholders.

CONCLUSION

The study showed that Sarlahi district contributes 30.44 percent of the total lentil production in Nepal. An average yield of lentil was 1,240 kg per hectare (ha) per season in Sarlahi district. The cost of production of lentil was found to be NRs 23,415 per ha. On an average, the return from lentil production was NRs 37,200 per ha per season. Net profit gained by the farmer was NRs 13,785. The farm gate price of lentil was found to be NRs. 30 per kg. Cost of production, up to harvesting, of lentil was NRS 18.88 per Kg and transportation cost was found to be NRs 35 from farm to the collector so the average total cost of lentil production was NRs. 20.18 per kg. The study showed that profit margin to wholesaler was higher than that of the other actors. followed by producer and retailers (52%, 26%, and 21%, respectively.). The lentil value chain does not seem to be strong enough due to poor vertical and horizontal linkages, market distortion and unhealthy competition among traders. The higher percentage of share to the wholesaler and producer may be due to the higher risk associated with production. Among the key market actors, large collectors, large millers and wholesalers have dominating role in pricing and supply of lentil in the market. There is no linkage and association among the producer farmers. There exists a weak negotiation among the actors. If they unite, they can collect huge amount of lentil at one place and they can negotiate with the collectors and they can get higher price. They lack storage facilities. There is low profit margin in lentil business when compared to other high value agricultural commodities. Availability of private service input suppliers should be made even in the villages.

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TECHNICAL EFFICIENCY DIFFERENTIALS OF TOMATO (*Solanum lycopersicum*) PRODUCTION UNDER TRADITIONAL AND IMPROVED TECHNOLOGIES IN NIGERIA

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ABSTRACT

This research work focused on technical efficiency differentials of tomato (Solanum lycopersicum) production under traditional and improved technologies in Nigeria. Multi-stage method of sampling was used. One hundred (100) tomato producers were sampled and selected. Primary data collected and used for this study were obtained through the use well-designed and also well-structured questionnaire. Data were analyzed using statistical and econometrics tools. The results show that the mean age in years were 46 and 43 for traditional and improved tomato production technologies respectively. Farm size and labour input were statistical and significant regressors influencing technical efficiency of traditional tomato production technologies. Farm size, fertilizer-input, seed-input, chemical-input, and labour input were statistical and significant regressors influencing technical efficiency of improved tomato production technologies. The statistical and significant socio-economic stimuli influencing technical inefficiency of traditional tomato production technologies *were age, size of households and experience in farming. Age, gender, educational level, marital status, size of households, and experience in farming were the statistical and significant socio-economic stimuli influencing technical inefficiency of improved tomato production technologies. The return to scale were 1.206 and 1,8604 for traditional and improved tomato production technologies respectively. This connotes increasing return to scale. The mean technical efficiencies were 0.39 and 0.57 for traditional and improved tomato production technologies respectively. The constraints facing tomato producers were lack of improved seeds (1st), lack of storage facilities (2nd) and high cost of farm inputs (3rd). The study recommends that farm inputs and storage facilities should be provided for tomato farmers to increase efficiency and productivity. Bureaucracy in accessing credit facilities should be removed so that tomato farmers can obtain credit facilities at low interest rate. Extension officers should be employed to disseminate new ideas, research results and innovations to tomato producers.*

Key words: Technical Efficiency, Differentials, Traditional and Improved Tomato Production Technologies, Nigeria

INTRODUCTION

Tomato (*Solanum lycopersicum*) is the most highly consumed, nutritious, stable vegetable food crop in the world. It is widely cultivated in subtropical, tropical, and temperate climate. In Nigeria, tomato can be grown in southern parts but it grows best in savannah agro-ecological zone. It ranks second after potato in the whole world in terms of been widely cultivated vegetable crop, value, and production (Mwangi *et al*., 2020; Mitra and Yunus, 2018). Tomato production serve as a very important source of livelihood to resource poor farmers being a source of employment and income to both rural and urban dwellers (Adenuga *et al*., 2013). Tomato contains minerals, antioxidants, vitamins C, vitamin B, phosphorus, iron, sugar, dietary fibre, crude fat, ash content, and essential amino acids. Tomato farming contributes to alleviating poverty, income generation, foreign exchange earnings, and employment for rural farming households (Mwangi *et al*.,2020). Tomato production in Nigeria stood at 3,693, 722 tonnes and 3,798,939 tonnes in 2020 and 2019 respectively. The total area under tomato production in 2020 was 844, 445 hectares in Nigeria. The yield and average yield of tomato in Nigeria in 2020 were 43, 471 hg/ha, and 10 to 30 metric tonnes/ha respectively (FAO, 2020). Tomato farmers in Nigeria are smallholder, resource poor producers and they cannot produce enough to meet the demand of consumers. In the whole world, the processing food industries and the fresh fruit markets needed tomato in commercial quantities. Tomato is a vegetable of excellence, it can be eaten raw as salad, and it is found in every meal. Tomato production faces challenges of low productivity; the low productivity comes from the inability of producers to fully utilize available technologies. Technical efficiency is necessary to find out the low yields of tomato and the variations that exists in the yields of tomato across the producers. Technical efficiency measures the gap between what the tomato farmers actually produce and what they can produce (agricultural experimental and research stations) given the technology and resources (Khan and Ghafar, 2013). Technical efficiency shows the tomato producers ability to achieve optimal production from level of technology and available resources (Shettima *et al*., 2015). Technical efficiency is the ability of farmers to obtain the highest possible output from given production resources using a particular technology (Obianefo *et al*., 2020). Tomato farmers with same resources are producing different output per hectare this is due to inefficiency in input management, traditional production techniques, limited use of modern farm technologies, and weak infrastructures, supportive services like credit, extension services, marketing, road, and poor agricultural policies (Abate *et al*., 2019). Inefficiencies in tomato production can arise from farmers and farm characteristics. Adoption of new farm technologies by tomato producers may not bring expected results, until inefficiency in utilization of agricultural inputs is removed. Tomato production requires large labour, high level of management, and capital input, therefore efficient use of resources and technologies are necessary to increase production (Ogunniyi and Oladejo, 2011). Tomato production and productivity can be improved through input use and increasing levels of technical efficiency of producers. One significant way of achieving food security is to increase productivity by increasing efficiency in tomato production (Tabe-Ojong and Molua, 2017; Wudineh and Endrias, 2016). Tomato production in Nigeria faces low yield and productivity, lack of improved technology, lack of marketing, processing infrastructures, and high postharvest losses (Akinniran *et al*., 2020). The yields of tomato are low in Nigeria due to poor production practices such as the use of old seed varieties, inadequate weed and pest control, low soil fertility, high postharvest losses due to poor distribution and handling systems. One major reason for low productivity and low efficiency worldwide is the inability of farmers to exploit fully the advantage of availability of resources. In developing countries, efficiency becomes a subject area of interest for research investigation because majority of farmers were smallholder, peasant, and resource poor (Ahmed and Oyewole, 2012). Improving the technical efficiency of tomato farmers will lead to an increase in the yield of farmers which will in turn lead to increase in food supply, food security, higher farm incomes, and better standard of living (Ogada *et al*., 2014).

The broad objective of this research work focused on technical efficiency differentials of tomato (*Lycopersicum species*) production under traditional and improved technologies in Nigeria..

MATERIALS AND METHODS

This research study was conducted in Kaduna State, Nigeria. Kaduna State occupies between Longitudes 06^0 $15^{|}$ and 08^0 $50^{|}$ East and Latitudes 09^0 $02^{|}$ and 09^0 $02^{|}$North of the equator. The State has land area totaling 4.5 million hectares. The state vegetation is divided into two (2), the Southern guinea savanna and Northern guinea savanna. There are two (2) seasons in Kaduna State. The seasons are: wet and dry seasons, the dry season is between October to March, and the wet season starts from April to October, in between the wet and dry seasons is the brief harmattan period which span from November to February. The mean or average rainfall is about 1,482mm, the temperature of Kaduna State ranges from 35^0C to 36^0C, which can be as low as 10^0C to 23^0C during the harmattan period. The population of Kaduna as at 2021 was 8.9 million people. They are involved in agricultural activities. Crops grown include: tomatoes, okra, pepper, maize, ginger, sorghum, rice, yam, cassava, and millet. Animal reared include: cattle, goats, sheep, rabbit, and poultry. Multi-stage method of sampling was used. One hundred (100) tomato producers were selected. Data obtained from tomato producers were of primary sources and the data were collected using well-designed and also well-structured questionnaire. The questionnaire was administered to tomato producers using well trained enumerators. Data were analyzed using the following statistical and econometrics tools:

Descriptive Statistics: This involves measures of central tendency such as mean, range, frequency distributions and percentages to summarize the socio-economics profiles of tomato farmers as stated specifically in objective one (i), and to determine the constraints facing tomato producers as specifically stated in objective five (v).

Stochastic Production Frontier Model

According to Alabi *et al*. (2022), the stochastic production frontier model is stated thus:

$$Y_i = f(X_i, \beta_i)e^{v_i - u_i} \quad \text{.......(1)}$$

$l_nY = \beta_0 + \beta_1 l_nX_1 + \beta_2 l_nX_2 + \beta_3 l_nX_3 + \beta_4 l_nX_4 + \beta_5 l_nX_5 + V_i - U_i$ ………..(2)

where,
Y_i = Output of Tomato (kg)
X_i = Vectors of Factor Inputs
β_i = Vectors of Parameters
V_i = Random Variations in Tomato Output
U_i= Error Term due to Technical Inefficiency
X_1 = Farm Size (ha)
X_2 = Fertilizer-Input in kg
X_3 = Seed-Input in kg
X_4 = Chemical-Input in litre
X_5 = Labour-Input in mandays

$U_i = \alpha_0 + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5 + \alpha_6 Z_6 \ldots\ldots\ldots\ldots\ldots\ldots.(3)$

where,
Z_1 = Age in years
Z_2 =Gender (as Dummy, 1, male; 0, otherwise)
Z_3 = Educational Level Attained (Likert, 0, non-formal; 1, primary; 2, secondary; 3, tertiary)
Z_4 = Marital Status (as Dummy, 1, married; 0, otherwise)
Z_5 = Size of Household (number)
Z_6 = Experience in Farming (years)
α_0 = Constant Term
$\alpha_1 - \alpha_6$ = Parameters to be Estimated
U_i= Error Term due to Technical Inefficiency

This will be used specifically to achieve objectives two (ii), three (iii) and four (iv)

Elasticity of Production (Ep) and Return to Scale (RTS): According to Alabi *et al.* (2020), elasticity of production (Ep) and return to scale (RTS) of tomato production can be defined as:

$$RTS = \sum_i^n EP \ldots\ldots\ldots\ldots\ldots\ldots\ldots.(4)$$

$$RTS = \sum_1^5 \beta_i \ldots\ldots\ldots\ldots\ldots\ldots(5)$$

RTS equal to 1 = Constant Return to Scale,
RTS greater than1 = Increasing Return to Scale,
RTS less than 1 = Decreasing Return to Scale,

Where
RTS = Return to Scale (Units), and
EP = Elasticity of Production (Ep) Inputs (Units),

This was specifically used to evaluate the elasticity of production (Ep) and return to scale (RTS) of tomato production as stated in objective four (iv).

