Research Article

EVALUATION OF HEAT TOLERANT CHILLI (*Capsicum annuum* L.) GENOTYPES IN WESTERN TERAI OF NEPAL

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ABSTRACT

A field evaluation of thirteen chilli genotypes was conducted in 'Randomized Complete Block Design' with three replications to identify the most appropriate chilli genotypes at western terai of Nepal in spring summer of 2005. Ten heat resistant genotypes introduced from AVRDC, Taiwan to Nepal and three commercial cultivars of Nepal were planted at 50x30 cm spacing in paired row plot. All the management practices were carried out uniformly for all the treatments. Genotype CCA-119A was the earliest for 50% green fruit maturity. Fruit set percent varied significantly with the average of 18.81 %. Fruit length, fruit diameter and ascorbic acid content also varied greatly. Ascorbic acid content (mg/100 g) ranged from 32.86 in CCA-984A to 173.7 in NS-1701. Wide variations were observed in yield potential of the genotypes ranging total fruit number per plant from 5.61 to 71 and in total fruit yield 7.97 to 95.33 q/ha. The genotype Mr. Lee No. 3 selex produced maximum marketable fresh fruit yield (90.69 q/ha) which was 234.5 % higher than that of Jwala (check). Genotypes Susan's Joy, CCA-119A and CCA-3288 had also 122.98, 49.06 and 25.48 % higher marketable yield respectively than that of Jwala. Higher yield in genotypes Mr. Lee No. 3 selex and CCA-119A were found with better fruit set, better fruit size and more fruit number per plant while the genotype Susan's Joy and CCA-3288 had higher yield mainly due to their predominantly larger fruit size. The genotypes with better fruit set and larger fruit size were more appropriate for the hot and dry condition of western terai of Nepal.

Key words: Temperature, capsicum, fruit set, fruit number, pepper, yield

INTRODUCTION

Pungent peppers, commonly known as chillies (*Capsicum annuum* L.), are widely cultivated species from terai to mid hills of Nepal. It is mostly accepted as spice crop and it occupied fourth position as a spice crop with a productivity of 3.45 t/ha (MoAC, 2003/04). It is an integral component of every Nepalese kitchen. Both green and dried chillies are commonly used for various purposes but 80 % and 24 % of dry and green chillies respectively are being imported from India (Anonymous, 2004). The production is seasonal due to lack of appropriate cultivars and techniques. Early summer to early rainy season is the lean period of production. Prevailing high temperature, blowing of hot wind and shortage of soil moisture during early summer, and high temperature and excessive moisture during rainy summer are the major factors limiting its cultivation during summer and rainy months. Such condition induces the abscission of flower buds, flowers and young fruits which is the most important factors limiting the production of chilli (AVRDC, 1986). The principal environmental factor for the abscission is the extreme temperatures i.e. too low or high (Cochran, 1936; Rylski and Spigelman, 1982; Olarewaju, 1989; Erickson and Markhart, 2001). Western terai and inner terai region are distinguished with relatively drier and warmer climate than other parts of Nepal. Such conditions further aggravate the problems of flower and fruit drop and reduces fruit size, fruit number resulting into reduced yield (Srinivasa Rao and Bhatta, 1993). Studies on chilli genotypes revealed that great variation exists in ability to flowering, fruit set, yield and other qualitative attributes under different agro-climates (Wien *et al.*, 1989; Rani, 1996; Gupta, 2003). Fifty two germplasms collected at AVRDC are claimed for the heat resistant with high yield potential and better horticultural characteristics (Gniffke, 2004). There is an ample possibility to increase the productivity by introducing these germplasms. However all the genotypes do not perform equally to the entire region. Hence, the present study aimed to identify the most appropriate chilli genotypes suitable for western terai condition of Nepal for spring-summer season.

