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Original Research Article

Estimate of Heterosis and *Per Se* Performance of Tomato F1 Hybrids for Leaf Curl Virus Resistance

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A B S T R A C T

Tomato is one of the most important fruit vegetable grown throughout the world. The successful cultivation of tomato is hampered by attacking several pest and disease. Leaf curl virus is one of the serious viral diseases of tomato. Managing the disease with pesticides has been a difficult task because of the rapid development of pest resistance to most insecticides. The experiment estimate of heterosis and *per se* performance of tomato F1 hybrids for leaf curl virus resistance was conducted at Department of Vegetable Crops, Tamil Nadu Agricultural University, Coimbatore during summer season. The experiment was laid out in a randomized block design and replicated thrice. The results revealed that significant difference was noticed between parents and hybrids for plant height, number of branches per plant, number of fruits per plant, total soluble solid salts, titrable acidity, ascorbic acid content, fruit weight, yield per plant, per cent of disease infection at 60 DAP, co efficient of infection at 60 DAP, total phenol content, peroxidase activity and poly phenol oxidase activity. The hybrid CLN 2123A X HN2, HN2 X CLN 2123A and LCR2 X CLN 2123A recorded higher per se values for plant height, number of branches per plant, number of fruits per plant, TSS, titrable acidity, ascorbic acid content, total phenol content in leaves, peroxidase activity, poly phenol oxidase activity and yield per plant. The hybrid HN2 X CLN 2123A excelled the check hybrid Lakshmi for the traits number of branches per plant, number of fruits per plant, TSS, ascorbic acid content and yield per plant indicated the superiority of the F1 hybrid. Similarly the same hybrids also registered low per se values for TLCV incidence. The hybrid CLN 2123A X HN2, HN2 X CLN 2123A and LCR2 X CLN 2123A is a product of high x low and low x high per se values for all the traits of the present study suggested that additive x dominance and dominance x additive type gene action plays a key role. The hybrid HN2 X CLN 2123A recorded positive and significant standard heterosis for the traits number of branches per plant, number of fruits per plant, TSS, ascorbic acid content and yield per plant.

Keywords

Tomato, LCV, Yield, *Per se*, Heterosis.

Introduction

Tomato (*Solanum lycopersicum* L. Mill) is the second most important vegetable crop in the world and is grown practically throughout India. India is the second top tomato growing country after China contributed about 11percent of the world tomato production (Anonymous, 2011). Tomato is mainly consumed as salad, cooked or processed into several preferred by products like ketchup, juice, puree, sauce and whole canned fruit. Tomato is a rich source of antioxidants (mainly lycopene and β-carotene), Vitamin A, Vitamin C and minerals like Ca, P and Fe in diet (Saleem *et al.*, 2013). Leaf curl virus is a serious disease of tomato and its incidence can

reach up to 100percent with yield losses often exceeding 90 percent (Saikia and Muniyappa, 1989). Tomato cultivation, especially in autumn season in North India and in summer season in South India is adversely affected due to high incidence of TLCV. The disease is caused by different species of genus Begomovirus (Family Geminiviridae), which are transmitted by whitefly (*Bemisia tabaci* Genn.). Managing the disease with pesticides has been a difficult task because of the rapid development of pest resistance to most insecticides (Horowitz *et al.,* 2005). In recent years, the hybrid cultivars of tomato have become very popular with the growers due to their superior *per se* performance, which is manifested due to better plant vigour, faster growth and development, earliness, increased productivity and higher levels of resistance to biotic and abiotic stresses (Yordanov, 1983). Choice of parents for hybridization is one of the critical and most important tasks for plant breeders. The common approach for selecting the parents based on *per se* performance does not necessarily lead to desired results. Heterosis studies are prerequisite in any plant breeding programme, which provides the desired information regarding the varietal improvement or exploiting heterosis for commercial purposes.