RESULTS AND DISCUSSION

Differentials of socio-economic profiles among farmers in tomato production under traditional and improved technologies

The summary statistics of socio-economic profiles of farmers under traditional and improved tomato production was presented in Table 1. The differentials of age classifications show that the mean age in years for farmers in traditional and improved tomato production were 46 and 43 respectively. The farmers under improved tomato production were relatively younger than that of farmers under traditional tomato production. The tomato producers were energetic, resourceful, active, resource poor, in their youthful age. Age of farmers is a significant socio-economic factor that can influence the ability of tomato producers in adoption of improved farm technologies, risk aversion and production decisions. The differentials of experience in farming shows that the mean values in years were 12 and 13 for traditional and improved tomato production respectively. Experience in farming is linked with age, as tomato producers advanced in age or get older, they must have acquired more experiences in tomato production. Averagely, the farm sizes were 1.2 and 1.6 hectares for traditional and improved tomato production respectively. This signifies that they were resource poor, smallholder, smallscale, peasant farmers who had less than 5 hectares of cultivated tomato farm land. The household sizes were large with an average of 6 and 7 people per household for traditional and improved tomato production technologies respectively. This connotes that fairly large household sizes signifies more family labour available for activities of tomato farming and less money will be needed to pay for hired labour. Averagely, tomato farmers under traditional technologies had primary education, while those under improved farm technologies had secondary education respectively. Education of tomato producers is a significant socio-economic stimulus that influences farmers' farm decisions, awareness, perceptions, receptions, and adoptions of new ideas, agricultural innovations that can increase management, efficiency, and productivity of a farm enterprise. Tomato farmers under traditional and improved technologies had access to credit facilities and were members of cooperatives organizations respectively. Membership of cooperatives organizations offers the tomato producers the opportunities to access farm inputs, credit facilities, and bulk purchase their farm inputs or bulk sold their farm produce.

Table 1. Summary statistics of socio-economic profiles of tomato producers

Variables	Traditional	Improved
	Mean Values	Mean Values
Age in Years	46	43
Experience in Farming in Years	06	13
Farm Size in Hectares	1.2	1.6
Household Size in Number of People	6	7
Educational Level Attained in Years	6	15
Access to Credit (Dummy)	Yes	Yes
Membership of Cooperatives (Dummy)	Yes	Yes

Source: Field Survey (2021)

Differentials of factors influencing technical efficiency of tomato production under traditional and improved technologies

The differentials in exogenous variables influencing technical efficiency or output of tomato production for traditional and improved farm technologies were presented in Table 2. The regressors in the technical efficiency component under consideration for both traditional and improved farm technologies were farm size, fertilizer-input, seed-input, chemical-input, and labour-input. All the regressors had positive coefficients both for traditional and improved farm technologies respectively. The statistical and significant predictors influencing technical efficiency of tomato production among farmers under traditional farm technologies were farm size $(P < 0.05)$ and labour-input $(P < 0.10)$. The statistical and significant regressors influencing technical efficiency of tomato production among farmers under improved farm technologies were farm size, fertilizer-input, seed-input, chemical-input, and labour input at $(P < 0.05)$ respectively. The total variances were 1.510 and 1.7021 for traditional and improved farm technologies and they were significant at 1% probability levels respectively. This connotes that the model is of good fit. The variance ratios were 0.5701 and 0.8740 for tomato production under traditional and improved farm technologies respectively. This means that 57.01% and 87.40% of variations in output of tomato production were explained by predictors included in the model for traditional and improved farm technologies respectively. The log likelihood was 306.21 and 471.12 for tomato production under traditional and improved farm technologies respectively.

Differentials of socio-economic factors influencing technical inefficiency of tomato production under traditional and improved technologies

The socio-economic stimulus that influences technical inefficiency of tomato production technologies was presented in Table 2. The socio-economic stimuli included in the technical inefficiency component of the stochastic frontier production model were age, gender, educational level attained, marital status, size of households, and experience in tomato farming. Age, size of households and experience in farming were statistical significant stimuli that decrease technical inefficiency among farmers under traditional tomato production technologies at 10% levels of probability respectively. In addition, age, gender, educational level attained, marital status, and size of households were the socio-economic stimuli that decrease technical inefficiency among farmers under improved tomato production technologies at 5% levels of probability respectively. Experience in farming is a socio-economic stimulus that decreases technical inefficiency among farmers under improved tomato production technologies at 1% level of probability.

Differentials of return to scale of farmers of tomato production under traditional and improved technologies

The differentials in return to scale of tomato production technologies was presented in Table 2.

The regression coefficients in the technical efficiency components are the elasticity of production and they were positive for both traditional and improved tomato production technologies.

The elasticity of production for farm size were 0.204 and 0.3423 for traditional and improved tomato production technologies respectively. The sum of elasticity of production gives the return to scale of tomato production technologies. The return to scale was calculated at 1.206 and 1.8604 for traditional and improved tomato production technologies respectively. This connotes increasing return to scale, an increase in any of the production inputs keeping others constant will leads to more than proportional increase in output of tomato produced for traditional and improved tomato production technologies respectively.

Differentials of technical efficiency scores of farmers of tomato production under traditional and improved technologies

Table 3 shows the summary statistics of technical efficiency scores of tomato producers. Majority (58%) of tomato farmers under traditional production technologies were between 21 to 60% efficiency levels, this implies that most farmers were less than average technically efficient.

Table 2. Maximum likelihood results of the stochastic frontier production model

Variables	Traditional				Improved		
	Parameters	Coefficient	Standard Error	t-Value	Coefficient	Standard Error	**t-Value**
Constant	β_0	3.021	2.4966	1.21	2.9210**	1.2590	2.32
Farm Size (X_1)	β_1	0.204**	0.0764	2.67	0.3423**	0.1282	2.67
Fertilizer-Input(X_2)	β_2	0.182	0.1504	1.21	0.2931**	0.1050	2.79
Seed-Input(X_3)	β_3	0.232	0.1694	1.37	0.3447**	0.1336	2.58
Chemical-Input(X_4)	β_4	0.218	0.1832	1.19	0.3982**	0.1573	2.53
Labour-Input(X_5)	β_5	0.370*	0.2450	1.51	0.4821**	0.1826	2.64
Return to Scale (RTS)		**1.206**			**1.8604**		
Inefficiency Component							
Constant							
Age(Z_1)	α_0	2.016*	0.9420	2.14	0.661*	0.2938	2.27
Gender(Z_2)	α_1	0.2105*	0.0952	-2.21	-0.180**	0.0616	-2.92
Educational Level(Z_3)	α_2	0.2409	0.2132	-1.13	-0.109**	0.0432	-2.52
Marital Status(Z_4)	α_3	0.3512	0.3376	-1.04	-0.201**	0.0785	-2.56
Size of Household(Z_5)	α_4	0.1722	0.1471	-1.17	-0.301**	0.1153	-2.61
Experience in	α_5	0.2214*	0.1006	-2.20	-0.102**	0.0406	-2.51
Farming(Z_6)	α_6	0.3201*	0.1684	-1.90	-0.215***	0.0598	-3.59
Diagnostic Statistics							
Total Variance		1.510***			1.7021***		
Variance Ratio	σ^2	0.5701			0.8740		
Log-Likelihood	γ	306.21			471.12		
Likelihood Ratio Test		227.01			326.31		

Source: Data Analysis (2021); *Significant at $P < 0.10$., **Significant at $P < 0.05$. ***Significant at $P < 0.01$

The mean technical efficiency was 39 % leaving a gap of 61% for improvement. In addition, the least technical efficiency score was 14.0% while the best performing tomato farm under traditional production technologies had the maximum technical efficiency of 84.0%.If the average tomato producers under traditional production technologies were to achieve the level of technical efficiency like most of its efficient counterparts, then the tomato farmers could make 53.57% cost savings. The calculated value for the most technically inefficient tomato farmers under traditional production technologies revealed a cost savings of 83.33%. .Majority (76%) of tomato farmers under improved production technologies were between 41 to 80% efficiency levels, this implies that most farmers were above average technically efficient. The mean technical efficiency was 57 % leaving a gap of 43% for improvement. In addition, the least technical efficiency score was 18.0% while the best performing tomato farm under improved production technologies had the maximum technical efficiency of 94.0%.If the average tomato producers under improved production technologies were to achieve the level of technical efficiency like most of its efficient counterparts, then the tomato farmers could make 39.36% cost savings. The calculated value for the most technically inefficient tomato farmers under improved production technologies revealed a cost savings of 80.85%.

Table 3. Summary statistics of technical efficiency scores of tomato producers

Efficiency Score	Traditional		Improved	
	Frequency	Percentage	Frequency	Percentage
0.00 – 0.20	18	18.00	06	06.00
0.21 – 0.40	36	36.00	08	08.00
0.41 – 0.60	32	32.00	44	44.00
0.61 – 0.80	12	12.00	32	32.00
0.81 – 1.00	02	02.00	10	10.00
Mean	0.39		0.57	
Standard Deviation	0.1998		0.1946	
Minimum	0.14		0.18	
Maximum	0.84		0.94	

Source: Field Survey (2021)

Constraints Facing Tomato Producers

The constraints facing tomato farmers were presented in Table 4. Lack of improved tomato seeds was ranked 1st among all the constraints, Lack of storage facilities, and high cost of farm inputs were ranked 2nd and 3rd among all constraints facing tomato producers, respectively.

