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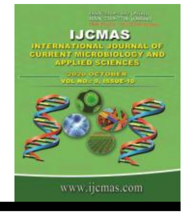

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Heterosis Studies for Growth and Yield Traits in Tomato (*Solanum lycopersicum* L.)

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A B S T R A C T

Standard heterosis over one check (DVRT-1) was experimented with thirty hybrids of tomato. Most of these hybrids proved to have unique variation for growth and yield traits in tomato. Standard heterosis over check for total yield/plant was recorded 99.76 %. Highest Heterosis variation was fund to be in number of primary branches/plant, followed by average fruit weight, fruit yield (q/ha), number of fruits/plant, number of fruits / cluster. The statistically 'highest significant positive standard heterosis for fruit yield (q/ha) was recorded in hybrid EC-570028 × EC-520061(99.76 %.), followed by hybrids EC-552141 × EC-520061 (96.57 %) and EC-552141 × Hisar Arun (96.43 %). The hybridEC-620500×Hisar Arun (-29.82 %) found to have the "statistically highest significant positive standard heterosis" for days to 50 % flowering, followed by hybridsEC-538405×EC-520061 (-13.06 %) and EC-538405 × Hisar Arun (-16.26). Thus these hybrids can be utilized by breeders for developing early flowering, maturing and fruiting types of tomato varieties. Thus from this experimentation we concluded that for the development of commercially high yielding tomato hybrids the breeder should include or select parents with high desirable genetic variability.

Introduction

Tomato (*Lycopersicon esculentum* Mill) is a widely cultivated vegetable crop which is a diploid species with 2n=2x= 24 chromosomes. Peru-Ecuador is considered to be the centre of origin of tomato (Rick, 1976), it is introduced by Portuguese in India during era colonization. Tomato is the world's second most consumed vegetable after potato (Foolad, 2007). The total world production of tomato is 161.7 million metric tons with a value of ~$59 billion. USA tomato production contributes 13.2 million metric tons with a value of $5 billion to the total world production. The India ranks in second position in the total world production of tomato after China (Anonymous, 2017). Heterosis breeding is an useful instrument for varietal upgradation of tomato as recommended by different researchers like Bhatt *et al.*, 1999; Premalakshme *et al.*, 2005; Fageria *et al.*, 2001; Thakur *et al.*, 2004; Duhan *et al.*, 2005. Though tomato is a self-pollinated crop, the unusual high heterosis observed in tomato proved to be highly outcrossing genus and has later evolved into a self-pollinated one(Rick, 1976). "Line × Tester" method can evaluate relatively more number of genotypes or lines in less time as compared to diallel and partial diallel crosses (Garg *et al.*, 2008). For estimating genetic component of variability the method used by (Haydar *et al.*, 2007) was practiced. In this study efforts have been done to identify parents suitable for tomato hybrid seed production.

Materials and Methods

This experiment were conducted during three *Rabi Seasons* 2015-2016, 2016-2017, and 2017-2018 at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, India**.** Located in the middle Gangetic plain (latitude: 25019'59'' longitude: 83000'00'' EN elevation above sea level: 77m) in the eastern part of the state of Uttar Pradesh. It is located in the Indo-Gangetic Plains of North India. The experimental material for this study comprised often lines as female and three testers as male which were selected based on their *perse* performance for various traits. Thirty cross combinations were obtained in a Line × Tester (Kempthorne, 1957) mating design. DVRT-1 was used as check. The parents were provided by ICAR, Indian Institute of Vegetable Research (IIVR), Varanasi, UP, India**.** The experimental material comprised ten genetically diverse lines (EC-620421, EC-620536, EC-620494, EC-620500, EC-620520, EC-620502, EC-552141, EC-538405, EC-570028 and EC-273966). Three testers (EC-520061, EC-520058, and Hisar Arun) along with their thirty F_1s developed by crossing them in a line × tester mating design (Kempthorne, 1957) and one check. During Rabi: 2015-16 ten elite lines and three testers of tomatoes were planted for producing F_1 by crossing in line × tester fashion. A total of 30 (10 × 3) crosses were made. Individual plants of parents were selfed to maintain pure seed. Again during *Rabi:*2016-17 thirtyF_1s and thirteen parents along with one check were raised in RBD in three replications and population size was thirty plants per treatment with standard spacing at Vegetable Research Farm, Department of Horticulture, Institute of Agricultural Sciences, Banaras Hindu university, Varanasi, UP, India. Data were recorded on yield and quality traits. FreshF_1s were obtained by crossing ten elite lines and three testers of tomato. During *Rabi* season of 2017-18 thirty F_1s, and thirteen parents along with one check were raised. Parents, F_{1S} were grown in RBD in three replications to study combining ability, heterosis and gene action for growth and yield characters. All the inter cultural operations were performed as and when required. The observations were recorded for nine different characters *i.e.* Plant height (cm), Day to 50 % flowering, Number of primary branches per plant, Number of fruits per cluster, Average fruit weight(g), Fruit length (cm), Fruit width (cm), Number of fruits per plant, Fruit yield (q/ha).