Materials and Methods

The experiment was conducted at Department of Vegetable Crops, Tamil Nadu Agricultural University, Coimbatore during summer season (March-June, 2007 and 2008). The experiment material consisted of three hybrids *viz*., CLN 2123A X HN2, HN2 X CLN 2123A and LCR2 X CLN 2123A obtained through diallele mating system, their parents *viz*., CLN 2123A, HN2 and LCR 2, check variety CO3, Hisar Lalit and check hybrid Lakshmi (A private hybrid resistant to LCV from Nunhem seeds, Hyderabad). Twenty five days old healthy seedlings of The F1 hybrids were transplanted in the field at a spacing of 60cm x 60cm along with their parents and check variety and hybrids. All the cultural practices were followed as per the recommendations in Package of Practices for Vegetable Crops (Anonymous, 2013a). To increase inoculum pressure, one row of TLCV susceptible cv. CO 3 was planted after every fifth row of the experimental plots. Plants were examined at weekly intervals for TLCV symptoms and recorded at 60 DAP. Disease spread and the severity of symptoms were recorded according to the disease severity scale described by Muniyappa *et al.,* (1991). The experiment was laid out in a Randomized Block Design and replicated thrice. Biometrical observations *viz*., plant height (cm), number of branches per plant, number of fruits per plant, TSS (^{o}brix), titrable acidity (%), ascorbic acid content (mg per 100 g of fruits), fruit weight (g), yield per plant (g), per cent of disease infection at 60 DAP, Co efficient of infection at 60 DAP, total phenol content (mg/g of leaves), peroxidase activity (changes in OD per mimutes per g of leaves) and polyphenol oxidase activity (changes in OD per mimutes per g of leaves) were taken from randomly selected ten plants and are subjected statistical analysis as suggested by Panse and Sukhatme (1976).

Results and Discussion

Significant difference was noticed between parents and hybrids for plant height, number of branches per plant, number of fruits per plant, total soluble solid salts, titrable acidity, ascorbic acid content, fruit weight, yield per plant, per cent of disease infection at 60 DAP, co efficient of infection at 60 DAP, total phenol content, peroxidase

activity and poly phenol oxidase activity. Regarding plant height the highest value of 134.03 was recorded by check hybrid Lakshmi. It was followed by the F1 hybrids HN2 X CLN 2123 A (127.86cm) and CLN 21123A X HN2 (127.30cm) and LCR2 X CLN 2123A (122.30cm). It was also observed that the two hybrids were on par with TLCV resistant check Lakshmi a hybrid of private company. The lowest plant height values of 72.36cm, 77.86cm and 94.33cm were recorded by CO 3, LCR2 and HN2 respectively. The hybrid HN2 X CLN 2123 A (14.20) recorded the highest number of branches per plant and it was closely followed by CLN 2123A X HN2 (13.73), Hisar Lalit (12.20) and Laksmi (12.10). The susceptible check Co3, the parents LCR2 and HN2 recorded the lowest number of branches per plant. The lowest plant height and number of branches per plant registered by these genotypes might be attributed due to the increase in temperature when most of the photo assimilates are utilized for increased rate of respiration, which might have led to considerable reduction in photosynthetic pigments there by affecting the crop growth. However the two synthesized hybrids *viz*., CLN 2123 A X HN2 and HN2 X CLN 2123 A showed significant increase in plant height and number of branches when compared to check varieties which might be due to the involvement of the parent CLN 2123 A. Since this parent CLN 2123A obtained genes from *hirsutum* blood which has more number of branches per plant. Similar results also made by Makesh (2004).

Number of fruits per plant, an important yield component is closely linked with yield. Based on the *per se* performance the newly synthesized hybrids CLN 2123 A X HN2 (49.09) and HN2 X CLN 2123 A (53.07) recorded the highest number of fruits per plant. For this trait both the hybrids were excelled the TLCV resistant hybrid Lakshmi (41.86) might be due to the involvement of the parent CLN 2123 A (41.88). The genes from heat tolerant line would have transgressed into CLN 2123A, which showed some amount of heat tolerance in this experiment. There was no much difference observed with direct and reciprocal crosses for the trait fruit weight (Table 1). However, both the hybrids recorded less fruit weight than better parent HN2. In tomato the dominance operates in negative direction as far as fruit size is concerned and this has been found to be true in the present study also. With respect to yield per plant both the hybrids excelled over their parents. Among the parents CLN 2123 A was found to have more yield than HN2. The results showed the presence of over dominant genes in the hybrids, which excelled the better parent HN2. Further these hybrids registered higher number of fruits per plant would have also resulted higher yield per plant. However, the two synthesized hybrids recorded the least TLCV and registered the highest per plant yield when compared to their parents and check varieties indicating the superior performance of these crosses.