Table 4. Constraints facing tomato producers

Constraints	*Frequency	Percentage	Rank
Lack of Storage Facilities	129	16.07	2nd
Diseases and Pest Infestations	101	12.58	5th
Lack of Improved Seeds	152	18.93	1st
Bad Road Infrastructures	98	12.20	6th
High Cost of Farm Inputs	120	14.94	3rd
Lack of Credit Facilities	116	14.45	4th
Poor Marketing Systems	87	10.83	
	Total	**100.00**	

Source: Field Survey (2021), *Multiple Choices

CONCLUSION

This study has established technical efficiency differentials of tomato production in Kaduna State, Nigeria. The mean age in years of farmers was 46 and 43 for traditional and improved tomato production technologies respectively. The tomato producers were energetic, active, and resourceful in their youthful age. They are smallholder, smallscale, resource poor farmers with average farm sizes of 1.2 and 1.6 hectares of land for traditional and improved tomato production technologies respectively. Farmers had long years' experience in tomato production, and they had access to credit facilities and were members of cooperative organizations. Farm size and labour input were statistical and significant regressors influencing technical efficiency of traditional tomato production technologies. Farm size, fertilizer input, seed-input, chemical-input and labour-input were statistical and significant regressors that influence technical efficiency of improved tomato production technologies. The statistical and significant socio-economic stimuli influencing technical inefficiency of traditional tomato production technologies were age, size of households and experience in farming. Age, gender, educational level, marital status, size of households, and experience in farming were the statistical and significant stimuli influencing technical inefficiency of improved tomato production technologies. The return to scale was calculated at 1.206 and 1.8604 for traditional and improved tomato production technologies respectively. This connotes increasing return to scale. The mean technical efficiency scores were 0.39 and 0.57 for traditional and improved tomato production technologies respectively. The constraints facing tomato producers were lack of storage facilities, disease and pest infestations, lack of improved seeds, bad road infrastructures, high cost of farm inputs, lack of credit facilities and poor marketing systems.

RECOMMENDATIONS

(i) Farm inputs such as improved seeds, chemicals, fertilizers, time should be provided at appropriate for tomato farmers to increase efficiency and productivity.

(ii) Storage facilities should be provided for tomato producers to solve the problem of perishability of produce.

(iii) Credit facilities should be made available to tomato farmers to increase productivity. Bureaucracy involves and cumbersome procedure in accessing the credit facilities should be removed.

(iv) Extension officers should be employed to disseminate new ideas, research results and innovations to tomato producers.

(v) Feeder roads should be constructed to enhance movement of tomato produce from producing areas to nearby markets.

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DYNAMICS OF AGRI-INPUT ENTERPRISES OPERATING IN KATHMANDU VALLEY

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ABSTRACT

Kathmandu valley is home to many agribusinesses and also hosts major agri-input enterprises on which a survey was conducted to know their dynamics after fixing an appointment with the business heads of the biggest 20 agri-input enterprises of Kathmandu valley. The major supplied products of each enterprise were enquired and their sales distribution was noted. Using the Strengths, Weaknesses, Opportunities, and Threats (SWOT) analysis technique, the paper looked into those businesses in depth. Also, a comparison was made regarding the revenue earned during the COVID-19 pandemic era and the time after that to better understand the impact of that pandemic on businesses. The business heads were also asked to rank the problems they face while importing the agri-inputs and marketing them throughout the country. The obtained information was analyzed by combining the software packages SPSS and MS Excel to figure out the factors determining the attainment of targeted revenue.

Key Words: Agri-input enterprises, dynamics, impact of COVID-19, marketing problems, SWOT

INTRODUCTION

Agriculture has proven to be a major economic sector of Nepal, employing 66 percent of the people and accounting for 25.8% of the country's GDP (MoF, 2021). Nepal has a population of 29 million people living in an area of 147,516 square kilometers, despite being a small landlocked country placed between two massive countries, China and India (CBS, 2021). Agribusiness is the backbone of Nepal's economy, providing jobs for the majority of the population, as well as being the country's principal source of GDP, pay, and employment prospects (Lehlokoanyane *et al.*, 2015). Due to the modernization and commercialization of agribusiness, as well as the expansion of government agencies into non-agricultural segments, the proportion of the people dependent on agriculture is steadily reducing. According to the Nepal Labor Drive Overview from 2008, 73.9 percent of the population was employed in the farming sector, however, this figure has dropped to 60.4 percent in 2018 (MoF, 2021).

Agribusiness entrepreneurship offers tremendous potential for economic growth in a country with a strong agricultural past, fertile soil, and diversified and suitable climatic circumstances like Nepal (Regmi and Naharki, 2020). All of the resources we use for production are referred to as agri-inputs. A fixed input might be an asset or a factor of production that a company cannot change in the short term to affect the quantity of yield produced. In the short-run generation, most firms have a few fixed inputs, such as buildings, hardware, insurance, machinery, interest on loans, and so on. Variable input, on the other hand, is an input whose value can be changed over the course of the time period under consideration. Labor is the most common example of a variable input. Variable inputs are the means by which a company controls short-run generation. Seeds, fertilizers, and other items are included (Xi Chen and Bertrand M. Koebel, 2017).

In agriculture, there is a direct link between the resources we utilize for production i.e. agri-inputs, and the commodity we acquire as a result of those resources (Debertin, 2002). Animal and human power are reported to be the two key powers used in agriculture, accounting for roughly 41% and 36% of the total control used in agribusiness, respectively. The utilization of farm machinery is found to be quite low in the context of Nepal (Gauchan and Shrestha, 2017). Only one portion of the five parts of power consumed in Nepal is machinery. Due to the emigration of young in search of work or education, labor scarcity is one of Nepal's primary issues (AED, 2017).

Modern machinery is not fully utilized in hills due to undeveloped roads, electricity, and terrace cultivation, so animal and human power are required. Here, traditional implements such as a wooden plough, hoes, and sickles are employed. Mini tillers and power tillers are utilized for tillage in the valleys where there are road facilities. The Terai region's principal animal-drawn implements include the traditional wooden plough, iron moldboard plough, disc harrow, and wooden plough, among others (AED, 2017). Agriculturists can increase their profit margins by utilizing innovative machinery while reducing wasted materials and labor costs (Schmitz and Moss, 2015).

Agricultural progress over time has been very slow compared to the population growth in Nepalese land. Previously being focused just on traditional farming, in recent years the agriculture ways have been modified slowly (Deshar, 2013).

Due to the geographical circumstances, landlocked Nepal is forced to make its major imports from India and China while the major import (about 90%) account for India. Thus, the country's heavy reliance on a single market has resulted in a slew of trade issues (Jayaraman and Shrestha, 1976). In recent years, the marketing of agricultural supplies has also been plagued by issues. Commercial farming in the city and surrounding areas has been hampered by the COVID-19 lockdown and transportation hurdles, which have resulted in a lack of quality inputs. Improper policies, poor quality of agricultural inputs, and uncertainty in the supply of inputs have been a few major problems in the Nepalese agriculture scene in recent times (Adhikari *et al.*, 2021).

SWOT analysis is the cornerstone for determining successful foundation movement directions, as well as identifying favorable prospects and threats on the side of the encompassing showcasing environment (Mandrazhi, 2021). This analysis will aid in the formation of a crucial arrangement that will allow the sector to remain competitive. Following that, this discussion will be focused on examining the segment's strengths, weaknesses, opportunities, and threats (Nuga and Asimiea, 2015).

SWOT analysis is advantageous when performed appropriately; yet, many investigations demonstrate that SWOT inquiry is deficiently outlined in many circumstances (Smith, 2006). Several factors contribute to this, the most important of which is the necessity for exact SWOT development. Making a SWOT chart may appear to be a simple task, but it appears that successfully establishing the four categories of things from a SWOT investigation isn't a simple task (Brad and Brad, 2015). SWOT, like many other seemingly simple instruments, requires adequate preparation and participation in order to be developed and used effectively (Smith, 2006). The SWOT matrix is depicted in Figure 2 below.

	Strengths	Weakness
Opportunities	How can I put these strengths to work for me in order to take advantage of these opportunities?	What can I do to overcome the flaws that hinder me from seizing these opportunities?
Threats	How can I make the most of my strength to lessen the impact of threats?	How do I solve the flaws that will allow these dangers to materialize?

MATERIALS AND METHODS

A semi-structured questionnaire was used after choosing 20 registered agri-input firms of Kathmandu valley with their markets throughout Nepal for the survey. This research employed both primary and secondary sources. Initially, each company was contacted by phone to schedule an interview with the business executive. Following that, the company executive was interviewed face to face. Secondary data were acquired from a variety of published and non-published sources, as well as peer-reviewed journals. The obtained information was recorded in the software package MS-Excel and later analyzed using SPSS.

Model Specification for Data Analysis

1. **Likert Scale:** The Likert scale (usually) offers five options for responses to a statement or question. It allows respondents to express how strongly they agree or disagree with the statement on a positive-to-negative scale. The most popular form of the scale takes the shape of a five- or seven-point scale.

2. Forced Ranking Method: In the forced ranking method, respondents were asked to assign ranks to a pre-determined set of problems, reasons or preferences on the basis of their severity as per their opinion. The choice with the highest index of importance is ranked I while the least index gives the least rank. The calculation of the index of importance was carried out using the formula stated below:

$$I_{imp} = \frac{\Sigma\, S_i\, F_i}{N}$$

Where,
I_{imp} = Index of importance
Σ = Summation
S_i = i^{th} scale value
F_i = Frequency of i^{th} importance given by the respondents
N= Total number of respondents
For calculation of the scale value,
Scale value = n* 1/n [for rank I choice]
(n-1)* 1/n [for rank II choice]
(n-2)* 1/n [for rank III choice]
(n-3)* 1/n [for rank IV choice]…….
1/n [for n^{th} rank choice]

3. **Binary Logistic Regression Model:** Regression technique is used to assess the strength of a relationship between one dependent and other independent variable(s). It helps in predicting how much variance is being accounted in a single response (dependent variable) by a set of independent variables. Binary Logistic Regression comes handy when trying to predict a binary or dichotomous outcome. The logistic regression calculates the probability of success over the probability of failure and the results of the analysis are in the form of an "Odds Ratio (OR)".

The working model is described below

$$P = \frac{e^{a+bX}}{1 + e^{a+bX}}$$

Where,
P = Likelihood of the occurrence of the target variable
e = Euler's number whose value is 2.718
a = y- intercept
b = slope of the line
X= independent variable
Here, in this study, target variable is "Attainment of desired revenue". Meanwhile, the independent variables specified as the factors influencing the attainment of desired revenue in the survey are:
X_1= Business head's education level
X_2= Business head's participation in business related seminars
X_3= Level of access to credit
X_4= Business head's membership in business related organizations
X_5= Age of business head
X_6= Experience of business head

RESULTS AND DISCUSSION

Major inputs supplied by the enterprises: It was found that the enterprises mainly focused on importing the farm machinery like tillers, pulpers, chaff cutters, brush cutters, combined harvesters, threshers, land levelers, planters, combined rice mills, etc. from India and China. The manufacturers were found to manufacture very simple drip irrigation systems, mulching plastic and poly pots.