MATERIAL AND METHODS

The experiment was undertaken in the terai of the mid western development region of Nepal at Khajura, Banke during spring summer of 2005 using Randomized Complete Block Design with three replications and thirteen genotypes as treatments. Ten genotypes CCA-3331, CCA-336B, CCA-984A, Mr. Lee No. 3 selex, PBC-142, Maor, CCA-119A, CCA-3288, Susan's Joy and CO-5678 introduced from AVRDC, Taiwan and three commercial cultivars of Nepal Suryamukhi, NS-1701 (F_1) and Jwala (check) were planted at 50x30 cm spacing in paired row plot. A basal dose of 40 kg N, 60 kg P_2O_5 and 60 kg K_2O per hectare and FYM @ 3 kg/ m^2 was applied. In addition to basal dose, two side dressing each with 40 kg N/ha were applied on 35 and 75 days after transplanting (DAT). Fifty five days old seedlings were transplanted on 8th February 2005. All the inter-cultural operations were carried out uniformly when necessary and prophylactic sprays of Thiodion 35 EC @ 2 ml/litre of water were given at 15 days interval up to the flowering stage.

Phenological characters like number of days to 50 % plant flowering and 50 % green fruit maturity after transplanting were recorded from the twenty observable plants of each plot. Fruit set efficiency of each treatment was assessed by marking fifty flowers at full bloom stage and it was computed by using the formula [Fruit set %= number of set flowers x 100/ total no. of flowers marked]. Fruit length and diameter were recorded from the ten randomly selected green mature fruits during second harvest. Ascorbic acid content (mg/100 g fresh green mature fruit weight without peduncle) of each treatment was assessed through the titration method as followed by Kumar (1999). Fruits harvested from ten tagged plants of each treatment at each picking were categorized into marketable and unmarketable fruits and summed up separately over all pickings. Then, fruit numbers per plant, fruit yield (q/ha) and 100 fruit weight (g) were computed. Analysis of variance for all parameters was carried out as per the procedures given in MSTATC. Duncan's Multiple Range Test for mean separations was used at 5 % probability level as suggested by Gomez and Gomez (1984).

The perusal of weather data indicates that the crop flowering and fruiting period coupled with high temperature and low humidity stress condition. Average weekly maximum and minimum temperatures recorded during the crop period were 30.89^{0}C and 16^{0}C respectively. Average weekly rainfall was 0.92 mm throughout the crop period and relative humidity ranged from 45.67% (3rd week of April, 2005) to 95.99% (2nd week of January 2005).

RESULTS AND DISCUSSION

Phenological and fruit set characters

Days to 50 % plant flowering and 50 % green fruit maturity after transplanting indicate the earliness of crop which differed significantly (Table 1). The genotypes Suryamukhi, CO-5678, CCA-3288, PBC-142 and Susan's Joy required more number of days to 50 % plant flowering as compared to the grand mean (66.48 days). It seems that growth habit is also one of the important characters, which determines the earliness of the crop. In this study, genotypes Suryamukhi and CO-5678 having erect fruits in cluster required more number of days to 50 % plant flowering. Chaudhary (2004) also found earlier flowering in Jwala (pendent type) than in Suryamukhi (erect type).

Results showed that highly significant variation was observed in fruit set percent with overall mean of 18.81 %. Significantly higher fruit set percent was observed in Suryamukhi and CO-5678 which was followed by the genotypes Mr. Lee No. 3 selex and CCA-119A. Anand *et al.* (1992) also found lower fruit set percent in chilli during summer with the average of 30.3 % while in the main season it was 40.2 %. In this study, it was observed that the fruit set percent was higher in the genotypes bearing flowers in upright position. Chaudhary (2004) also reported higher fruit set percentage in Suryamukhi than in Jwala. Among the tested genotypes, CO-5678 and Suryamukhi beared the flowers on the apical part of the shoots that might be associated with better fruit set probably due to apical dominance. In addition, higher fruit set percent might be due to more convenient pollination in the short styled flowers and promotion of self pollination in the long styled flowers when passing the stigmas through the anther sacs in the erect flowers. Rylski (1986 cited in Anand *et al.* 1992) reported that the frequency of stigma protrusion was greater in small fruited chilli cultivars under high temperature condition. Rana and Kalloo (1992) also reported that number of fruits per plant varied depending upon the flower bearing habit in tomato.

