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Research Article

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Evaluation of Hot Pepper Genotypes (*Capsicum annuum*) In Western Terai of Nepal.

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Abstract

A set of experiment was conducted to find the best hot pepper genotypes for the Western Terai of Nepal in the October, 2017 and April, 2018 at Agricultural Research Directorate, Lumbini Province, Khajura. The experiments were conducted in Randomized completely block design with four replications. The treatments consisted of hybrid genotypes SV1947HA, SV4884HA, SV2319HA, SV1551HA; two hybrids check cultivars NS 1701 and NCH-1120 and Pusa Jwala which is check open pollinated cultivar of hot pepper. In normal (October) season planting, the highest fresh yield (15.17 t/ha) was obtained from NS 1701 and similar yield was obtained from the genotype SV1947HA (13.86 t/ha) while in the off season (April) planting, the highest fresh yield (7.97 t/ha) was obtained from NCH-1120 and same level of yield with genotypes SV1551HA (6.83 t/ha). Highly significant differences among cultivars were observed in yield and yield attributing characters. Hot pepper yield were observed lower in the April planting due to the crop failure by disease in the heavy rainfall period. The genotypes with better fruit set and yield in respective growing season were needed to be further tested in order to ensure their performance.

Keywords: Design, Genotypes, Hot Pepper, Yield,

Introduction

Hot pepper (*Capsicum annuum* L.) is a highly used and important spice in Nepalese kitchen (Pun, 1988). It is one of the members of Solanaceae and genus Capsicum (Shanmugavelu, 1989). The genus Capsicum refers for sweet and pungent fruits of numerous shapes, sizes and pungency levels (Simon et al., 1984). Hot peppers are generally known as chillies and cultivated throughout the world (Singh, 2001). Bose et al. (1986) reported that the center of diversity of the common cultivated pepper *Capsicum annuum* is probably Mexico with a secondary center at Guatemala. The fruits of most Capsicum are pungent and pepper pungency is a desirable attribute in many foods. Pungency present in Capsicum is due to the placenta accumulates capsaicinoids (e.g. capsaicin) (Thompson et al., 2005), while domesticated C. annuum are non-pungent (sweet) (Bosland &Votava, 2000).

In Nepal, hot pepper ranks as a spice crop after cardamom and ginger and grown in almost all parts of country (MOALD, 2019).The gross area under chilli was 9687 ha. with a productivity of 10.35 t/ha (fresh) during 2018/19 in Nepal (MOALD, 2019). Huge amount of chillies were being imported from India i.e. around 80% of dry and 24% green chillies (Anoymous, 2004). The demand for chilli (including green and dry) in Nepal was 72000 tons per year (Budhathoki, 2006).

All the authors declares that there is no any conflict of interest.

Hot weather is favorable for the growth of hot pepper but night temperature more than 24°C is not good for fruit set. Optimum day temperature for chilli pepper growth ranges from 20 to 30°C. The temperature below 15°C and more than 32°C for longer periods could reduced growth and yield (Berke et al., 2005). A temperature below 16°C and above 32°C prevents fruit set (Bosland, 1994). The maximum flower set was found for day and night temperature of 21°C and 16°C respectively whereas yield is high when the daily air temperature for fruit set between 1832°C (Olareweju, 1988; Aloni et al., 1991). In Terai region of Nepal, chilli is commercially grown during July-August to November. The major problems for chilli production during early summer and early rainy months are high temperature; prolong drought and shortage of moisture.

Lower production of chilli in open field condition is due to high temperature, hot wind and shortage of soil moisture during early summer, and high temperature and excessive moisture during rainy months. Hot temperature and moisture stress leads to the abscission of flower buds, flowers and young fruits of chilli (AVRDC, 1986). Western Terai and inner Terai region are relatively drier and warmer climate than other parts of Nepal. Dry and hot conditions increase the problems of flower and fruit drop, reduces fruit size and number of fruits per plant and finally reduce yield (Srinivasa Rao & Bhatta, 1993). Besides this, limited availability of suitable varieties for both on and off-season in this region hampers the good quality capsicum production.

Generally, hot pepper is cultivated in two seasons of a year; the first in February to escape from frost and low temperature and second in August to avoid high temperature and heavy rains (Pandey & Yonjon, 1991 and Pun & Karmacharya, 1989).

Chilli is a day neutral plant (Singh et al., 1990). It can be grown in any season, using suitable varieties. The information on high yielding heat tolerant varieties for inner Terai conditions of Nepal is scarce.