Table1. Major inputs supplied by the agri-enterprises and their nature of business

S.N.	Agri-input enterprise	Nature of the business	Major inputs supplied
1	Nepal Agro Live Pvt. Ltd	Importer	Drip irrigation system, spray tank, power tiller, mini tiller
2	Shalom Agriculture Pvt. Ltd	Importer	Drip irrigation system, UV-plastic, mulching plastic, insect net, hail net, coco peat, peat moss, seedling tray, poly pot, greenhouse
3	SKT Nepal Pvt. Ltd	Importer	Power tiller, mini tiller, chaff cutter, coffee pulper
4	Nepal Thopa Sinchai	Manufacturer	Drip irrigation system, mulching plastic, greenhouse, poly pots
5	Nepal China Agriculture Centre	Both importer and manufacturer	Mini tiller, reaper, brush cutter, chainsaw, spades, shovels, insect net
6	Total Machinery Pvt. Ltd	Importer	chilling vat, pasteurizer, grinder, dryer, oven filler, mincer
7	Shrestha Agri Inputs	Both importer and manufacturer	Thresher, laser land leveler, cultivator, MB plough, potato planter, rice transplanter, tractor attachments, seed grading machine, seed treater, cattle feeder, goat feeder
8	Kabita Agri Pvt. Ltd	Importer	Mini tiller, power tiller, reaper, rotavator, thresher, rice planter, potato planter, maize planter, aerator, chaff cutter, combined harvester
9	BTL Trade Pvt. Ltd	Importer	Power tiller, mini tiller, combined rice mill, thresher, corn sheller, chaff cutter, water pumps, spray tank
10	Muktinath Krishi Company Limited	Importer	Power tiller, brush cutter, thresher, seed grading machine, spray tank, coco peat, seedling tray, combined harvester, drip irrigation system
11	Bhagwati Machinery Suppliers Pvt. Ltd	Importer	Thresher, power tiller, corn sheller, mincer
12	Aeromax International	Importer	Egg candler, Incubator. Hot air over, Feeding tray, watering can, debeaker
13	The Beekeeping Shop	Both importer and manufacturer	Bee hive tool, hives, queen cage, smoker, queen gate, pollen, honey
14	Biocomp Nepal	Manufacturer	Biofertilizers, compost
15	Dahal Trading Concern	Importer	Mini tiller, reaper, brush cutter, chainsaw, spades, shovels, insect net

16	Jyoti Polymers Udyog	Both importer and manufacturer	Drip irrigation system, mulching plastic, greenhouse
17	Luna Nepal Chemicals and Fertilizers Pvt. Ltd	Importer	Urea, Diammonium Phosphate, Murate of Potash, Sulphate of Potash, insecticides and herbicides
18	Bagmati Fertilizers and Chemicals	Importer	Urea, Diammonium Phosphate, Murate of Potash, Sulphate of Potash, insecticides and herbicides
19	GM Agro Services	Importers	Reapers, Combined harvester, Thresher
20	Jay Kisan Seed Centre	Importer	Seeds, polypots, agar, drip irrigation system, shovels, mulching plastic

Source: Field Survey, 2022

Table 2. Sales distribution of agri-input enterprises

SN	Agri-input enterprise	Total Sales		
		Direct customers (%)	Retailers (%)	Dealers (%)
1	Nepal Agro Live Pvt. Ltd.	80	10	10
2	Shalom Agriculture Pvt. Ltd.	25	40	35
3	SKT Nepal Pvt. Ltd.	20	0	80
4	Nepal Thopa Sinchai	70	20	10
5	Nepal China Agriculture Centre	100	0	0
6	Total Machinery Pvt. Ltd.	50	25	25
7	Shrestha Agri Inputs	2	18	80
8	Kabita Agri Pvt. Ltd.	10	20	70
9	BTL Trade Pvt. Ltd.	25	25	50
10	Muktinath Krishi Company Limited	20	0	80
11	Bhagwati Machinery Suppliers Pvt. Ltd	80	20	0
12	Aeromax International	20	20	60
13	The Beekeeping Shop	70	30	0
14	Biocomp Nepal	20	80	0
15	Dahal Trading Concern	100	0	0
16	Jyoti Polymers Udyog	80	20	0
17	Luna Nepal Chemicals and Fertilizers Pvt. Ltd	80	20	0
18	Bagmati Fertilizers and Chemicals	90	10	0
19	GM Agro Services	100	0	0
20	Jay Kisan Seed Centre	60	40	0

Source: Field Survey, 2022

Total sales distribution: The enterprises seem to have split their sales among direct customers, retailers, and dealers. The companies importing farm machinery have the majority of their sales dedicated to the dealers. Meanwhile, other agri-inputs like drip, mulching plastic, greenhouse, spades, and shovel are generally directly sold to the customers or the retailers. This trend was quite popular among the manufacturing and dual kind of businesses.

Factors determining the attainment of desired revenue: "Attainment of desired revenue" is set as the target variable and other dichotomous categorical independent variables are established to find their impact on the target variable. Here, university level education is the reference category for the variable "Business head's education level".

Table 3. Factors determining the attainment of desired revenue

Target variable and independent variables		B	Standard Error	p-value	OR [Exp(B)]	95% C.I.for EXP(B)	
						Lower	Upper
Attainment of desired revenue	Business head's education level	-1.771	1.863	0.042	0.17	0.004	6.551
	Business head's participation in business related seminars	3.437	2.235	0.024	31.107	0.39	2483.35
	Level of access to credit	1.988	1.558	0.002	7.304	0.345	154.73
	Business head's membership in business related organizations	2.764	2.141	0.037	15.858	0.239	1053.25
	Age of business head	-5.088	4.136	0.219	0.006	0	20.468
	Experience of business head	0.485	1.269	0.702	1.625	0.135	19.555

Source: Computed by authors, 2022

Similarly, active participation is the reference category for "Business head's participation in business related seminars". Also, easy access to credit is the reference category for "Level of access to credit". Likewise, for "Business head's membership in business related organizations", active participation is the reference category. Age and experience of the business head being continuous variable are adjusted by taking their log values.

As the p-value for "Business head's education level", "Business head's participation in business related seminars", "Level of access to credit" and

"Business head's membership in business related organizations" are less than 0.05, only these factors have a significant effect on the target variable. Furthermore, for the significant variables, value of OR greater than 1 indicate increase in the chances of happening (i.e. probability) of the target variable with respect to the reference category. Similarly, when the value of OR is less than 1, it means the chance of occurrence of the target variable decreases with respect to the reference category.

Here, the log odds of attainment of targeted revenue through below university level education of the business head decreases by 0.17 as compared to university level of education. Similarly, the probability for attainment of targeted revenue through active participation of business head in business related seminars increases by 31.107 compared to no participation. We can see that with easy access to credit, the chances of attainment of target variable increases by 7.307 compared to when the access to credit is hard. Likewise, active membership of the business head in business related organizations increases the probability of attainment of targeted revenue by 15.858 compared to when there is no membership taken.

Impact of COVID-19 on agri-input enterprises: Lately, issues have also arisen in the marketing of agricultural supplies. The COVID-19 lockout and transportation challenges have impacted commercial farming in the city and adjacent areas, resulting in a shortage of quality inputs (Adhikari *et al.*, 2021). COVID-19 has disrupted the market's supply chain by impairing production and distribution, as well as a labor shortage and input supply. It was found that this has in turn negatively affected the financial condition of the agri-input enterprises as a whole.

Working Formula:
1. Decline in revenue due to COVID-19 in 2020= [(Annual Revenue in 2019- Annual Revenue in 2020)/ Annual Revenue in 2019]*100
2. Boost in revenue after COVID-19 in 2021= [(Annual Revenue in 2021- Annual Revenue in 2020)/ Annual Revenue in 2020]*100

Import problems

The business heads were asked to rank the pre-listed import problems in the questionnaire on Likert scale where it was found that the high customs duty was the major problem for importing. The high cost of spare parts for agrarian apparatus is the reason for high import duty and Value Added Tax (VAT). The high duty (15-45%) on bringing in raw materials for fabrication has deterred all local engineering firms from producing and selling machinery, tools, and equipment locally(Gauchan and Shrestha, 2017).

Table 4. Impact of COVID-19 on the annual revenue of the agri-input enterprises

Agri-input enterprise	Annual revenue in 2021 (NRs)	Annual revenue in 2020 (NRs)	Annual revenue in 2019 (NRs)	Decline in revenue due to COVID-19 in 2020 (%)	Boost in revenue after COVID-19 in 2021 (%)
Nepal Agro Live Pvt. Ltd.	60000000	40000000	50000000	20.00	50.00
Shalom Agriculture Pvt. Ltd.	250000000	100000000	200000000	50.00	150.00
SKT Nepal Pvt. Ltd.	600000000	320000000	350000000	8.57	87.50
Nepal Thopa Sinchai	75000000	45000000	50000000	10.00	66.67
Nepal China Agriculture Centre	50000000	25000000	45000000	44.44	100.00
Total Machinery Pvt. Ltd.	140000000	110000000	120000000	8.33	27.27
Shrestha Agri Inputs	1000000000	550000000	600000000	8.33	81.82
Kabita Agri Pvt. Ltd.	400000000	110000000	180000000	38.89	263.64
BTL Trade Pvt. Ltd.	230000000	220000000	250000000	12.00	4.55
Muktinath Krishi Company Limited	400000000	220000000	300000000	26.67	81.82
Bhagwati Machinery Suppliers Pvt. Ltd	40000000	20000000	30000000	33.33	50.00
Aeromax International	450000000	300000000	400000000	25.00	50.00
The Beekeeping Shop	30000000	17500000	20000000	12.50	71.42
Biocomp Nepal	10000000	2500000	5000000	50.00	300.00
Dahal Trading Concern	50000000	25000000	45000000	44.44	100.00
Jyoti Polymers Udyog	30000000	10000000	25000000	60.00	200.00
Luna Nepal Chemicals and Fertilizers Pvt. Ltd	50000000	20000000	30000000	33.33	150.00
Bagmati Fertilizers and Chemicals	20000000	10000000	15000000	33.33	200.00
GM Agro Services	45000000	20000000	30000000	33.33	125.00
Jay Kisan Seed Centre	70000000	50000000	60000000	16.67	40.00

Source: Field Survey, 2022

Marketing problems: The commercialization of agricultural supplies in Nepal is fraught with difficulties. There is limited access to market knowledge, a poor level of education among agriculturists, various channels of dispersion that drain both agriculturists and buyers' pockets. Government support for farmers is still in its early stages, and most small ranchers still rely on leeches who charge exorbitant loan rates (Mehta, Chauhan and Ganguli, 1994).

