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Performance Evaluation of Chili (*Capsicum Annum* L.) Genotypes Under Mid-Hill Agro-climatic Conditions of Kirtipur, Nepal

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ABSTRACT

A study was conducted to evaluate ten chili pepper genotypes for yield performance under Preliminary trial in Kirtipur, Himalayan College of Agricultural Sciences and Technology, from March to July 2025. The genotypes, including Karma 747, Nepa Hot, Karma 777, Anna 3, Big Mama, Omega, Super Tara, Sudra, Premium, and the check variety 'Pusa Jwala', were evaluated in an open field using a Randomized Complete Block Design (RCBD) with three replications. The genotype Nepa Hot demonstrated the highest productivity (16.60 t/ha). It was an early-maturing variety, reaching 50% flowering in 47 days and 50% fruiting in 55 days. Despite having smaller fruits (length: 4.08 cm, width: 15.89 mm), its high fruit set resulted in superior yield. In contrast, Big Mama yielded the lowest (8.43 t/ha). Other promising genotypes included Super Tara, Omega, and Premium. The study identifies Nepa Hot as a prime candidate for farmer-led field trials and subsequent varietal release, promising to enhance chili productivity and sustainability in the mid-hills of Nepal, Kirtipur.

Keywords: Chili pepper, genotypes, mid-hill conditions, yield, varietal trial.

INTRODUCTION

Chili pepper (*Capsicum* spp.) is an economically important vegetable and spice crop in Nepal, yet domestic production remains insufficient to meet national demand, resulting in substantial imports of dried chili from India (MoALD, 2022; FAO, 2022). The genus *Capsicum* (Solanaceae) comprises more than 40 species, of which *C. annuum, C. chinensis, C. baccatum, C. frutescens,* and *C. pubescens* are domesticated (Barboza et al., 2022). These species exhibit extensive genetic diversity in plant architecture, fruit morphology, pungency, nutritional profile, and stress tolerance (Tripodi and Kumar, 2019).

In Nepal, chili is cultivated across a wide range of agro-ecological zones, with about 23,000 ha under cultivation and an annual production of ~185,000 metric tons in 2021 (MoALD, 2022; Poudyal et al., 2023). Despite favorable environments, national productivity (~8 t/ha) is low due to pest and disease pressures, limited availability of suitable varieties, and suboptimal cultivation practices (Poudyal et al., 2023). Although 16 varieties have been released to date, most are older types or unsuitable for hill cultivation, and more than 70% of production presently depends on costly imported hybrids (SQCC, 2021; Poudyal et al., 2023). The scarcity of high-yielding, hill-adapted genotypes represent a key constraint to increasing national production.

To address this gap, the present study evaluated ten chili genotypes—including widely cultivated local lines and the check variety 'Pusa Jwala'—under mid-hill agro-climatic conditions in Kirtipur. The objective was to assess phenological, vegetative, and yield-related traits to identify promising genotypes for subsequent farmer-participatory evaluation and potential varietal release.

MATERIALS AND METHODS

Experimental site and climate

The study was conducted during the 2025 growing season (March-July) at the research farm of Himalayan College of Agricultural Sciences and Technology (HICAST) in Kirtipur, Nepal (27.6835°N, 85.2771°E; 1350 m asl). The site experiences a subtropical climate with mean summer temperatures ranging from 20-28°C and annual precipitation of 2,812 mm.

Plant materials and experimental design

Ten chili genotypes (*Capsicum annuum* L.) were evaluated: Karma 747, Nepa Hot, Karma 777, Anna 3, Big Mama, Omega, Super Tara, Sudra, Premium, and the check variety 'Pusa Jwala'. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Each plot measured 1.8 m × 1.25 m with a plant spacing of 0.5 m × 0.5 m, accommodating six plants per plot.

Crop management

Seeds were sown in a protected nursery on 1 March 2025, and seedlings were transplanted to the main field on 31 March 2025. Fertilizers were applied at a

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recommended dose of 150:120:100 kg $N:P_2O_5:K_2O$ ha^{-1}, supplemented with farmyard manure at 20 t ha^{-1}. Integrated pest management practices were implemented, including the use of yellow sticky traps for whitefly monitoring. Standard agronomic practices for irrigation, weeding, and staking were uniformly maintained across all plots.

Agronomic cultural practices

Seedlings were raised in a nursery on 1st March, 2025 and transplanted to the main field on 31 March 2025 at the specified spacing as in Table1. Irrigation, weeding, and staking were performed as needed. The recommended fertilizer ratio was 150:120:100NPK kg/ha and FYM 20t/ha. Based on this standard recommendation, the calculated fertilizer amounts per plot were 103 g of urea, divided into 47 gm as basal dose and 2 split dosages of 28 g each; 75 g of Diammonium Phosphate (DAP); and 37 g of Muriate of Potash (MOP). In addition to these fertilizers, Farm Yard Manure (FYM) at 5 kg per plot was used. After transplanting, soil was drenched with bavistin @2gm/lt. Pest and disease management was carried out following integrated pest management (IPM) principles using sticky traps for whiteflies.