The production of chilli in Nepal is more seasonal because of limited varieties (heat and drought tolerant varieties) and lack of knowledge on advanced production technologies for specific locations. Limited supply and higher demand during summer to early rainy season has caused the higher market price of hot pepper and hence farmers can fetch good returns if they could manage to produce the chilli during that period. In addition, summer month are suitable time to produce green/dry chilli due to abundant sunlight, which enhance early maturing/ ripening and drying of the harvested fruits. Hence the experiment was conducted to evaluate the hybrid genotypes of hot pepper in the normal and off-season planting season of the locality.

Materials and Methods

Experimental sites and weather parameters

The area of Agricultural research directorate, Lumbini province lies between at 810 37" east longitudes and 280 06" north latitude. The altitude was 181 meters above mean sea level. Average annual rainfall of the station is 1000-1500 mm. The temperature range of minimum to maximum for this station is 5.4°C and 46°C respectively having relative humidity at the range of 27 to 94%. Overall, the humidity is low for most of the periods of year (RARSN, 2017/18).

Table 1: Meterological data of Agricultural research directorate, Khajura (2017/18)

Year	Air temperature (°C)		Soil Temperature (°C)		Rainfall (mm)
	Maximum	Minimum	5 cm depth	10 cm depth	
2017-Oct	37.85	23.55	26.35	27.05	47.9
2017-Nov	28.2	16	19.65	20.6	0
2017-Dec	23.55	12	16.75	17.55	0
2018-Jan	11.15	18.55	15.1	14	9.7
2018-Feb	26.15	12.65	17.45	17.85	12.8
2018-Mar	33.15	18.15	23.75	24.05	5.3
2018-Apr	37.05	27	31.8	31.65	9.9
2018-May	36.85	28.75	32.95	32.7	13.6

Source: Annual Report, RARS, Khajura, 2017/18

Table 2: Meterological data of Agricultural research directorate, Khajura (2018/19)

Month	Average Relative humidity %	Average Maximum Temperature (°C)	Average Minimum Temperature (°C)	Cumulative rainfall (mm)
July 17-Aug 16, 2018	87.3 %	32.82	26.61	392.8
August 17 - September 16, 2018	85.7 %	33.51	26.34	170.4

Source: Annual Report, RARS, Khajura, 2017/18

Varieties and experiment

The experiment was conducted to evaluate the different hot pepper genotypes with higher yield and wider adaptability in April planting (off-season) and October (normal season) for Western Terai area of Lumbini province during 2017 and 2018. The hybrid (F1) genotypes SV1947HA, SV4884HA, SV2319HA, SV1551HA from National Horticulture Research Center (formerly Horticulture Research Division), Khumaltar, Lalitpur, Nepal were brought and checked against already established varieties for normal season namely Pusa Jwala (OP), NS 1701(F1) and NCH-1120(F1). One month old seedlings of hot pepper were transplanted in first week of October, 2017 in Randomized Complete Block Design (RCBD) with four replications. Seedlings were transplanted in 60x30 cm apart in a plot of 3.6 m2 (2.4 m×1.5 m) size. The number of rows per plot was fourwith fiveplants per row consisting of twenty plants per plot. For the off season planting, one month old seedlings of six genotypes of hot pepper namely SV1947HA, SV4884HA, SV2319HA, SV1551HA, NCH-1120 and Pusa Jwala were transplanted in first week of April, 2018. The experiment was also laid out in RCBD with four replications. The size of plot was 2.4 ×1.5 (3.6m^2) and the spacing was 60x30cm. The number of rows per plot was four and number of plants per row was five and numbers of seedlings planted per plot were twenty. In both experiment, recommended dose of fertilizer (30 ton compost and 100:100:60 kg NPK/ha). The Nitrogen dose was split 3 times (half dose as basal and remaining was split at 20 days and 40 days of transplanting). Inter-cultural operations were carried out in similar fashion during crop growing stage for all varieties. From the four sample plant of each plot excluding the border line, we made observation for the required parameters. Observations were taken on plant height, plant vigor, Days to 50% plant flowering, yield and yield attributing parameters like individual fruit weight, number of fruits per plot and total fresh yield per plot and finally estimated yield was calculated as ton per hectare. Plant height was measured from the base of ground to the tip of top leaves. Plant vigor was recorded during first harvest on the basis of 1-5 vigor scale where scale was given 1(Very Poor), 2(Poor), 3(normal/ medium), 4(good) and 5(highly vigorous).