Table 5. Ranking import problems using the forced rank method

Import Problems	Index value	Rank
High custom duty	0.8839	I
Untimely delivery of goods	0.5344	IV
Difficult and costly transportation	0.6511	II
Difficulty in access to bank loan for import business	0.5008	V
Unhealthy market competition	0.6342	III
Unstable agri-input market	0.3006	VI

*Rank I is the most severe and rank VI is the least severe.

Table 6. Ranking the marketing problems using the forced rank method

Marketing problems	Index value	Rank
Lack of adequate manpower	0.2837	VI
Poor credit recovery	0.6177	IV
Unhealthy market competition	0.4841	V
Transportation issue due to difficult geography	0.6845	II
Majority of farmers are small and poor	0.6340	III
Unfavorable government policies decline the sales	0.8010	I

* Rank I is the most severe and rank VI is the least severe.

The study also showed that unfavorable government policy has been the major problem in the marketing of agri-inputs for the enterprises which is causing the fall in their sales. Difficult geography and transportation issue has also proved to be another barrier for the agri-input enterprises to distribute the products in the market.

Table 7. SWOT analysis of the agri-input enterprises

	Strengths	Weaknesses
Endogenous Factors	• Hardworking, responsive, and responsible staff. • Regularity in work. • High-quality products are being supplied. • Co-operation among the staff. • Trust with the importing companies and customers. • Highly capable technical team. • Goodwill of the business and business head.	• Manipulative market scenario. • Lack of manpower. • Weak marketing of the products. • Lack of market research. • Ineffective market monitoring. • No check-back system is being adopted. • Cannot fulfill the customer demand in peak time due to capital constraints. • The business is completely under the mercy of government policy. • The highly vague agricultural scenario of Nepal makes it difficult to address every niche. • The financial crisis at times.
Exogenous factors	Opportunities	Threats
	• The increasing interest of the farmers regarding modern agricultural inputs. • Availability of raw materials in the country. • Increased youth involvement in agriculture would ultimately increase the demand for inputs. • The government is organizing several training programs regarding modern farming that will attract several farmers. • Literate and more aware customers that prefer quality products over quantity. • Farmers experience unique problems in their field owing to Nepal's difficult topography which provides an incredible opportunity for businesses to manufacture machinery specific to those farmers. • Agribusiness Promotion Policy-2006 focuses on	• Political instability and strikes. • Unhealthy market competition. • Pandemics such as COVID-19. • Productive land area being used for residential purposes. • Improper custom policy. • Small Nepalese market. • Poor quality Nepali products are increasing distrust among the farmers for Nepali agri-input enterprises. • Lack of government support and appreciation to the private ventures for contributing to the agricultural scenario of the

	commercialization of Nepalese farming through the involvement of private sector. • Agriculture Development Strategy (2015-2035) supposed to guide Nepalese agriculture scenario for the period of 20 years aims in making the country self-sufficient in agriculture by the development of agribusinesses and agri-industries.	country. • Poor governance. • Difficulty in access to loans for import businesses.

CONCLUSION

The agri-input enterprises in the context of Kathmandu valley were found to have been major providers of farm inputs to the majority of the country. Most of the imports are dependent on India and China. The study shows that the agri-input enterprises seem to have a healthy financial position as of now despite once being devastated by the impact of COVID-19. The attainment of desired revenue of the business seemed to have a direct relationship with the business head's education level, their participation in business related training and seminars, their involvement in business related organizations and ease of accessibility to credit. Machinery-friendly farming has been something relatively new for a country like Nepal that had been highly dependent on animal draft and human labor for agriculture. This means that the agri-input enterprises are also newcomers in the Nepalese market. Due to the majority of farmers being relatively small and poor, the adoption of farm machinery is a major challenge in the country. The custom policy of the government has also proved to be a major thorn in the way of agri-input importers. These sorts of businesses do have a good scope for an agricultural country like Nepal but due to the lack of management and migration of youth to a foreign land, agri-input enterprise's development stays stagnant here.

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ANALYSIS OF HEAVY METALS IN MUSHROOM PRODUCED USING WATER HYACINTH

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ABSTRACT

Water hyacinth is a perennial, wide spreading invasive plant species and it is laborious to control in wetland.In this experiment Pleurotus ostreatus species of Oyster mushroom was used for the mushroom cultivation. In this experiment root of water hyacinth was excluded and only stem and leaf parts were used.Five seperate combination of rice straw (RS) and water hyacinth (WH) i e only RS, only WH, RS+WH (1:1), RS+WH (2:1) and RS+WH (1:2) were used for the heavy metal analysis in mushroom. Lead, Cadmium, Arsenic and Mercury in mushroom samples were analyzed using AOAC 2015.01.21st Edn method in the laboratory of National Food and Feed Reference Laboratory. The study showed that highest concentration of arsenic, lead and mercury were found in controlled rice straw treatment i.e. 2.1 mg/kg, 10.2 mg/kg and 0.47 mg/kg respectively. Lead concentration in 1:1 ratio also was found (3.65mg/kg) controversial as it is greater than the standard guideline. However, cadmium in all treatments was found to be within the standard limit. Normally, mushroom cultivation is carried out using paddy straw, which is not available throughout the year whereas water hyacinth is abundant and available free of cost. It is considered as hazard aquatic bodies and absorbs heavy metals from polluted water. This could further affect the quality of yielded mushroom. However, this result shows that the whole process layouts the option for sustainable management of WH as well as an alternative substrate of rice straw for mushroom farming. The obtained results also suggest that water hyacinth can be used as alternative than rice straw for mushroom production as a substrate in terms of presence of heavy metals.

Keywords: Water hyacinth, Wetland, Mushroom, Heavy metal

INTRODUCTION

Water hyacinth (*Pontederia crassipes*) is an erect, perennial macrophyte locally known as *Jalkumbhi*. It is one of the fastest growing water weed of the world which is laborious to control (Reddy & Sutton, 1984). The plant is known to withstand the severe condition but during extreme conditions like drought it sinks itself in the bottom of water and becomes dormant until the condition becomes favorable for its growth (Dahal, 2007).

Water hyacinth was first witnessed in Western Nepal in 1972 as a result of international trade. From the 1970s to the 1990s, the Phewa Lake transitioned from oligotrophic to mesotrophic to eutrophic, with a current maximum depth of 23 meters (Lamichane, 2000). These lakes have favorable condition for the growth of water hyacinth which is mainly caused due to heavy pressure from both natural and human factors. Lately, much emphasis has been given to use this plant for practical uses to offset the cost of removing it from water sources (Lata & Dubey, 2010). For recreational areas such as Phewa Lake use of contingent valuation method is essential as they estimate the willingness to control the invasive plant (Richardson & Loomis, 2009).

Mushrooms have the ability to contribute in the worlds' food supply since they can convert from nutritionally worthless waste into protein rich food (Muller et al., 1995). Normally mushroom cultivation is carried out using paddy straw, sorghum stalks and sugarcane bagasse which are not available throughout the year. According to Food and Agriculture Organization (FAO) mushroom has significant contribution in protein intake of Nepal (Chang & Miles, 2004). However, in Nepal there are many challenges and issues in mushroom farming which include lack of improved technology and increasing price of raw substrate especially rice straw. Increasing price of substrate can be dealt by identifying diverse raw substrates which are locally available (Raut, 2019).

During the last few decades, Oyster mushroom (*Pleurotus spp.*) cultivation has tremendously increased throughout the world and founded the second largest genus of cultivated mushrooms in the world (Gregori et al., 2007). Oyster mushrooms are commonly grown on rice or wheat straw, there are reports that they can be grown on a wide range of plant waste as substrate eg, saw dust, sugarcane bagasse, paddy straw, corn stalk, corn cobs, waste cotton, leaves and pseudo stem of banana, water hyacinth, duckweed etc. does not require costly processing method and enrichment material (Quimio 1980, Leong 1980, Zakia et al., 1979). But water hyacinth is not used in mushroom production in Nepal.

The ability of water hyacinth to absorb efficiently has considered it to suitable bio sorbent for removal of toxic metals from waste water (Isarankura-NaAyudhya et al., 2007). Water hyacinth absorbs heavy metals using roots, transfers it to shoots and other parts of the plant. These heavy metals can be extracted after burning the plant into ash (Jadia & Fulekar, 2009). Water hyacinth is also recommended in aquaponics due to its' high ability to absorb pollutants from water and other potential applications and economic values (Zhang et al., 2014).

In a similar study conducted by Greenfield *et al.*, 2007 foliage tissues of water hyacinth were found to accumulate Hg from contaminated water body. The uptake of metal concentration by water hyacinth plant depends on the particular part i.e.whether the metal has been absorbed by shoots or roots. Experimentally it has been observed that usually mercury uptake of shoot is higher than that of root (Riddleetal., 2002).

Water hyacinth absorbs heavy metals from polluted water. This could further affect the quality of yielded plant. However, water hyacinth which is considered as menace to other plants and aquatic bodies can actually bean opportunity. According to Sharma et al., (2015) Phewa Lake is the potential source of trace elements pollution including lead (Pb), cadmium (Cd) and mercury (Hg). It also indicates the possible sources of Cd and Pb could be direct discharge from industrial sites. The standard limit of heavy metals in food permitted by WHO/FAO is 1 mg/kg for Cadmium (Cd), 30 mg/kg for Arsenic (As), 2 mg/kg for Lead (Pb) and 0.2 mg/kg for Mercury (Hg).

In Nepal, rice straw cannot be available throughout the year and is quite costly whereas water hyacinth can be found easily in lakes like Phewa Lake free of cost. On the other hand, government is having hard time and costly to remove water hyacinth. It is requiring both investment of time and money. This study also shows how rice straw grown mushroom which has been consumed by so many people on daily basis are at risk and the possibility of bioaccumulation in people. Therefore, this study supports the fact and layout the option for sustainable management of water hyacinth along with alternative substrate for mushroom farming.

MATERIALS AND METHODS

The study was based on experimental research design. Plant samples of water hyacinth were collected from the Phewa lake of Pokhara. First, water hyacinth, were used for growing mushroom in five different compositions with three replications.

