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Genotypic response to heat stress tolerance in brinjal (*Solanum melongena* L.)

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Abstract

The experiment was conducted out at Vegetable Experimental Area, Department of Vegetable Science, Punjab Agricultural University, Ludhiana. Sixty three brinjal genotypes were evaluated for heat stress tolerance during summer and rainy season. Ten characters were analyzed and had shown significant differences for all traits during both the seasons. Among all genotypes, high yield was observed in BL205, BL215, BR123, BL201 and BL214 during summer and G414, BL222, BR104, BR102 and S331 during rainy season. The lowest yield was observed in BL223, BL219 and BR119 during summer season. Genotypes showed 50% flowering in less than 25 days after transplanting were SR318, SR305 and GL403. Reduction in pollen fertility causes flower drop, fruit drop and lower the fruit yield at high temperature. Among all, BL205, BL215 and BR123 showed minimum seasonal differences for yield due to high pollen viability and fruit setting. Thus, these genotypes can further be exploited during summer season *per se* or by involving in breeding programme.

Keywords: Eggplant, genotypes, heat stress, tolerance

Introduction

Temperature is one of the most critical factor affecting growth and development of the plants. Worldwide, extensive agricultural losses are attributed to heat and often in combination of drought and other abiotic stresses (Mittler 2006). The response of plant to heat stress is complex and depends upon the signal that flow information to sense the change in surrounding environment and induces the gene expressions accordingly (Kotak et al 2007). The growth of brinjal is most optimum, when temperature ranges between 20-30 °C, but often decline during summer months when temperature increases above optimum range. However, summer months (April-June) are hot, dry, and temperature remains above 35°C with low relative humidity (30-45%). In brinjal, a marked reduction in yield has been observed with high night (22-24 °C) and day (33-39 °C) temperature (Mohanty and Prusty 2000, Thapa 2002). The rate of fruit setting reported to decrease with increasing average maximum temperature and higher precipitation during first 5 days of anthesis (Sun et al 1990). Lombardi and Restaino (1981) observed influence of both temperature and genotype on anthesis, but the fruit set was affected more by genotype. Warner and Erwin (2005) observed natural variation for floral bud abortion at high temperature in *Arabidopsis thalianin*. Therefore, brinjal genotypes were evaluated for heat stress tolerance in this experiment.

Material and Methods

This study was conducted at Vegetable Research Farm, Department of Vegetable Science, Punjab Agricultural University, Ludhiana, a total of 63 genotypes were evaluated for 10 characters in a Randomized Block Design (RBD) with three replications during summer and rainy seasons. The seeds were sown during sown summer (stress condition) in 1st week of March and rainy (favorable condition) during 2nd week of June. Seedlings were transplanted at spacing of 60 cm x 30 cm. All recommended cultural practices were followed to raise a healthy crop. The data was recorded for the agronomic traits, such as plant height, plant spread, days to 50% flowering, number of flowers per inflorescence, pollen viability, fruit setting, fruit weight, seeds per fruit, fruits per plant and fruit yield per plant. Observations were recorded from seven plants selected randomly in each genotype. All analyzes were performed with the computer software CPCS 1 developed by Singh and Cheema (1985). Quantitative effect of seasonal heat stress differences (summer vis-a-vis rainy) were obtained in percentage as per method suggested by Wardlaw et al (1989): $\% S = 100 [1 - (P_v / P_i)]$

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Where, P_v and P_i are the mean of each genotype, experiments in summer and rainy, respectively, for each of the characters. Subsequently, the genotypes were sorted out in ascending order as to their percentage of seasonal difference (% S).

Results and Discussion

The analyzes of variance showed significant difference among genotypes for all traits, both for in rainy and summer season, which show that genetic variability for these traits in the two environments evaluated (Table 1), whereas the means squares due to replications were non-significant for all the characters during both the seasons. The means squares due to genotypes were highly significant for all other characters except days to 50% flowering and fruit setting. The means squares due to genotype x environment interactions were observed highly significant except days to 50% flowering, flowers per inflorescence and fruit setting. Hence, high degree of genetic variability was recorded in the evaluated genotypes during summer and rainy seasons. Yield is the prime objective of a breeding programme, which depends on the number of traits such as plant height, plant spread, days to 50% flowering, number of flowers per inflorescence, pollen viability, fruit setting, fruit weight, seeds per fruit and fruits per plant. There was huge variability in the genotypes during both the seasons of experiment, which indicated the scope for improvement of total yield.