The days to fifty percent flowering from the date of transplanting was calculated from the plants present in each plot. Individual fruit weight was calculated from the average weight of 20 sample pepper fruits from plot in the second harvest. The number of fruits per plot and total fresh yield was calculated from the total plants harvested from each plot. The data were analyzed with statistical software R (version 3.6.3) and RStudio1.3.1093.

Results

Evaluation for normal season planting (October Planting)

Plant height, Plant vigor, and Days to 50% flowering

The results show that the genotypes were significantly different in terms of plant height, plant vigor and days to 50% flowering after transplanting (Table 3). Among the tested genotypes, SV2319 HA showed the highest plant height (73.35 cm) which was at par with SV1947 HA (68.85 cm) and NS 1701 (64.35 cm), and followed by SV4884 HA (62.95 cm) and SV1551 HA (50.25 cm) while the Pusa Jwala was the shortest (49.90 cm). The plant vigor (1-5scale) was found maximum (rated 4 out of 5) in genotypes SV1947 HA which was followed by NS 1701(3.25), SV2319 HA (3.25), SV4884 HA (2.5), SV1551 HA (2.25) and the lowest (2) in Pusa Jwala. Among the genotypes planted, Pusa Jwala was found to be the earliest (23 DAT) to 50% flowering which was followed by genotypes SV2319 HA (46 days), SV4884 HA (48 days), SV1551 HA (49 days), and NS1701(51 days) and the longest (52 days after transplanting) to fifty percent flowering was recorded in SV1947 HA.

Average fruit weight, Number of fruits/plot and Yield

The yield and yield attributing characters among the genotypes were found significantly different (Table

3). The individual fruit weight was highest (5.9 g) from genotype SV1947 HA which was at par (5.41 g) with genotype NS1701 and followed by genotypes SV1551 HA (4.72 g), Pusa Jwala (4.64 g) whereas it was minimum (2.76 g) in genotype SV2319 HA (2.76 g) which is similar to the genotype SV4884 HA (3.51 g). The number of fruits per plot was also found significantly different among genotypes. The number of fruits per plot was maximum (2298.5) from NS 1701 which is at par with SV2319 HA (2004.25) and followed by genotypes SV1947 HA (1729), SV4884 HA (1567.5), SV1551 HA (1107.71) and the lowest fruit per plot was in Pusa Jwala (452.25). The significant variation among genotypes in terms of fresh pepper yield was found. The highest (15.17 t/ha) fresh pepper yield was obtained from NS 1701 which was at par with SV1947 HA (13.86) followed by SV2319 HA (9.46 t/ha), SV4884 HA (8.94 t/ha), and SV1551 HA (8.68 t/ha), and the least yield was obtained from Pusa Jwala (4.01 t/ha).

Table 3: Performance hybrid Hot pepper genotypes at Agricultural Research Directorate, Khajura planted in October, 2017.

Varieties	Plant height (cm)	Plant vigor (1-5)	Days to 50% flowering (DAT)	No. of harvested plant per plot	Ind. Fruit weight (g)	No. of fruits per plot	Fresh Yield (t/ha)
SV1947 HA	68.85^{ab}	4.00^{a}	52.00^{a}	16.75^{a}	5.90^{a}	1729.00^{b}	13.86^{a}
SV4884 HA	62.95^{b}	2.50^{c}	48.25^{ab}	13.00^{b}	3.51^{c}	1567.50^{bc}	8.94^{b}
SV2319 HA	73.35^{a}	3.25^{b}	46.00^{b}	15.75^{a}	2.76^{c}	2004.25^{ab}	9.46^{b}
SV1551 HA	50.25^{c}	2.25^{c}	49.00^{ab}	9.00^{c}	4.72^{b}	1107.75^{c}	8.68^{b}
NS1701(check)	64.35^{ab}	3.25^{b}	51.00^{ab}	16.50^{a}	5.41^{ab}	2298.50^{a}	15.17^{a}
PusaJwala (check)	49.90^{c}	2.00^{c}	23.00^{c}	15.25^{ab}	4.64^{b}	452.25^{d}	4.01^{c}
Grand Mean	61.60	2.87	44.87	14.37	4.49	1526.54	10.02
SEM (±)	38.51	0.20	12.48	2.45	0.39	122839.4	5.40
LSD0.05	9.35***	0.68***	5.32***	2.36***	0.95***	528.23***	3.50***
CV%	10.07	15.87	7.87	10.89	14.05	22.95	23.18

Means within the column followed by the same letter are not significant different at 5 % level of significance by DMRT.