Mushroom production: In this experiment *Pleurotus ostreatus* species of Oyster mushroom was used for the cultivation. For substrate, rice straw (RS) and sun dried water hyacinth (WH) were used for the cultivation of *Pleurotus* spp of mushroom in five different treatments. Cultivation trials were conducted at room temperature on five different treatments which were as follows:

Mushrooms were grown at room temperature (20-25°c) on five different treatments which were; i) Controlled water hyacinth only and ii) Controlled rice straw only. iii) RS+WH (1:1), iv) WH+RS (2:1), v) WH+RS (1:2), Thereafter, grown mushroom sample from each treatments were collected for further heavy metals (Lead, Cadmium, Mercury and Arsenic) analysis.

Study area: Phewa Lake is a stream fed dam regulated and semi-natural located in Kaski District of Nepal at the South Western edge of Pokhara valley 28° 1' N, 82° 5' E, altitude 742 m. The total surface area covered by the lake was estimated of 4.43 km^2 whereas the area of the catchment is 122.5 km^2. It is the second largest lake in Nepal which is situated in Pokhara valley. It has a maximum depth of 24 m and a mean depth of 7.5 m, lying at an altitude of 742 (Rai et al., 1995).

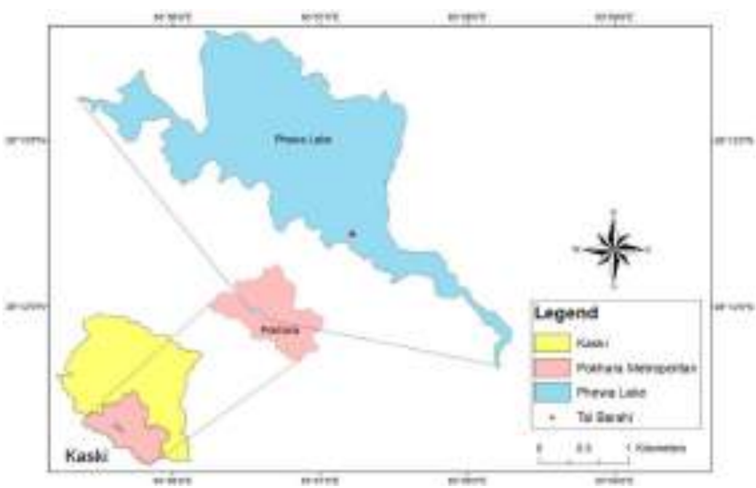


Figure 1. Map of study area

Heavy metals analysis in mushroom: Mushrooms grown from different compositions were air dried and grinded in the powder form using grinder. For heavy metal analysis 20 gm samples of mushroom were taken in powdered form. The powdered samples were then employed to laboratory for heavy metals analysis. For heavy metals analysis, determination of Arsenic, Cadmium, Lead and Mercury were done using AOAC 2015.01.21st Edn method. Lead, Cadmium, Mercury and Arsenic analysis were carried out inlaboratory of National Food and Feed Reference Laboratory, Kathmandu, Babarmahal.

RESULTS AND DISCUSSION

Arsenic and Cadmium concentrations in mushroom sample were found within the guideline of WHO/FAO i.e. 30 µg/kg and 1µg/kg. Similarly, Lead concentration was found within the standard guideline in WH, 1:2 and 2:1 treatments. But RS and 1:1treatment were found 10.2 µg/kg and 3.65 µg/kg respectively. These levels are higher than the standard guideline especially of controlled rice straw only treatment which is five times higher. Mercury concentration level was also found within the guideline except for controlled rice straw only treatment which was 0.47 µg/kg. Thus, obtained results are presented in table 1 below:

Table 1. Heavy metals concentration present in mushroom produced using water hyacinth

SN	Parameters	Unit	WH	RS	1:1	1:2	2:1	WHO/FAO Guideline
1.	Arsenic	mg/kg	0.38	2.1	1.10	1.20	1.60	30
2.	Cadmium	mg/kg	<0.08	<0.08	<0.08	0.09	<0.08	1
3.	Lead	mg/kg	1.12	10.2	3.65	1.00	1.80	2
4.	Mercury	mg/kg	0.11	0.47	0.10	0.10	0.09	0.2 (µg)

Source: FAO/WHO

Highest concentration of Arsenic, Lead and Mercury were found in controlled rice straw treatment i.e. 2.1 µg/kg, 10.2 µg/kg and 0.47 µg/kg respectively. Both Lead and Mercury concentrations were found greater the standard WHO/FAO guideline i.e. 2 µg/kg and 0.2 µg/kg. Lead concentration in 1:1 ratio also was found controversial as it is greater than the standard guideline. However, Cadmium in all treatments were found to be within the standard limit. Experimentally, it has been observed that usually Mercury uptake of shoot is higher than that of root (Riddle et al., 2002). In this experiment root of water hyacinth was excluded and only stem and leaf parts were used. The obtained results suggest that water hyacinth can be an alternative substrate combination with rice straw for mushroom production to reduce presence of heavy metals in rice straw. In this experiment root of water hyacinth was excluded and only stem and leaf parts were used.

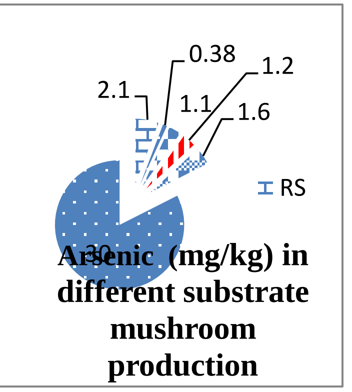
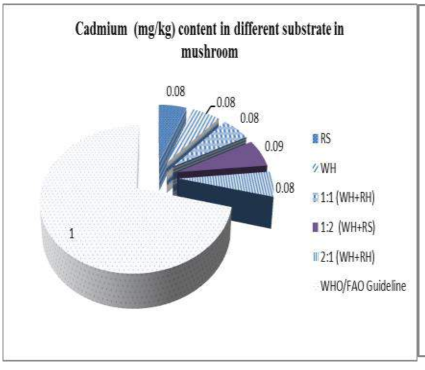


Figure 1. Mushroom production **Figure 2. Arsenic content in mushroom**



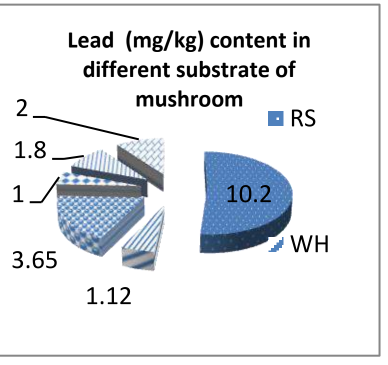


Figure 3. Cadmium content in mushroom Figure 4. Lead content in mushroom

The obtained results suggested that water hyacinth can be an alternative to rice straw for mushroom production as a substrate in terms of presence of heavy metals. In a study conducted by Nageswaran et al., (2003) where water hyacinth and paddy straw was combined in a ratio of 25:75 for the oyster mushroom production. The combination yielded the highest oyster mushroom.

CONCLUSION

Water hyacinth being an abrupt invasive plant species has been laborious to manage globally. Similar situation is found in Nepal. Mushroom production in Nepal is traditionally done using rice straw. This study reveals the risk of using rice straw as substrate for mushroom production in terms of heavy metal accumulations. Water hyacinth which is a problem in most of the lakes of Nepal including Pokhara can be used in the place of rice straw solving the management issue of invasive plant species use as a resource. In the meantime, the study showed that mushroom farming was cost-effective by mixing water hyacinth and rice straw. The study showed that the concentration of Lead, Arsenic, Mercury and Cadmium was found less in water hyacinth substrate used for mushroom production in the study site. Therefore, it is safe to consume mushrooms produced using the water hyacinth of Phewa Lake.

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PREVALENCE OF COMMON GASTROINTESTINAL NEMATODES IN GOATS OF PAKHRIBAS MUNICIPALITY, DHANKUTA

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ABSTRACT

Goats are among the major livestock's contributing for the economic gain and nutritional security among marginal farmers of Nepal. However, factors such as parasitic infestation, disease condition and low plane of nutrition has resulted in reduced productivity of the animals. In order to study the prevalence of gastrointestinal (GI) nematodes in three wards (Ward3, 9, and 10) of Pakhribas Municipality, Dhankuta a total of 342 fecal samples were collected from July to December, 2020 by doing farmers households visits. Samples thus collected were examined under microscope by using differential flotation technique by Soulsby, 1976 and egg per gram (EPG) in faeces was counted by the Mc Master technique as described by Urquhart et al 1988 at Veterinary Laboratory of Uttarpani Technical School.*In the study area, 67.54% (231/342) samples were found to be positive for nematodes. The prevalence of Strongyle sp. was found highest 88.31 % (189/231) and least was Trichuris sp. 17.74% (41/231). Ward No. 9 showed the highest prevalence 71.05% (81/114) followed by Ward no. 3 and Ward 10 consecutively. Age wise prevalence was found to be highest among the samples from goats more than six months age group 72.39 % (139/192) with mean EPG 300 and least among samples from goats below six months 61.33% (92/150) with mean EPG of 286***.** *The rate of prevalence of nematodes was found more in male goats 72.93% (159/218) than in female goats 58.06% (72/124) with significant statistical difference (p = 0.0047).*

Keywords: Goats, Nematodes, EPG, Pakhribas

INTRODUCTION

Goat farming has immense potentialities in Nepal, and is becoming popular among farmers much rapidly as compared to other livestock's with an annual increment of 4.69% in goat population (Krishi Diary, 2079). The reason behind it being the requirement of low capital investment with fast turnover for goat related venture, no social, cultural and religious taboos, or caste restrictions for rearing goats, and wide market potentiality(Ghimire, 1987; Sapkota *et al* ., 2016 and Neupane, Neupane, & Dhital, 2018). Also, internal and international migration of youth especially males, leaving only females and children in villages has increased the popularity of the small ruminants because of the ease in handling them compared to larger ruminants (Maharjan, Bauer, & Kner., 2013). Additionally, unsuitable climatic condition to grow surplus crops for consumption and sale has got more people interested in goat farming. Furthermore, prioritization of the species for upscaling livelihood by proving financial and technical support by organization like Food and Agriculture Organization (FAO) and Heifer has contributed to the flourishment of the species throughout the nation and has made it possible to attain economic and nutritional security in the marginalized communities by providing meat, milk, fibers and hide (FAO 2018, 2022 and Heifer, 2020). However, the production system has suffered severely from various infectious diseases of bacterial, viral and parasitic nature along with other management problems leading to morbidity and mortality of animals. This fact has been supported by studies of Acharya, Poudel, & Acharya, 2018; Ghimire, and Bhattarai, 2019; Gompo *et al*., 2021. Limited number of studies and lack of appropriate control strategies are the main factors behind large number of goat population harboring diseases. Furthermore, lack of satisfactory facilities of Veterinary care and haphazard use of drugs has worsen the condition.