Significant differences were observed for all the 10 traits during both seasons of brinjal cultivation. Out of 63 evaluated genotypes for different traits, mean performance of the top most 10 have been given in Table 2. Plant height is one of the most important growth parameters in brinjal. The data showed that plants under summer season grow tall (141.67 cm) than the rainy season (116.22 cm). Higher plant height during summer season may be due to longer period for vegetative growth and unfavorable conditions for reproduction or fruit setting duration during hot summer months in Punjab. Whereas, plant spread was range was 49.33 to 127.78 cm during summer and 44.89 to 133.78 cm during rainy season. The earliest genotypes that had come to 50% flowering in less than 25 days after transplanting were SR318 (21.67), SR305 (24) and GL403 (24.67). The days to 50% flowering was early during summer season (21.67-59.67 days) and late during rainy season (32.67-65.33 days). The difference in flowering during rainy and summer season may be due to difference in effective accumulative temperature (EAT) required for inducing flowering. Since, the prevailing temperature during rainy season (July-Dec) is in decreasing order and *vice versa*

Table 1: Analysis of variance of different characters in brinjal genotypes

Character	Mean sum of square					F ratio			
	Rep.	E	G	E x G	Error	Rep.	E	G	E x G
Plant height (cm)	200.09	18309.77	1287.77	295.67	10.68	18.72	1713.13**	120.49**	27.66*
Plant spread (cm)	101.21	1756.02	1581.40	495.91	11.69	8.65	150.10**	135.17**	42.39*
Days to 50% flowering	77.36	3000.61	208.12	111.73	13.08	5.91	229.31**	15.91	8.54
Flowers per inflorescence	0.18	78.22	11.35	1.87	0.11	1.75	726.58**	105.49**	17.43
Pollen viability (%)	73.63	44774.14	709.62	670.38	14.78	4.98	3028.02**	47.99*	45.34*
Fruit setting (%)	142.14	62100.57	592.14	601.94	43.06	3.3	1442.09**	13.75	13.98
Fruit weight (g)	310.24	870911.90	19009.78	7455.16	156.55	1.98	5562.98**	121.43**	47.62*
Seeds per fruit	1351.24	17642740	420514.2	175307.5	2628.41	0.51	6712.34**	159.99**	66.70*
Fruits per plant	4.07	4108.17	333.45	95.13	1.72	2.36	2379.37**	193.13**	55.10*
Fruit yield per plant (g)	5353.39	130928900	533822.4	586137.8	6442.74	0.83	20321.92**	82.86*	90.98*

*, ** Significant at 5% and 1% level respectively

Rep-Replications, E- Environment, G- Genotypes, E x G- Environment x Genotype interaction

Table 2: Mean performance of the top 10 comparative heat tolerant and 3 most heat susceptible genotypes of brinjal.