NS = Not Significant; *, * *and *** = Significant at 0.05, 0.01 and <0.001 levels, respectively

Evaluation of genotypes for off-Season planting (April Planting)

Plant height, Plant vigor and Days to 50% flowering

Plant height, plant vigor and days to 50% flowering after transplanting were significantly different among tested genotypes during April planting at Khajura in 2018 (Table 4). The plant height was observed the highest (118.6 cm) in genotype SV4884HA which is at par with the genotypes SV1947HA (118.20 cm), SV2319HA (110.66 cm) and NCH-1120 (102.86 cm) followed by SV1551HA (96.4 cm) and it was found the shortest (87.46 cm) in Pusa Jwala. Plant vigor was observed the lowest in Pusa Jwala which was different from other genotypes. The result showed that the maximum (4) vigor was found from all the tested genotypes except in Pusa Jwala with a score of 3.

The earliest (30 DAT) flowering (50% flowering after transplanting) was recorded from genotype NCH-1120 which was at par with SV2319HA (35 days) and SV4884HA (38 days). The genotypes which took longer period for 50% flowering were SV1947HA (47 days), SV1551HA (40 days) and Pusa Jwala (45 days).

Fruit weight, Number of fruits per plot and Yield

Variation on individual fruit weight among genotypes was observed (Table 4). The average fruit weight was maximum (5.11 g) for Pusa Jwala followed by SV1947 HA (3.93 g) and the minimum (1.87 g) individual fruit weight was recorded from genotypes SV2319 HA which is similar to the genotypes SV1551 HA (2.68 g), SV4884 HA (2.15 g) and NCH-1120(2.8 g).

Genotype variation for the number of fruits per plot

was observed to be significant. The highest (1506) number of fruits per plot was recorded from genotype NCH-1120 followed by SV1551 HA(921) which was at par with SV4884 HA (679.66), SV2319HA (630) and the lowest (96.33) from genotype SV1947HA which was similar with Pusa Jwala (186.66). Similarly, there were significant differences among the varieties on the yield. The highest (7.97 t/ha) yield was obtained from NCH-1120 and same level of yield was from genotypes SV1551HA (6.83 t/ha) which was followed by SV4884HA (4.02 t/ha), SV2319HA (2.39 t/ha), Pusa Jwala (2.05 t/ha) and the lowest (1.1 t/ha) yield was observed in SV1947HA genotype.

Table 4: Performance of hot pepper genotypes at Agricultural Research Directorate, Khajura planted in April planting, 2018.

Varieties	Plant height (cm)	Plant vigor (1-5)	Days to fifty% flowering (DAT)	Ind. Fruit weight (g)	No. of fruit per plot	Yield (t/ha)
SV1947HA	118.20^{a}	4^{a}	47^{a}	3.93^{b}	96.33^{d}	1.10^{c}
SV4884HA	118.60^{a}	3^{b}	38^{bcd}	2.15^{c}	679.66^{bc}	4.02^{b}
SV2319HA	110.66^{ab}	3^{b}	35^{cd}	1.87^{c}	630.00^{c}	2.39^{bc}
SV1551HA	96.40bc	3^{b}	40^{abc}	2.68^{c}	921.00^{b}	6.83^{a}
NCH-1120 (check)	102.86^{abc}	3^{b}	30^{d}	2.80^{c}	1506.00^{a}	7.97^{a}
Pusa Jwala (check)	87.46^{c}	3^{b}	45^{ab}	5.11^{a}	186.66^{d}	2.05^{c}
Grand Mean	105.7	3.16	39.16	3.09	669.94	4.06
SEM (±)	102.79	3.94	18	0.25	22159.86	0.89
$LSD_{0.05}$	18.44*	3.61***	7.71**	0.92***	270.81***	1.71***
CV%	9.59	6.27	10.83	16.45	22.22	23.26

Means within the column followed by the same letter are not significant different at 5 % level of significance by DMRT.