The goat population in Dhankuta was around 1,76,773 in the year 2019 according to Veterinary hospital and livestock service expert center (VHLSEC), Dhankuta, with mixed farming being a popular choice among goat keepers. However, trends have been changing with more farmers opting towards commercial goat farming. And despite goat farming being undoubtedly a profitable business and means of uplifting rural livelihood; infestation by GI parasites such as *Trichostrongylus sp., Bunostomum s., Nematodirus sp., Fasciola sp., Oesophagostomum sp., Haemonchus, Ostertagia, Strongyloides sp. Trichuris sp* etc has always been a major constrain under Nepalese farming system impeding productivity (Adhikari *et al* ., 2017; Sukupayo, *et al* ., 2018; Sah and Sah, 2019 and Das, Neupane, & Sulistyowati, 2019). This has been characterized by low feed intake and weight gain, compromised immunity, milk reduction and death in complicated infections. Further, farmer's loose additional money in the form of expenditure incurred to treatment of animals. There has been report of about 24% of deaths in goats due to internal parasites and total economic losses of around 25 % due to GI nematodes in goats (Lohani and Rasalli, 1995).

Globally, parasitic nematodes of small ruminants and other livestock have been reported to have major economic impacts (Roeber *et al*., 2013). Local environment and climatic conditions along with traditional management practices and prevalence of intermediate host in the tropic and subtropics contribute to the cause (Sharma, Paul & Gururaj, 2020). Although, epidemiological study could be a gateway to intervene the spread, the likelihood for it to change as an effect of natural and manmade adversaries of various natures can't be denied. Factors like age of the host, the breed, the parasite species involved (Tembely *et al*., 1997), chemical uses in agriculture, and shift in husbandry practices due to depleting resources are likely to influence the occurrence and severity of these infections (Sharma, Paul & Gururaj, 2020) . Moreover, the climatic factors such as temperature, rainfall and humidity are conducive to the development of eggs (Menkir *et al*., 2007) and different stages of parasites which might result variation in strain phenology, within genotype or host switching, as survival strategy to cope with altered habitat structure, biodiversity, host demographics and evolution (Cable *et al.*, 2017). This could bring positive or negative impact for parasite survivality.

In past, few studies have already reported the prevalence of nematodes from many parts of Nepal and in many domesticated species. However, prevalence of this disease in goats has rarely been documented from the eastern part of Nepal. Hence, this study was done to find out the prevalence of nematodes infestations in goats at various sites of Pakhribas municipality lying in Dharan district of eastern Nepal.

MATERIALS AND METHODS

The study was conducted during July to December, 2020 by visiting household of farmers. Observational and a cross-sectional study was done for assessment-where fecal examination was an ante-mortem means of diagnosing helminthes of goats. A questionnaire format was prepared to identify the age and sex of goats from the collected data; knowledge of the goat owners was also analyzed. By random sampling method 114 fecal samples were collected from rectum manually from each of the three wards of Pakhribas municipality namely – Uttarpani (Ward no 9) , Chungwang (Ward no 10) and Chetana marga, Shanti tole, Jordhara, Kholetar (Ward no 3) in order to examine and identify the helminthes common to the area and their prevalence in the region. Following the sample collection, samples were placed in a separate ziplock bags with proper labelling including animal identification, date and place of collection. Samples were then transported to Veterinary Laboratory of Uttarpani Technical School, Uttarpani, Dhankuta in a cool ice box for laboratory examination. Fecal samples were examined by differential floatation technique as described by Soulsby, (1976) for the detection of nematode eggs. For quantitative investigation, egg per gram (EPG) in feaces was counted by the Mc Master technique as described by (Urquhart *et al.*, 1988).

Data were tabulated and analyzed using Microsoft excel for statistical analysis. Chi-squared ($\chi2$) test was used for determining association or non-association between variables. The level of significance was considered and P-value (<0.05) was calculated to show significant. Necessary tables, and charts are presented wherever relevant and necessary.

RESULTS AND DISCUSSION

Overall prevalence: The overall prevalence of nematodes in Pakhribas was found to be 67.54% (231/ 342) representing high parasitic load in goats of the area. Das, Neupane and Sulistyowati (2019) also reported a prevalence of 65.27% nematodes in goats of Kapilbastu. Whereas, relatively low prevalence rate than our study was reported in previous reports – 6.77% by Sukupayo and Rayamajhee (2018) in Roshi rural municipality and 35.84% % by Tripathi (2015) in Kapilvastu.

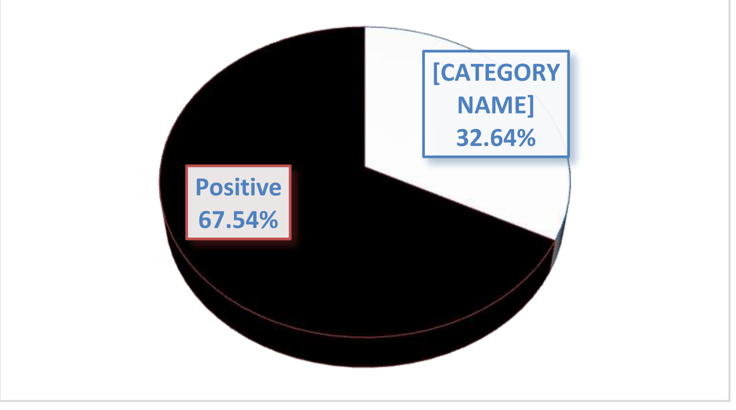

Figure 1. Overall prevalence of nematodes in three wards of Pakhribas municipality, Dhankuta

The reason behind the high parasitic load in the area might be due to the parasites being endemic in the area. Sah (2018) also reported high prevalence of nematodes (51.4%) in pigs raised in Dhankuta and Sunsari. Factors such as variation in the management system, topography and climatic condition of the area that favored the survival of infective stage of the parasite and intermediate hosts (Singh *et al*., 2013 and Sharma, Paul & Gururaj, 2020), natural resistance (Cable *et al*., 2017 and Sharma, Paul & Gururaj, 2020), drug treatment (Kaushik *et al*., 2016), nutritional factor might be accountale for the variations among the regions. The most common parasites encountered were *Strongyle sp.*, *Strongyloides sp. and Trichuris sp* in the study area *(Table 1).* Both sex and age groups were affected.

Table 1. Classes of nematodes reported

Nematode species	Number of nematode species / Total positive samples	Prevalance %
i.*Strongyloides sp.*	189/231	81.81
ii.*Trichuris sp.*	41/231	17.74
iii. *Strongyle sp.*	204/231	88.31

Area-wise prevalence of nematodes: Ward No. 9 showed the highest prevalence (71.05%) followed by Ward no. 3 and Ward 10 consecutively (Fig. 1). The reason behind the high infestation rate in the areas may be due to the low plane of nutrition, poor management conditions and lack of regular deworming practices among the farmers making the goats more vulnerable.

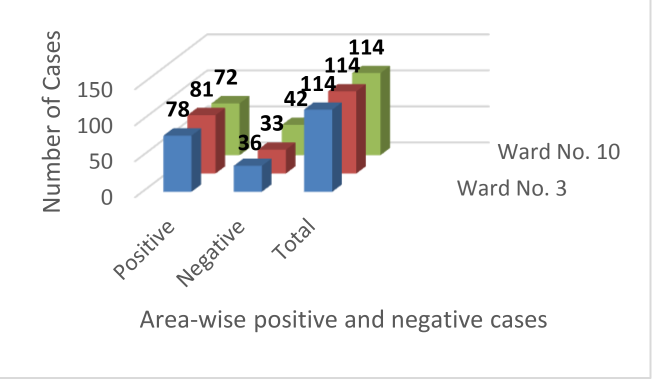

Figure 2. Area-wise prevalence of nematodes parasites

Also, the practice of grazing the goats in common pasture by all three communities due to less availability of fodder and forages in the area might have contributed for flaring the condition. Nematode infestation has doubled in Dhankuta district in less than 15 years, which is proved when compared with study done by Thakuri *et al.*, 1994, reporting only 34% prevalence in the area. The changing climatic situation, open road access allowing movement of animals, and lack of regular deworming practice might be the contributing factor for the present condition

Age-wise prevalence of nematodes: Table 2 shows the prevalence of nematodes were maximum in adult goats when compared with those less than 6 months of age with significant difference ($p < 0.05$). The findings are in agreement with finding of Singh *et al* (2017) in Punjab, India. Factors contributing for higher infestation in adult goats might be the managemental practices adopted in the region. The adults are grazed in common areas where there are exposed with shedding from infected animals on the pastures whereas kids are kept in confinement reducing the exposure for parasitic infestation. Similarly, minimal practice of deworming could be another reason behind it. Also, fewer sample size of kids might have contributed for minimal prevalence percentage than the adults. The load of mean egg per gram (EPG) was also found to 300 and 286 in adult goats and young one, respectively.

Table 2. Age-wise prevalence of nematodes

Age	Positive cases/ Total number off samples	Prevalence %	Chi Square Test	p-value <0.05
Young(0-6 months)	92/ 150	61.33	4.70	0.030
Adult (> 6 months)	139/ 192	72.39		
Total	231/ 342	67.54		

.**Table 3. Sex-wise prevalence of nematodes**

Sex	Positive cases /Total number of samples	Prevalence %	Chi Square Test	p-value <0.05
Male	159/ 218	72.93	7.97	0.0047
Female	72/ 124	58.06		
Total	231/ 342	67.54		

Sex wise prevalence

The occurrence rate of nematodes was higher in male animals (72.93%) than female animals (58.06%) with significant difference ($p < 0.05$) (Table 3). The reason behind the higher prevalence in male could be due to stimulatory effects of estrogen and inhibitory effect of androgens on immune responses.

CONCLUSION

This study found overall prevalence of 67.54% with three common nematodes viz. *Strongyloides sp, Trichuris sp and Strongyle sp* in the study area. Though the result might not be true reflection of the parasitic infestation in Dhankuta district as sample was purposive, but still it gives a clear figure about the parasitic problem in goats of Pakhribas municipality. Thus there is need for further studies with larger sample size using the molecular methods for estimation of the challenges held by the parasites and can be helpful in the fight to control the parasites in the area. The higher rate of prevalence suggest the need for adoption of proper control strategy for elimination of parasite. The work on female worm fecundity would be helpful to overcome the frequent infection by improving the pasture conditions.