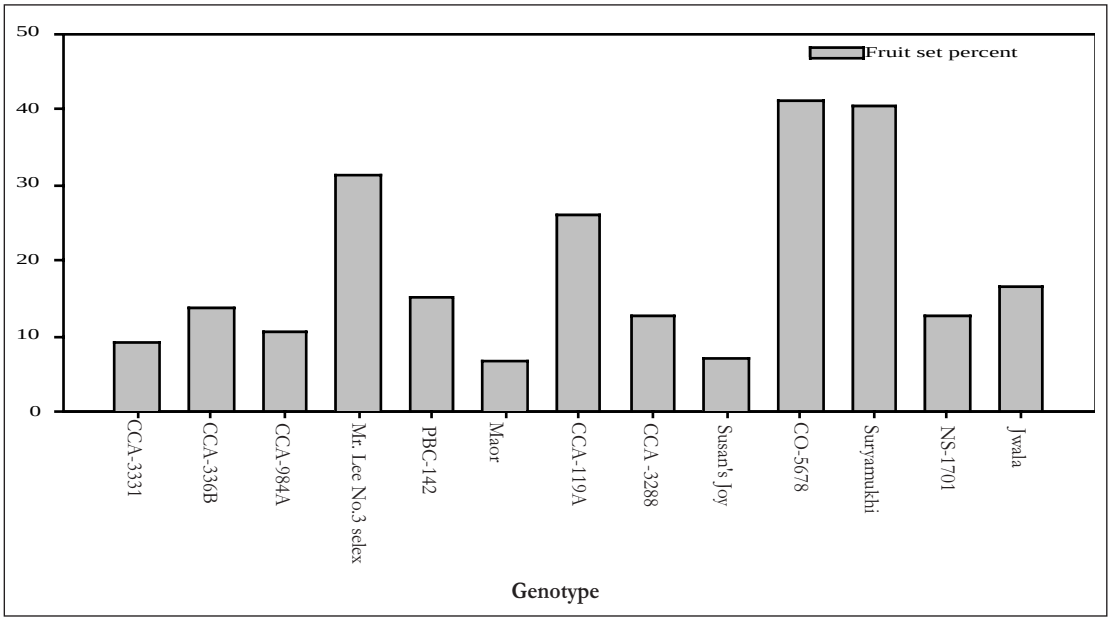

Figure 1. Distribution of fruit set percent in thirteen chilli genotypes under field conditions in spring-summer at Khajura, Banke, 2005

During intensive flowering and fruiting period weekly temperatures exceeding average weekly max./min. temperatures of 32/15^{0}C prevented fruit set in some genotypes. Kraikraun (1998) observed no fruit set in four hot pepper cvs. under prevailing high temperature (37-40^{0}C) whereas Erickson and Markhart (2001) noted that elevated temperature (33^{0}C) decreased fruit set but did not reduce the flower production. In this study, when the average weekly max/min temperature from 4th week of the May, 2005 exceeded 39.01/24.76+2.05^{0}C temperature then several genotypes could not bear even flowers. Hewitt and Curtis (1948) reported that high temperature increases respiration, decreases CHO level and prevents the flower production in tomato.

Table 1. Fruit set percent, fruit characters and ascorbic acid content (mg/100 g) of chilli genotypes tested at Khajura, Banke, Nepal in spring summer of 2005