Agronomic and phenological traits

Plant height (cm) and the number of primary branches were recorded from six randomly selected plants per plot at 60 and 90 days after transplanting (DAT). Collar diameter (mm) was measured at the stem base using a vernier caliper. Plant uniformity and vigor were visually assessed at 50 DAT using a 1–5 scale, where 1 represented poor/uniform growth and 5 represented excellent/vigorous growth. Leaf length, width, and petiole length (cm) were measured from five mature leaves per plot at 76 DAT.

Yield and fruit parameters

Days to 50% flowering and fruiting were recorded as the number of days from transplanting until 50% of plants per plot had at least one open flower or fruit set, respectively. At harvest (117 DAT), ten marketable fruits per plot were sampled to determine fruit length, diameter (measured at the proximal third), peduncle length (cm), and average fruit weight (g). The total number of fruits per plant was counted, and fruit weight per plant (g) was recorded. Plot yield was converted to productivity in metric tons per hectare ($t \cdot ha^{-1}$).

Data collection and analysis

Data were recorded on phenological traits (days to 50% flowering and fruiting), vegetative growth (plant height, collar diameter, leaf characteristics), and yield components (fruit size, number per plant, and weight). Total yield was recorded per plot and extrapolated to tons per hectare. Data were subjected to Analysis of variance (ANOVA) using ADEL-R software, and treatment means were compared using the Least Significant Difference (LSD) test at a 5% significance level**.**

RESULTS AND DISCUSSION

Significant variation was observed among the ten chili genotypes for key vegetative growth parameters (Tables 1 &2). Plant height, measured at 90 days after transplanting (DAT), showed highly significant differences (P<0.001). Genotypes Super Tara and Big Mama consistently exhibited the greatest plant height, reaching 110.47 cm and 96.85 cm at 90 DAT, respectively, indicating vigorous vegetative growth. In contrast, Sudra and Karma 747 were among the shortest genotypes. While greater plant height is often associated with improved light interception and photosynthetic capacity (Poorter et al., 2009), the tallest plants did not necessarily translate to the highest yields, suggesting a potential trade-off between vegetative growth and reproductive allocation.

Leaf morphological traits and stem robustness also varied significantly. Pusa Jwala and Karma 777 had the largest leaves and greatest leaf area, which can enhance photosynthetic potential. Super Tara possessed the thickest collar diameter (27.30 mm), a trait associated with better mechanical strength and vascular transport (Bosland & Votava, 2012). However, the genotype with the highest yield, Karma 777, exhibited intermediate values for these vegetative traits, indicating that optimal growth architecture for yield is not solely defined by maximum vegetative size. Larger leaves contribute to increased light interception and photosynthetic capacity, thereby enhancing plant growth and productivity (Poorter et al., 2009). However, under high-radiation or water-stressed conditions, smaller leaves can be advantageous by minimizing transpiration losses (Nicotra et al., 2011).

Phenological development and reproductive traits

The genotypes displayed a wide range in their phenological development (Table 2). Nepa Hot (47.33 and 53days to 50% respectively) followed by Anna 3 was

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the earliest to flower and fruit (47.67and 54 days to 50%, respectively), while Super Tara was the latest (63 and 69 days). The high-yielding genotype Karma777 displayed an early to mid-season phenology (59 days to flowering, 65 days to fruiting). Early maturity is a critical adaptive trait for the mid-hills, allowing the crop to complete its key reproductive phase before the onset of unfavorable conditions (Kafle et al., 2021). The significant genetic diversity in phenology offers breeders and farmers options to select varieties suited to different growing windows.

Table 1. Effects of chili genotypes on plant height, leaf size and collar diameter