SUGGESTIONS

Periodic fecal examination and anthelmintic treatment should be done for getting maximum productivity from the goats in the study area. Additionally, consultation with veterinarian prior to anthelminthic use is suggested to prevent anthelminthic resistance. Strategic deworming in high risk period is recommended along with adoption of rotational grazing, or biological/ chemical control in contaminated pasture with goat's droppings. Furthermore, need for conduction of awareness program regarding parasitic infection, its mode of transfer and control among farmer is crucial to improve the condition.

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MICRO GREENS: PRODUCTION AND ITS NUTRITIONAL HEALTH BENEFITS

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ABSTRACT

In recent years, there has been an increase in demand for fresh, ready-to-eat, functional foods including microscale vegetables (sprouted seeds and microgreens) due to society's increased interest in healthy eating. The crops typically utilized for microscale vegetable production are briefly described in this article. Microgreens are a newly developing superfood since they are immature seedlings of natural herbs and vegetables that grow in 7 to 21 days. The concept of microgreens is entirely new. Microgreens are rich in nutrients and are a nutritious addition to salads, burgers, dishes, and several other dishes that go well with them. The attraction solely depends on the handling's bioactivity and environmental value. Due to their higher concentration of bioactive components than fully expanded environmentally friendly plants, such as minerals, antioxidants, and vitamins, all of which are advantageous to human health and wellbeing and health, microgreens appear to be growing more popular.

INTRODUCTION

The environmental sustainability of plant production has come into view as analytical initiatives attempt to feed the world's constantly expanding population. Microgreens are a newly emerging type of plant that produces a substantial amount of nutrients without the need for biofortification or genetic engineering. Many fruits, vegetables, grains, and herbs, primarily those in the Brassicaceae, Lamiaceae, Amaryllidaceae, Apiaceae, Amaranthaceous, Cucurbitaceae, Fabaceae, and Asteraceae families, have immature, fragile, hypocotyl-colored, cotyledonary leaves that are known as microgreens (Choe, Yu, & Wang, 2018). North America and European countries are the major producer. Any grain or seed can be used to produce microgreens. Different grains used for producing microgreens include monocotyledons and dicotyledons. They require high light levels, preferably natural sunlight with low humidity and good air circulation.

Figure 1. Microgreen and its parts

Microgreens are an emerging food consisting of young edible vegetables and herbs, which are harvested when cotyledonary leaves have fully developed and the first true leaves have emerged (usually 7–21days after germination). They are also becoming more well-known due to their range of delicious flavors, textures, and tones, as well as their high standards for quality (Renna, & Di Gioia, 2017). The evidence that is now available indicates that microgreens are rich in trace elements and bioactive chemicals, and their top quality may be superior to that of their grown equivalent.

Important vegetables as microgreens are Red amaranth, Radish, Beetroot, Broccoli, Cabbage, Pea, Fenugreek, Lettuce,Basil, Red cabbage etc.

HISTORY

In the 1960's sunflower, buckwheat and radish were frequently grown in sunny windows as winter "Greens".In the 1970's, healthy home grown "Grasses" were popularized for their health benefits. In the 1980's, chefs started growing "Cresses" and "Seedlings" for garnishing. The first documented use of the word "MICROGREENS" in USA 1998.Then in the 2000's, local producers throughout North America started distributing fresh "Microgreens" to their local retail outlets. In 2010 microgreens started to appear at grocery stores (Pinto *et al.*, 2015).

Sprouts and Microgreens?

Sprouts are generally grown in dark, moisture saturated conditions conducive to microbial proliferation that may leads to food borne epidemics. Microgreens have much stronger flavor enhancing properties than sprouts and abroad range of leaf color, variety & shape. Substantial increase in vitamin C content from amaranth sprouts (8mg/100g) to microgreens (23.33mg/100g) (Ebert, 2022).

FUTURE DEMAND

For microgreens to become an important gardening product, be more fully integrated into the global food chain, and have their health benefits assessed and shared, market integrity must be recognized. Giving customers more information about the dietary qualities of the foods they purchase can inspire them to make future purchases, especially if they are health-conscious consumers. Preference and taste are significant factors influencing customer food purchases (Asioli *et al.*,2017). Microgreens contain higher amounts of important phytonutrients (ascorbic acid, β-carotene, α-tocopherol, and phylloquinone) and minerals (Ca, Mg, Fe, Mn, Zn, Se, and Mo) than their mature parts (Pinto *et al*., 2015).

Microgreens production at your home

At home, there are two ways to grow microgreens: hydroponically and in soil. A method similar to that used in hydroponics is used to cultivate microgreens hydroponically. Before covering the bottle and the initial seed with tissue paper, the seed should soak overnight. In order to ensure that top cells come into contact with water from below in indirect sunlight, additional containers are also situated immediately beneath the main container. One to three inches of moistened soil can be kept and also frequently leveled with light pressure in order to grow the soil-based mini eco-microgreens. The pre-soaked seeds can either be lightly pressed into the soil with your fingertips or sprayed on top of it. Water should be sprayed on the tissue sheet once or twice a day to keep it moist.

Table 1. Various microgreens and the kinds of bioactive compounds they contain (Reddy *et al.*, 2021):

Common Name	Family	Scientific Name	Bioactive compounds
Beet root	Amaranthaceae	*Beta vulgaris* L.	Sensory attributes
Basil	Lamiaceae	*Ocimum sanctum* L	Total ascorbic acids,phylloquinone, carotenoids, tocopherols and total phenolics
Broccoli	Brassicaceae	*Brassica oleracea var. italica*	50 times more sulforaphane
Cabbage	Brassicaceae	*Brassica oleracea var. capitata*	Ascorbic acids, phylloquinone, carotenoids, tocopherols
Carrot	Apiaceae	*Daucus carota*	Anthocyanins and carotenoids
Cauliflower	Brassicaceae	*Brassica oleracea var. botrytis*	Polyphenols, anthocyanin,flavonol, glycosides, hydroxybenzoic acid, hydroxycinnamic acid
Fenugreek	Fabaceae	*Trigonella foenicum-graecum* L.	Sensory quality, phytochemical content and antioxidant activity
Radish	Brassicaceae	*Raphanus sativus*	Ascorbic acids, phylloquinone, carotenoids, tocopherols, total sugars
Lettuce	Asteraceae	*Lactuca sativa*	Total phenolic concentration and antioxidant capacity
Spinach	Amaranthaceae	*Spinacia oleracea* L.	Vitamin C, B9,K1 and carotenoids
Red cabbage	Brassicaceae	*B. oleracea var. capitata* F. *rubra*,	Ascorbic acids, phylloquinone, violaxanthin, Beta carotene, Lutein/Zeaxanthin
Celery	Apiaceae	*Apium graveolens* L.	Sensory quality, phytochemical content and antioxidant activity

Microgreens at greenhouses: With additional lighting and home heating, microgreens can be cultivated in a greenhouse all year long with a variety of outcome times. In a cleaned and also loosening soilless growth instrument, microgreens can be cultivated. Your desired tool should be partially filled into a tray to a depth of 1/2 inches, depending on your watering strategy.

Microgreens commercially: The usage of floor covering systems is frequently combined with a practical manufacturing method that comprises of deep NFT-type troughs. For certain plants, the fabric mat might be sufficient on its own, but others might need a gentle coating with a tool after planting. Both batch and real-time seeding methods are available. Referrals based on seeding density are difficult to employ. Many farmers believe that they should seed as heavily as possible to increase yield, but they do not want to seed too heavily because crowding results in longer stems and increases the risk of illness. Given that the seed supplies adequate nutrition for the developing plant, some plants require little or no plant food. Mini carrots, as well as dill, are two microgreen plants that thrive for a long period.

Presently, several private companies and owner have started up doing microgreens production and business *viz.,* Brothers microgreens, Bhaktapur, Muttha, Lalitpur, The microfarm, Kathmandu.

HEALTH BENEFITS OF MICROGREENS

Although only a few studies have focused on the *in vivo* health benefits of microgreens, their effectiveness in blood glucose and weight control, as well as regulation of adipose tissue as shown in *in vitro* and *in vivo* studies lay the foundation for studying the potential value of microgreens on preventing and treating chronic diseases, such as obesity, type 2 diabetes, and cardiovascular diseases (Wadhawan *et al.,* 2018).

Tomas *et al*. (2021) investigated the in vitro bioaccessibility of polyphenols and glucosinolates in Brassicaceae microgreens kale, red cabbage, kohlrabi, and purple radish microgreens. In this study, the highest percentage of total phenolics and glucosinolate levels were released from kohlrabi and kale microgreens, respectively, after in vitro digestion. The high bioaccessibility of these bioactive compounds after digestion can provide anti-inflammatory, anticancer, antimicrobial, and anti-diabetic activities (Le *et al.*, 2020)

Mustard and radish microgreens showed stronger ant proliferative effects than kale and broccoli, in line with their higher VC, total carotenoids, and total iso-thiocyanates contents (De la Fuente *et al.*, 2020).

Huang *et al.* (2016) investigated the effects of red cabbage microgreens on modulating hypercholesterolemia in obese mice induced by high fat diet. Rats fed with a high fat diet and red cabbage microgreens powder showed a significantly lower plasma low-density lipoprotein (LDL) level and lower hepatic triglycerides level compared with those receiving a high fat diet supplemented with mature red cabbage powder.

Xiao *et al.* (2018) revealed that Brassicaceae microgreens are a good source of both macro elements (e.g., K and Ca) and microelements (e.g., Fe and Zn) in a balanced human diet and the consumption of microgreens could be a health-promoting strategy to meet the requirement of element dietary reference intakes, particularly for children

CONCLUSION

Microgreens are unique functional food sources that have the ability to sustainably diversify the world's food systems, advance human health, and make it easier for an urban population that is rapidly expanding to get fresh microscale veggies. These innovative food sources can be bought in supermarkets or even cultivated at home for daily harvesting as needed. They offer vibrant colors, intriguing textures, and a variety of scents and tastes. Additionally, because of their quick development cycles, these nutrient-dense food sources may be produced with little labor and no pesticides, resulting in low environmental impacts and widespread acceptability among customers who value their health. Furthermore, since sprouts and microgreens are often eaten fresh, food preparation virtually ever results in the loss or degradation of heat-sensitive micronutrients or vitamins.

FUTURE PERSPECTIVE

- Microgreens is an emerging aspect of agribusiness sector and there is a good scope for future research in this area due to increase in its demand and consumption among health conscious people.
- Standardization of microgreens production technologies for different crop seeds will accelerate the interest among growers.
- Advancements of postharvest processing techniques and packaging technology will help to maintain the quality for longer periods of time and extend their shelf life.

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