SN	Genotype	Fruit Length (cm)	Fruit Diameter (cm)	100 marketable fruit wt. (g)	Ascorbic acid mg/100 g	Fruit set percent
1	CCA-3331	4.76^{de}	0.86e^{-g}	100.8^{ef}	136.3^{d}	9.33^{c-e}
2	CCA-336B	5.09^{de}	0.93d^{-g}	141.9^{c-e}	47.84^{h}	14.00^{c-e}
3	CCA-984A	6.20^{cd}	1.24^{b}	308.1^{b}	32.86^{i}	10.68^{c-e}
4	Mr. Lee No.3 selex	7.05^{bc}	1.18^{bc}	333.1^{b}	144.8^{c}	31.28^{b}
5	PBC-142	4.92^{de}	0.77^{g}	77.85^{f}	153.1^{b}	15.02^{cd}
6	Maor	4.62^{e}	1.04^{cd}	152.3^{cd}	166.4^{a}	6.66^{e}
7	CCA-119A	5.46^{de}	0.92d^{-g}	189.3^{c}	54.50^{h}	26.28^{b}
8	CCA -3288	7.85^{ab}	1.05^{cd}	295.1^{b}	75.71^{g}	12.66^{c-e}
9	Susan's Joy	8.52^{a}	1.60^{a}	499.6^{a}	85.70^{f}	7.33^{de}
10	CO-5678	4.64^{e}	1.00d^{e}	99.85^{ef}	93.74^{f}	41.33^{a}
11	Suryamukhi	4.37^{e}	0.94d^{-f}	110.6^{d-f}	90.41^{f}	40.66^{a}
12	NS-1701	7.64^{ab}	0.86e^{-g}	146.7^{c-e}	173.6^{a}	12.66^{c-e}
13	Jwala	5.50^{de}	0.80f^{g}	105.5^{d-f}	113.7^{e}	16.66^{c}
LSD (p=0.05)		1.29	0.15	43.99	7.89	7.25
S Em+		0.44	0.051	15.07	2.70	2.48

Means within the column followed by the same letter (s) do not differ significantly at 0.05 level by DMRT

Fruit characters and ascorbic acid

The longest and the widest fruits were recorded in Susan's Joy followed by CCA-3288 and CCA-984A. The genotypes Mr. Lee No. 3 selex had also significantly longer fruits than Jwala. It was found that the fruit length of Jwala (5.50 cm) and Susan's Joy (8.50 cm) were shorter than those reported by others. Kawarkhe *et al.* (1989) found maximum fruit length in Jwala (9.6 cm) than other studied. The genotype Susan's Joy had 17.5 cm fruit length during spring while it was 12.6 cm in summer at Taiwan (AVRDC, 2003). It reveals that the environmental condition influenced fruit size. Extremely high temperature and dry weather condition reduced the fruit size and quality. The hundred marketable fruit weight was the highest in the genotype Susan's Joy (499.6 g) followed by Mr. Lee No. 3 selex, CCA-984A and CCA-3288.

The great variation was observed in ascorbic acid content. Mean values were ranged from 32.86 mg/100g in CCA-3288 to 173.6 mg/100g in NS-1701 with an overall average of 105.28 mg/100g. Ascorbic acid content in NS-1701 was maximum and it was at par with Maor followed by PBC-142, Mr. Lee No. 3 selex and CCA-3331. The small sized fruit with thin pericarp contain more amount of ascorbic acid than the long and large fruits (Ananthaswami *et al.*, 1960; Deb *et al.*, 1963). In contrast to these findings, Mr. Lee No. 3 selex which had comparatively larger fruits and lower fruit dry weight percent but higher ascorbic acid content.

Fruit numbers per plant

The mean values of total number of fruits of tested genotypes ranged from 5.61 in CCA-984A to 71 in Jwala. Out of total number of fruits harvested per plant only 85.55 % were marketable. Number of marketable fruits per plant ranged from 5.4 (CCA-984A) to 61.37 (Mr. Lee No. 3 selex). In comparison to total fruit number and marketable fruit number per plant of Jwala and Mr. Lee No. 3 selex, it revealed that the Jwala had more number of unmarketable fruits per plant. Out of total number of fruits harvested, only 73.70 % fruits were marketable in NS-1701 while it was 96.71 % in CCA-3331. Similarly, the genotypes CCA-119A and Jwala had 78 % and 81.08 % marketable fruits, respectively, while Mr. Lee No. 3 selex had 88.99 %. It revealed that the genotypes NS-1701, CCA-119A and Jwala produced more number of unmarketable (diseased, sun scalded and dried) fruits as compared to others. Summer season studies conducted in Taiwan showed that the summer chilli fruits were shorter, narrower and lighter than those produced in the spring season and there was reduction in the marketable and total yields by 65 % and 63 % respectively in hot pepper (AVRDC, 2003).