Treatment	Plant height 60DAT	Plant height 90 DAT	Leaf length (cm)	Leaf Width (cm)	Stalk length of leaf (cm)	Leaf Area (cm^2)	Collar Diameter (mm)
1 Karma 747	53.50^{cd}	79.28^{d}	7.29^{bc}	2.85^{cde}	3.00^{a}	6.99^{cde}	26.19^{b}
2 Nepa Hot	62.50^{abc}	82.61^{d}	7.64^{abc}	4.10^{a}	2.53^{ab}	9.44^{a}	20.12^{f}
3 Karma 777	58.08^{abcd}	95.11^{bc}	8.17^{ab}	3.91^{ab}	1.86^{bc}	9.45^{a}	25.78^{b}
4 Anna 3	66.56^{ab}	89.53^{bcd}	5.12^{d}	3.56^{abc}	2.36^{ab}	6.77^{de}	17.99^{h}
5 Big mama	68.17^{a}	96.85^{b}	8.19^{ab}	2.45^{e}	1.32^{c}	3.62^{f}	21.38^{e}
6 Omega	48.33^{d}	79.78^{d}	7.10^{c}	3.86^{ab}	1.93^{bc}	7.76^{b}	19.24^{b}
7 Super Tara	67.58^{a}	110.47^{a}	6.87^{c}	3.45^{abcd}	2.51^{ab}	6.58^{de}	27.30^{a}
8 Sudra	52.19^{cd}	78.25^{d}	6.80^{c}	2.77^{de}	2.77^{a}	7.56^{bc}	20.12^{f}
9 Premium	55.11^{bcd}	84.17^{cd}	7.21^{c}	3.21^{bcd}	2.35^{ab}	6.39^{e}	22.51^{d}
10 Pusa Jwala (Check)	62.39^{abc}	83.78^{cd}	8.47^{a}	3.06^{cde}	3.00^{a}	7.17^{bcd}	23.81^{c}
Grand Mean	59.44	87.98	7.29	3.32	2.36	7.17	22.44
F- test	*	***	***	**	**	***	***
StdMSE	7.25	7.17	0.56	0.42	0.46	0.35	0.25
LSD(5%)	12.44	12.30	0.96	0.73	0.8	0.6	0.42
CV%	12.20	8.15	7.65	12.72	19.68	4.87	1.10

Mean in the column followed by unlike letters indicates significant difference at P=0.05

*Note: Means with same letters are non-significant at p=0.05 by DMRT (Duncan's Multiple Range Test), *significant at 0.05% level of significance, **significant at 0.01% level of significant, ***significant at 0.001% of significance, NS- Non-Significant*

Fruit characteristics, including length, diameter, and peduncle length, showed highly significant variation (P<0.001), reflecting the diverse genetic background of the tested materials (Table 2). Pusa Jwala produced the longest fruits (10.09 cm), whereas Karma 747, despite having shorter fruits (3.6 cm) followed by Nepa

Hot (4cm) fruit length, had the greatest fruit diameter (15.35 mm). This compact, blocky fruit type can be preferable for certain market segments.

Table 2. Effects of chili genotypes on number of primary branches, uniformity, vigor and fruit size

Treatments	Number of primary branches	Uniformity	Vigour	Days to 50% flowering	Days to 50% fruiting	Fruit length (cm)	Fruit width (mm)	Fruit peduncle length (cm)
1 Karma 747	6.40[ab]	5.00[a]	5.00[a]	52.00[d]	57.67[de]	3.60[d]	12.73[abc]	3.09[bc]
2 Nepa Hot	5.83[bc]	4.67[a]	5.00[a]	47.33[e]	53.00[f]	4.08[cd]	15.35[a]	2.84[c]
3 Karma 777	6.87[ab]	4.00[b]	4.00[b]	59.33[ab]	64.67[ab]	7.51[b]	7.39[e]	3.72[ab]
4 Anna 3	6.85[ab]	5.00[a]	5.00[a]	47.67[e]	54.00[ef]	8.46[b]	7.09[e]	3.49[abc]
5 Big mama	6.52[ab]	4.00[b]	5.00[a]	53.00[cd]	60.00[cd]	7.85[b]	7.91[de]	3.33[abc]
6 Omega	7.90[ab]	5.00[a]	5.00[a]	62.00[a]	67.67[a]	5.18[c]	10.51[cd]	2.72[c]
7 Super Tara	6.64[ab]	5.00[a]	5.00[a]	62.67[a]	68.67[a]	4.54[cd]	11.19[c]	3.11[bc]
8 Sudra	8.18[a]	4.00[b]	4.67[a]	56.67[bc]	62.33[bc]	7.44[b]	11.22[c]	2.81[c]
9 Premium	7.76[ab]	5.00[a]	5.00[a]	53.00[cd]	60.00[cd]	5.27[c]	14.04[ab]	2.87[c]
10 Pusa Jwala (Check)	4.11[c]	4.67[a]	4.67[a]	50.33[de]	56.67[def]	10.09[a]	11.44[bc]	3.98[a]
Grand Mean	6.71	4.63	4.83	54.40	60.47	6.40	10.89	3.20
F-test	*	***	**	***	***	***	***	*
StdMSE	1.28	0.24	0.27	2.31	2.62	0.90	1.57	0.47
$LSD_{0.05}$	2.20	0.42	0.46	3.96	4.50	1.55	2.70	0.80
CV%	19.13	5.26	5.49	4.24	4.34	14.12	14.44	14.62