NS = Not Significant; *, **and *** = Significant at 0.05, 0.01 and <0.001 levels, respectively

Table 5: Days to first harvesting and last harvesting from the date of planting in the October and April Planting of hot pepper

	October 2017 Planting		April 2018 Planting	
Varieties	Days to first harvest (DAT)	Days to Last harvest (DAT)	Days to first harvest (DAT)	Days to last harvest (DAT)
SV1947HA	137	259	87	96
SV4884HA	137	253	80	106
SV2319HA	127	253	80	106
SV1551HA	127	259	87	106
NCH-1120 (check)	-	-	80	106
NS 1701	127	253	-	-
Pusa Jwala (check)	86	253	80	106

The days to first harvesting was longer for the October planting as compared to the April planting chilies (Table 5). But the harvesting period was much longer from October planting as compared to the April planting. The early harvesting was found for the Pusa Jwala (86 DAT) and late harvesting were recorded for the SV1947HA(137 DAT) and SV4884 HA (137 DAT) in the October planted hot pepper genotypes and the harvesting period reached upto the 253 to 259 DAT. However for the April planted hotpepper genotypes

the earliest harvesting were recorded 80 DAT for Pusa Jwala, NCH 1120, SV2319HA and SV48884 HA and the last date of harvesting were recorded for the SV1947HA (96 DAT) and 106 DAT for the remaining genotypes.

Discussion

Variations of different hot pepper genotypes for different parameters like number of fruits per plant, yield per plant, fruit length and diameter, pedicel length, numbers of seeds per fruit and maturity periods have been observed. The difference in fruit set in chilli is due to varietal characteristic and greatly influenced by environmental condition.Great variation were reported among chilli genotypes for flowering, fruit set, yield and other qualitative attributes under different agro climatic conditions (Wien et al., 189a; Rani, 1996; Gupta, 2003). Kawarkhe et al. (1989) studied sixteen chilli varieties and found maximum plant height (62.7 cm) in Malkapur local whereas the maximum number of primary branches and minimum plant height (44.33 cm) were observed in Pusa Jwala.

The difference in yield among the tested genotypes can be seen in both the growing season. Dahal (2005) found significant variation in marketable yield of hot pepper varieties from 7.73q/ha (CCC-984A) to90.69 q/ha (Mr. Lee No.3 Selex). Moreover, Bishwakarma (2006) also found similar result in yield of marketable red chilli from 4.57 t/ha (Suryamukhi) to 18.26 t/ ha (Soldier) during summer-spring crop season in Khajura, Banke, Nepal.

The variation in plant height was recorded among hot pepper genotypes in both growing season may be due to their varietal characteristics. Pandey et al. (1981) recorded 43.5 cm plant height and 12.2 cm fruit length from Pusa Jwala genotypes tested at Vegetable Research Farm, Haryana during 1976, 1977 and 1978.The variations in plant height among hot pepper genotypes were also recorded by Kawarkhe et al., (1989) and Dahal (2005).

Variations among genotypes were observed in both seasons. It may be due to the genetic characteristics as well as environmental factors. Plant height was found to be higher in all genotypes during April planted chilli than those of genotypes planted in October. It is due to the favorable temperature and growing condition for chilli which is supported by the climate data of Khajura (Table 1 and 2). Fruit set is decreased by temperatures below 16°C and above 32°C. Pungency is minimum in chilli fruit in low growth temperatures (Cotter, 1980), and high temperature reduces the fruit set % (Anand et al., 1992) and fruit size (AVRDC, 2003).

The short crop duration were recorded for the April planting of hotpepper genotypes. The yield reduction on the crop was due to the crop collapse because of the disease development in hot and heavy raining period. Among diseases, viral diseases are the most prevalent and followed by anthracnose in hot pepper (Yoon et al., 1989). The occurrences of diseases were more on the summer season planting. According to a report of (OECD, 2006), hot peppers are susceptible to fungi and the major fungal diseases in chilli are anthracnose (*Colletotrichum* spp.), early blight (*Alternaria solani*), Cercospora leaf spot (*Cercospora capsici*), damping-off/ seedling disease (*Pythium ,Rhizoctonia, Fusarium*, etc.), Fusarium stem rot (*Fusarium solani*), Phytophthora blight and root rot (*Phytophthora capsici*).

Conclusion

High yielding varieties are one of the important technologies to increase the productivity. Among the different evaluated genotypes, overall yield was high on normal season planted crop compared to the April planted. SV1947 HA was at par in terms of yield with the popular hybrid NS 1701 at normal season while SV1551HA yielded more during April planting. On the basis of our study, these high yielding varieties could be included in participatory varietal selection program and should also be tested in farmer's field at different season and across the location for their adaptability as well as for farmers' acceptance. Along with further validation in farmer's field, their marketable yield, nutritional value and post-harvest quality should be studied.

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Declaration of conflict of interest and ethical approval:

The authors declare no conflict of interest for publication of this manuscript.

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