Table 2. Mean fruit numbers per plant and fruit yields (q/ha) of chilli genotypes tested in spring-summer at Khajura, Banke, 2005

SN	Genotypes	Number of fruits per plant		Fruit yield (q/ha)	
		Marketable	Total	Marketable	Total
1	CCA-3331	51.67^{ab}	53.34^{b}	23.16^{ef}	23.63^{ef}
2	CCA-336B	36.27^{c}	39.90^{c}	23.07^{ef}	24.69^{ef}
3	CCA-984A	5.40^{e}	5.61^{d}	7.73^{h}	7.970^{g}
4	Mr. Lee No.3 selex	61.37^{a}	68.96^{a}	90.69^{a}	95.33^{a}
5	PBC-142	28.00^{cd}	33.62^{c}	9.81^{gh}	11.24^{g}
6	Maor	29.17^{cd}	36.46^{c}	20.46^{ef}	22.87^{ef}
7	CCA-119A	48.17^{b}	61.76^{ab}	40.41^{c}	45.68^{c}
8	CCA -3288	25.33^{d}	28.86^{c}	34.02^{cd}	35.72^{d}
9	Susan's Joy	27.17^{cd}	29.78^{c}	60.45^{b}	64.23^{b}
10	CO-5678	53.50^{ab}	63.30^{ab}	23.77^{ef}	25.76^{ef}
11	Suryamukhi	30.17^{cd}	37.85^{c}	15.17^{f-h}	17.00^{fg}
12	NS-1701	28.30^{cd}	38.40^{c}	18.22^{e-g}	21.26^{ef}
13	Jwala	57.57^{ab}	71.00^{a}	27.11^{de}	30.62^{de}
	LSD (p=0.05)	9.266	10.20	8.758	8.834
	S Em+	3.175	3.49	3.001	3.026

Means within the column followed by the same letter (s) do not differ significantly at 0.05 level by DMRT

Fruit yields

The total and marketable fruit yields were maximum in the genotype Mr. Lee No. 3 selex. The minimum yield was recorded in CCA-984A (7.97 q/ha). The scrutiny of data revealed that the four genotypes Mr. Lee No. 3 selex, Susan's Joy, CCA-119A and CCA-3288 produced 234.5 %, 122.98 %, 49.06 % and 25.48 % higher marketable yield than that of Jwala. The commercial cultivars NS-1701 and Suryamukhi produced even lower yield than Jwala. Mean data presented in Table 2 clearly showed that total fruit yield and marketable fruit yield had similar pattern of variation among the genotypes. The fruit weight mainly determined the yield than the fruit number in the tested genotypes.

Rani (1996) found that the high temperature adopted varieties yielded 48.01 % more yield than Jwala. In this study, the yield of all genotypes was lower as compared to normal season crops. Genotypes like CCA-984A and CCA-336B were observed with drying of buds which could not develop even sufficient number of flowers when temperature increased above 32^0C which caused tremendous reduction in the fruit yield. High temperature, long drought period and blowing of hot wind during flowering and fruiting period severely affected the fruit set and fruit size. It was observed that the temperature above 40^0C adversely affected flower and fruit development in most of the chilli genotypes.

CONCLUSIONS

The chilli genotypes varied greatly in major phenological characters, fruit set efficiency, yield and its quality under hot and dry condition of western terai of Nepal. Mr. Lee No. 3 selex and Susan's Joy showed outstanding performance in terms of total yield, marketable yield and fruit size during extreme hot and dry condition. Besides these, genotypes CCA-119A and CCA-3288 also had higher marketable and total yield than that of Jwala (check cv.). These varieties had also far better yield in comparison to the commercial cultivars Suryamukhi and NS-1701 (F_1). So, it is concluded that chilli yield can be promoted by using heat tolerant chilli cultivars during spring-summer season under the western terai condition of Nepal.

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