*Note: Means with same letters are non-significant at p=0.05 by DMRT (Duncan's Multiple Range Test), *significant at 0.05% level of significance, **significant at 0.01% level of significant, ***significant at 0.001% of significance, NS- Non-Significant. Mean in the column followed by unlike letters indicates significant difference at P=0.05.*

Yield and component analysis

Yield and its components exhibited significant genetic differences, with Karma 777 emerging as a top performer (Table 3). Although the check variety Pusa Jwala recorded the highest individual fruit weight (7 g) and the highest theoretical yield (20.80 t/ha), Karma 777 achieved a comparable and statistically similar high yield (18.31t/ha) followed by Nepa Hot (17.16 t/ha).

Table 3. Effects of chili genotypes on yield parameters

Treatments	**Average Fruit weight of 10 ripe fruits (g)**	**No of fruits per plant**	**Fruit Yield/ Plant (kg)**	**Fruit Yield (t/ha)**
1 Karma 747	3.48^{de}	109.06^{d}	0.47^{bc}	12.44^{bc}
2 Nepa Hot	4.83^{cd}	207.06^{ab}	0.64^{ab}	17.16^{ab}
3 Karma 777	4.63^{cd}	160.50^{bcd}	0.69^{ab}	18.31^{ab}
4 Anna 3	2.70^{e}	187.34^{bc}	0.53^{bc}	14.13^{bc}
5 Big mama	2.50^{e}	136.91^{cd}	0.39^{c}	10.49^{c}
6 Omega	3.90^{cde}	185.98^{bc}	0.58^{abc}	15.38^{abc}
7 Super Tara	3.57^{cde}	258.51^{a}	0.56^{abc}	14.93^{abc}
8 Sudra	7.57^{a}	133.83^{cd}	0.48^{bc}	12.71^{bc}
9 Premium	5.37^{bc}	165.11^{bcd}	0.68^{ab}	18.04^{ab}
10 Pusa Jwala (Check)	7.00^{ab}	133.11^{cd}	0.78^{a}	20.80^{a}
Grand Mean	4.55	167.74	0.58	15.44
F-test	***	**	*	*
StdMSE	1.10	33.93	0.13	3.45
LSD $_{0.05}$	1.89	58.20	0.22	5.92
CV%	24.15	20.23	22.32	22.34

*Note: Means with same letters are non-significant at p=0.05 by DMRT (Duncan's Multiple Range Test), *significant at 0.05% level of significance, **significant at 0.01% level of significant, ***significant at 0.001% of significance, NS- Non-Significant. Mean in the column followed by unlike letters indicates significant difference at P=0.05.*

This highlights a key yield adaptation strategy: Karma777 compensates for its smaller fruit size with a remarkably high fruit set followed by Premium as well as Nepa Hot. This efficient partitioning of assimilates towards reproductive structures, rather than excessive vegetative growth or individual fruit size, is a hallmark of a well-adapted genotype (Wahyuni et al., 2013). Super Tara, which had the highest fruit count (258.51 per plant), achieved a strong yield (14.93 t/ha), but its later maturity and potentially larger plant structure may be less efficient than Karma 777 , Premium, and Nepa Hot's more compact and early-maturing profile. Larger fruits, are linked to greater photosynthetic translocation and are preferred for fresh markets, while smaller, lighter fruits suit the spice industry (Uwah et al. 2013). Fruit number in chili is primarily influenced by genetic makeup but is also affected by environmental factors such as nutrient availability, soil fertility, and temperature conditions during flowering and fruiting (Bosland and Votava 2012). Genotypes that exhibit strong vegetative growth and thicker stems, such as Super Tara, tend to sustain a higher fruit load without compromising individual fruit quality. Furthermore, environmental factors such as sunlight, temperature, and nutrient management also play crucial roles in optimizing fruit set and yield (Singh et al., 2017).

Conversely, genotypes like Big Mama and Karma 747 yielded the lowest (10.49 and 12.44 t/ha, respectively), primarily due to a lower number of fruits per plant. This underscores that fruit number is a more critical determinant of final yield in this context than individual fruit weight.

CONCLUSION

The results demonstrate that Karma 777 possesses an ideal combination of traits for the mid-hill conditions of Nepal: early maturity, a high number of fruits per plant, and efficient plant architecture, culminating in high yield. Its performance suggests it is less prone to the sink-source imbalances seen in overly vigorous genotypes. The identification of Karma 777, along with other promising genotypes like Premium and Nepa Hot, provides valuable genetic resources for improving chili productivity in the region. We recommend Karma777 for immediate inclusion in farmer-participatory trials as a precursor to potential varietal release.

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