Regarding TSS, titrable acidity and ascorbic acid content of fruits the parent HN2 (5.13 ^{o}brix, 0.70 per cent and 33.33 mg/g of fruits) had higher *per se* value than CLN 2123 A (4.63^{o}brix, 0.60 per cent and 29.66 mg/g of fruits). Between the two hybrids the reciprocal cross HN2 X CLN 2123 A showed higher TSS (5.36 ^{o}brix), titrable acidity (0.76 percent) and ascorbic acid (37.00 mg/g of fruits) and excelled both the parents. This might be due to over dominance of genes contributed by the female parent. Involvement high performing parent HN2 is the major reason for high TSS, titrable acidity and ascorbic acid content observed in the hybrid HN2 X CLN

2123 A. The results of the present study suggested that cytoplasmic genes contributed by HN2 would have resulted in increased TSS, titrable acidity and ascorbic acid. These findings are in line with the findings of Makesh (2004). In the present study it was also noticed that the two synthesized hybrids excelled private hybrid Lakshmi for these traits. These results are in line with the findings of Nainar (1996), Sankari (2000), Kalloo and Banarjee (2000), Thangam (2004), Makesh (2004) and Sriharsha (2004).

In respect to TLCV incidence, percent of disease infection at 60 DAP and co efficient of infection at 60 DAP revealed that both the hybrids CLN 2123 A X HN2 (7.93 and 3.96) and HN2 X CLN 2123 A (9.88 and 6.42) registered the lowest *per se*. Among the parents CLN 2123 A (9.41 and 4.70) had less TLCV incidence. The least incidence of TLCV observed by CLN 2123A suggested that it is a potential donor for imparting resistance to TLCV and it can be used for further breeding programme. The parent CLN 2123A involved in these crosses has imparted stable resistance which resulted less TLCV incidence in hybrids. Among the checks Lakshmi (11.42 and 5.00) showed less TLCV incidence and the susceptible check Co 3 (36.90 and 47.49) and the parent HN2 (37.76 and 64.32) recorded the highest incidence of TLCV (Kalloo and Banerjee, 2000). The total phenol content in leaves indicates the degree of resistance to any disease. According to Harborne (1960), phenolic compounds have a role in interfering the multiplication of virus. The two hybrids CLN 2123 A X HN2 and HN2 X CLN 2123A registered the highest total phenol content in leaves. Among the parents CLN 2123A registered high amount of total phenol content in leaves than HN2. The TLCV resistant hybrid Lakshmi registered the highest total phenol content in leaves and it was on par with the two test hybrids. Corroborative results were also given by Sriharsha (2004). The two crosses recorded higher leaf phenol content than the susceptible check CO 3 and on par with TLCV resistant check Lakshmi. Increase in peroxidase and polyphenol oxidase activity in leaves of plants was found to be a resistant mechanism to leaf curl virus. The parent CLN 2123A was found to have high *per se* than the other parent HN2. However, the hybrids *viz*., HN2 x CLN 2123A and CLN2123A x HN2 expressed higher *per se* for peroxidase and polyphenol oxidase activity than the both the parents indicating the existence of heterobeltiosis.