Genotype	Plant height (cm)		Plant spread (cm)		Days to 50% flowering		Flowers/ inflorescence		Pollen viability (%)		Fruit setting (%)		Fruit weight (g)		Seeds per fruit		Fruits per plant		Fruit yield per plant (g)		
	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	S (%)
BL205	96.55	70.11	92.00	90.11	38.67	41.67	3.78	5.11	88.83	97.50	63.33	73.33	40.00	152.33	211.27	894.33	32.27	13.86	1253.00	1691.33	-25.92
BL215	86.66	56.78	89.22	68.56	42.33	47.67	3.78	4.67	92.37	94.30	70.00	83.33	46.33	43.00	151.33	345.77	22.90	31.26	908.50	1212.83	-25.09
BR123	101.22	73.55	97.11	87.78	38.00	42.67	1.00	1.11	57.77	90.77	50.00	83.33	110.00	181.50	606.33	828.33	7.93	8.79	881.00	1283.33	-31.35
BL201	92.66	73.78	93.66	97.56	30.33	42.67	3.56	5.67	65.00	96.50	53.33	46.67	78.33	131.50	403.83	698.83	11.80	12.99	861.33	1472.83	-41.52
BL214	84.33	60.67	77.11	65.66	39.67	54.67	2.11	1.78	84.77	95.27	63.33	63.33	57.00	270.33	297.33	613.33	16.74	10.00	780.33	1416.83	-44.92
BL203	114.11	79.78	94.11	103.78	33.33	50.00	2.78	3.89	73.10	95.40	50.00	83.33	89.33	225.33	529.27	1010.60	12.89	13.86	779.67	2117.33	-63.18
S333	91.77	56.44	65.33	50.44	30.67	40.67	3.89	5.44	91.13	96.80	60.00	83.33	28.00	37.33	364.50	514.00	27.23	50.63	731.33	1821.17	-59.84
SR310	91.55	74.56	103.33	79.78	43.00	44.00	3.33	5.67	69.43	96.80	50.00	75.00	48.33	101.00	539.67	685.17	18.88	22.00	711.67	1736.83	-59.02
G409	98.78	81.22	96.56	90.11	44.33	45.67	2.78	4.44	76.37	70.67	50.00	66.67	36.83	112.67	242.83	918.67	20.16	18.06	676.00	1603.83	-57.85
SR301	83.33	62.44	79.00	65.44	34.00	44.67	3.00	4.89	55.37	92.07	50.00	83.33	32.00	44.67	357.33	433.33	21.44	28.73	652.33	1145.00	-43.03
BL223	88.55	84.56	92.11	86.55	59.67	43.33	2.33	7.67	11.60	93.87	10.00	83.33	12.33	69.00	39.50	383.67	1.04	24.84	13.50	1384.00	-99.02
BL219	86.11	63.56	84.89	73.11	59.33	41.00	2.78	5.67	12.87	97.07	13.33	73.33	15.33	83.83	23.00	644.08	1.07	24.80	16.50	1865.00	-99.12
BR119	102.44	93.44	127.78	100.44	57.67	48.00	1.11	1.11	12.23	91.70	16.67	83.33	19.17	312.33	39.33	1508.83	1.13	8.55	21.67	2124.33	-98.98

G-Genotypes, I-Summer season, II-Rainy Season, S (%)-Seasonal difference

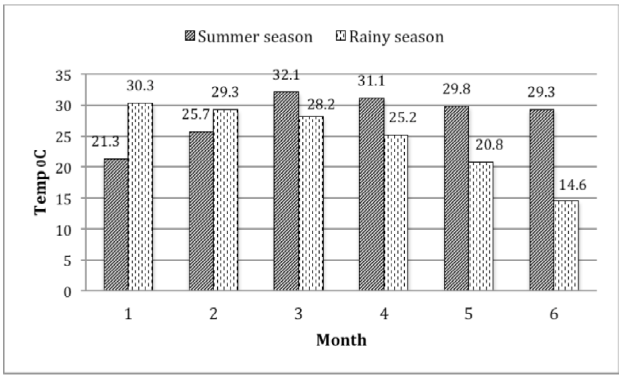

Fig. 1: Temperature difference during summer and rainy seasons (crop period)

during second season (March- June) (Fig.1). Mohanty *et al* (2002) also reported seasonal differences for days to flowering, as it was early during the summer season (41.86 days) and late during winter (91.13 days).

The number of flowers per inflorescence observed during summer season was less with a range 1 to 3.89, whereas 1 to 7.67 during rainy season. The genotypes possessing more number of flowers per inflorescence at high temperature (summer season) indicates inherent ability to heat tolerance. The fruit setting and pollen viability was recorded high in BR104 (61.7, 96.0), S333 (71.7, 93.9) and BL215 (76.7, 93.3) during both the seasons, respectively. High pollen viability and fruit setting during rainy season was due to favorable conditions prevailed during flowering month, while during summer season, although conditions are favorable for vegetative growth, but not for fruit setting. Significant decreased in pollen viability was observed along with decrease in pollen grains production, pollen grain release and *in vitro* pollen germination of different tomato genotypes (Soylu and Comlekcioglu 2009). Levy et al. (2007) observed that fruit set varied between 77.3–16.3 % in the heat tolerant and heat sensitive genotypes of tomato, respectively. According to them, the characters contributing to low fruit set were the bud drop and reduction in the quantity and functionality of the gametes. Reddy *et al* (1989) also reported that all the accessions showed poor performance with respect to weight per fruit due to high temperature conditions in tomato. Maximum fruits per plant were observed in BL205 (32.27), S333 (27.23) and SR322 (25.66) during summer and in S333 (50.63), SR318 (40.24) and SR305 (36.45) during rainy season. The genotype possessing more number of fruits per plant at high temperature (summer season) is an indication of inherent heat tolerance ability. As hot and dry months of summer causes reduction in pollen viability and ultimately fruit setting and number of fruits per plant. Whereas, it was in contrast during rainy season as a result fruit number were more. Least fluctuation due to season on fruits per plant was observed in SWR230-4 and BL203. Maximum seeds per fruit were counted in BR115 (1229.33) during summer and WL503 (1775.67) during rainy season.