When the hybrids were analyzed for heterosis it was pronounced well among the hybrids. The two hybrids CLN 2123 A X HN2 (19.42 and 7.09) and HN2 X CLN 2123 A (19.95 and 7.57) showed positive and highly significant relative heterosis and heterobeltiosis values for the traits plant height and number of branches per plant. This combination is a result of high x low and low x high performing parents suggested the involvement of high performing parents CLN 2123 A might have resulted in increased plant height and number of branches per plant. Similarly the two hybrids excelled TLCV resistant check hybrid Lakshmi for the trait number of branches per plant inferred superiority of F1 hybrids (Table 2). Higher number of branches per plant by CLN 2123 A might be due to this parent obtained genes from *hirsutum* blood which has more number of branches per plant. Heterosis for number of branches per plant was also reported by Sidhu *et al.,* (1981) and Prema (1989). Heterosis estimates for the trait number of fruits per plant of the two synthesized hybrids showed that these two hybrids registered positive and significant heterosis for all the three bases of heterosis might be

due to the involvement of the parent CLN 2123 A. Sidhu *et al.*, (1981) also reported over dominance nature of gene action in tomato for number of fruits per plant. The hybrids CLN 2123 A X HN2 and HN2 X CLN 2123 A expressed positive heterosis in all the three bases of the heterosis indicating the superiority of the donors for improving this trait. These hybrids are the product of high x low and low x high *per se* suggesting additive x dominant and dominant x additive type of gene interaction. With regard to heterosis for TSS and titrable acidity the hybrid HN2 X CLN 2123 A showed positive and significant heterosis for all the three bases of heterosis indicating the superiority of the donors for improving this trait. Further the hybrid involving HN2 as ovule parent recorded positive heterosis might be due to the maternal effect. Similar type of results was also opined by Sriharsha (2004). This hybrid also registered positive significant heterosis over TLCV resistant hybrid Lakshmi for these traits. Regard to heterosis for ascorbic acid content the reciprocal cross HN2 X CLN 2123 A showed positive heterosis in all the three bases of heterosis.

This hybrid also registered positive significant heterosis over private hybrid Lakshmi. The hybrid CLN 2123A x HN2 represents low x high *per se* and HN2 x CLN 2123A represents high x low *per se* suggesting the role of dominant x additive and additive x dominant type of gene interaction. For the traits TSS and titrable acidity both the crosses excelled all the check variety/hybrids.

Negative estimate heterosis for disease resistance is preferred. In the present experiment the newly synthesized hybrids CLN 2123 A X HN2 and HN2 X CLN 2123 A showed significant and negative relative heterosis (-66.37 and -58.11), heterobeltiosis (-78.99 and -73.83) and standard heterosis (-30.06 and -13.49) for the trait per cent of disease infection at 60 DAP and Co-efficient of infection at 60 DAP (-88.51 and -81.38-di, -93.83 and-90.01-dii and -20.80 and -28.40-diii). The hybrids are the product of high X low and low X high *per se* suggesting the role of dominant x additive and additive x dominant type of gene interaction. The hybrids CLN 2123 A X HN2 and HN2 X CLN 2123 A exhibited significantly higher standard heterosis indicated the superiority of the hybrids.

Analysis of heterosis for total phenol content in leaves showed that the hybrids CLN 2123 A X HN2 and HN2 X CLN 2123 A expressed positive significant relative heterosis (47.36 and 42.21) and heterobeltiosis (27.27 and 22.72) suggested that involvement of high performing parent CLN 2123 A might have resulted better heterosis for this trait. The parent CLN 2123 A developed by introgression of *Lycopersicon esculentum* with the blood of *Lycopersicon hirsutum* f. *glabratum* might have got the trait of better synthesis of phenols from *Lycopersicon hirsutum* f. *glabratum* which was found wild in its normal habitat possessing natural resistance to diseases/pests through better synthesis of phenols.

The hybrids CLN 2123 A X HN2 and HN2 X CLN 2123 A expressed positive significant heterosis for all the three bases of the heterosis indicating the superiority the donors for improving peroxides and polyphenol oxidase activity. Parents with low *per se* resulted in hybrid with increased peroxidase and polyphenol oxidase activity might be due to complementation of genes from both the parents. Similar report on heterosis for peroxides and polyphenol oxidase activity was also reported by Prema (1989) and Makesh (2004).

Table.1 *Per se* performance of parents, hybrids and check varieties/hybrids for yield and TLCV

Genotypes	Plant height	No. of branches	No. of fruits	Total soluble solids (^{o}brix)	Titrable acidity (%)	Ascorbic acid content (mg/g of fruits)	Fruit weight (g)	Yield per plant (g)	Per cent of disease infection at 60 DAP	Co efficient of infection at 60 DAP	Total phenol content (mg/g of leaves)	PO (changes in OD mimutes^{-1} g^{-1} leaves)	PPO (changes in OD mimutes^{-1} g^{-1} leaves)
CLN 2123 A	118.86	8.06	41.88	4.63	0.60	29.66	40.00	2141.98	9.41	4.70	0.22	0.34	0.06
HN2	94.33	6.76	22.88	5.13	0.70	33.33	56.88	1459.73	37.76	64.32	0.17	0.29	0.03
CLN 2123A X HN2	127.30	13.73	49.09	5.33	0.63	35.00	53.70	2867.06	7.93	3.96	0.28	0.37	0.10
HN2 X CLN 2123A	127.86	14.20	53.07	5.36	0.76	37.00	50.44	3296.86	9.88	6.42	0.37	0.42	0.10
LCR2	77.86	6.20	19.48	4.83	0.56	28.00	61.45	1335.74	36.34	47.13	0.18	0.16	0.03
LCR2 X CLN 2123A	122.30	11.23	42.26	5.06	0.56	31.33	51.31	2455.05	14.83	13.63	0.22	0.35	0.08
HisarLalit	110.06	12.20	41.47	5.10	0.63	31.33	50.42	2402.88	33.86	59.32	0.19	0.27	0.04
Lakshmi	134.03	12.10	41.86	4.83	0.63	31.33	61.51	2815.52	11.42	5.00	0.29	0.47	0.10
CO3	72.36	5.93	20.18	4.33	0.53	29.33	53.46	1177.66	36.90	47.49	0.17	0.14	0.03
SED	4.09	0.83	2.23	0.16	0.05	2.39	9.76	183.89	2.13	3.31	0.05	0.03	0.007
CD	8.07	0.23	4.74	0.34	0.11	5.07	20.69	389.92	4.53	7.02	0.11	0.06	0.014

Table.2 Heterosis for growth, yield and TLCV resistant

Traits	CLN 2123A X HN2			HN2 X CLN 2123A		
	di	dii	diii	di	dii	diii
Plant height	19.42**	7.09**	-5.02	19.95**	7.57**	-4.60
No. of branches	85.17**	70.25**	13.47*	70.25**	76.03**	17.35*
No. of fruits	44.88**	56.63**	17.27**	9.38**	18.25**	26.77**
Total soluble solids	9.22**	9.90**	10.35**	3.90*	4.55*	10.97**
Titrable acidity	-2.56	17.95*	0.00	-9.52	9.52	20.63*
Ascorbic acid content	11.11*	17.46**	11.71*	5.00	11.0*	18.09*
Fruit weight	5.00	11.39**	-12.69*	-8.28	-2.69	-17.99**
Yield per plant	59.21**	33.85**	1.83	83.07**	53.92**	17.09*
Per cent of disease infection at 60DAP	-66.37**	-78.99**	-30.06**	-58.11**	-73.83**	-13.49*
Co efficient of infection at 60 DAP	-88.51**	-93.83**	-20.80**	-81.38**	-90.01**	-28.40**
Total phenol	47.36**	27.27**	-3.44	42.21**	22.72**	27.59**
Peroxidase	5.70*	7.95*	-21.28**	32.33**	23.47**	-10.64*
Poly phenol oxidase	102.00**	106.67**	0.00	59.47**	63.16**	0.00

* Significant at 5 % level, sv - TLCV Resistant check (Lakshmi), ** Significant at 1 % level

From the results it could be concluded that the newly synthesized hybrids CLN 2123 A X HN2 and HN2 X CLN 2123 A showed tolerance to tomato leaf curl virus by registering low disease incidence coupled with high plant vigour and yield during summer at natural epiphytotic condition indicated that these two hybrids are potential hybrid for growing tomato during summer with least incidence of tomato leaf curl virus with high yield.

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