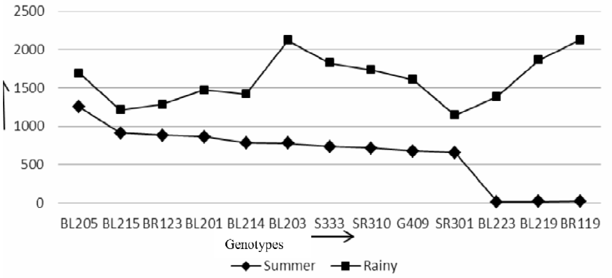

Fig. 2: Comparison of fruit yield/plant during summer and rainy season

The fruit yield during summer season was observed lower in all the genotypes as compared to genotypes during rainy season (Fig.2). The top five ranked genotypes in terms of fruit yield per plant in descending order were BL205 (1253 g), BL215 (908.5 g), BR123 (881 g), BL201 (861.33 g) and BL214 (780.33 g) during summer season whereas, G414 (2804.33 g), BL222 (2787.83 g), BR104 (2476.33 g), BR102 (2448.83 g) and S331 (2442.83 g) during rainy season. Genotypes BL223, BL219 and BR119 were observed most sensitive to heat due to lowest yield during summer season. The seasonal differences were minimum in BL205, BL215 and G418 for yield by the growing conditions. The highest fruit yield obtained during rainy season may be due to high fruit weight, increase in fruit set and more number of fruits per plant due to high pollen viability. While the lower fruit yield recorded during summer season may be due to vice-versa effects as explained above. Peet et al. (1997) also showed that fruit set of tomato decreased under high temperature and caused significant reduction in fruit yield.

Conclusion

In present study, out of 63 genotypes BL205, BL215 and BR123 gave maximum yield during summer due to high pollen viability, fruit setting, fruits per plant and fruit weight, whereas, BL223, BL219 and BR119 lowest yield. Thus, genotypes BL205, BL215 and BR123 can be evaluated further to release as heat tolerant varieties or can be involved in breeding programme to get transgressive segregants to cope with changing climate.

सारांश

बैंगन की 60 प्रभेदों का ताप प्रतिबल सहनशीलता के प्रति मूल्यांकन ग्रीष्म एवं वर्षा काल में सब्जी विज्ञान विभाग, पंजाब कृषि विश्वविद्यालय लुधियाना, पंजाब में किया गया। कुल 10 घटकों का विश्लेषण किया

गया जिसमें ग्रीष्म एवं वर्षा काल में सार्थक विभिन्नता पायी गयी। सभी प्रभेदों में अधिक उपज वाले प्रभेदों जैसे बी.एल.–205, बी.एल.–215, बी.आर.–123, बी.एल.–201 तथा बी.एल.–214 ग्रीष्म काल में तथा जी.–414, बी.एल.–222, बी.आर.–104, बी.आर.–102 तथा एस.–331 वर्षा काल में अधिक उपज प्रदान किये। निम्नतम उपज प्रभेद बी.एल.–223, बी.एल.–219 तथा बी.आर.–119 ग्रीष्म काल में पाया गया। पौध रोपण के मात्र 25 दिनों में 50 प्रतिशत पुष्पन करने वाली प्रभेदों में एस.आर.–318, एस.आर.–305 व जी.एल. 403 प्रमुख थी। परागकण की उर्वरता की कमी से पुष्प का झड़ना, फल का गिरना व कम फल का बनना उच्च तापमान पर पाया गया। सभी प्रभेदों में बी.एल.–205, बी.एल.–215 व बी.आर.–123 में अधिक परागकण जीवन क्षमता व फल धारण के कारण निम्नतम मौसम विविधता उपज के प्रति पायी गयी। इस प्रकार इन सभी प्रभेदों का ग्रीष्म काल में उपयोग किया जा सकता है अथवा प्रजनन में सम्मिलित कर सकते हैं।

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