For design of experiment, analysis of variance was carried out following Panse and Sukhatme (1967). The significance of differences among treatment means (parent and crosses)was tested by 'F-test'. For assessment of general and specific combining ability variances and their effects, the' line×tester' analysis was carried out following method given by Kempthorne (1957) and elaborated by Arunachalam (1974). Line×tester analysis was used on a limited scale to determine GCA and SCA of different lines. It is analogous to "North Carolina Design II" (Comstock and Robinson, 1952). In this design, a random sample of '*l*' lines is taken and each line is mated to each of the't' testers (Singh and Chaudhary, 1977). Heterosis in F_1's will be calculated as the difference of F_1 cross performance from the check (Standard heterosis) and better parent (heterobeltiosis) by using the formulae (Kempthorne, 1957). The nature and magnitude of heterosis was computed as percentage increase or decrease of the mean values of cross (F_1's) over better parent (BP) and the standard check (SC). Significance of heterosis was tested following the 't' test. The calculated 't' value was compared with table value of 't' at error degree of freedom from ANOVA comprising parents and F_1s P = 0.05 and P = 0.01.

Results and Discussion

The source of variation showed highly significant and significant differences for most of the yield and quality traits. The analysis of variance indicated highly significant differences with respect to general combining ability of parents for days to 50 % flowering'; number of fruits' percluster, number of branches' per plant, pericarp' thickness (mm),fruit weight (g), fruit yield (q/ha),fruit length (cm), fruit width (cm), number of fruits per plant for standard heterosis over check. Nine different characters in tomato for superior three hybrids are presented in table no.1. The highest significant standard heterosis over the check was exhibited byhybrid EC-273966 × EC-520058 (19.43 %). This proves the presence of both non-additive gene effect and additive gene effects in these hybrids for plant height. Similar finding were reported by Harer *et al.*, (2006); Sharmaand Thakur (2008); Mehta and Asati (2008); Kumar *et al*., (2016), Pattnaik *et al*., (2020a); and Pattnaik *et al.*, (2020b). Earliness in days to 50per cent flowering and days to 50 % fruit setting is one of the important components to develop early maturing tomato hybrid variety. Hybrid EC-620500 × Hisar Arun expressed highest significant negative heterosis over check parent (-29.82%). This was good general combiner for early maturity. Negative heterosis for days to first flowering was also reported by Singh and Singh (1993); Kulkarni (2003); Mahendrakar (2004); Duhan *et al.*, (2005); and Premalakshme *et al*., (2005) over the better parent in many of the cross combinations in their diallel progenies. Statically "maximum significant heterosis over the check" was found to be in hybridEC-570028 × EC-520058 (251.93 %).It suggesting the requirement of non-additive gene action. Patil (2003), Duhan *et al.*, (2005) and Ramezan *et al.*, (2009) also reported same result. Number of fruits per cluster was proved to be the highest over the check parent in hybrid EC-620494 × Hisar Arun (80.93 %). This result is in accordance with the observation of Sharma and Thakur (2008), Kumari and Sharma (2011) and Kumar *et al.*, (2012). Average fruit weight was expressed maximum over the check parent by the hybrid EC-273966 × EC-520061 (209.53 %). Average fruit weight is one of the most necessary yield characters for breeding high yielding tomato varieties. Four cross combinations showed significantly useful heterobeltiosis for average fruit weight which was observed by Gul (2010). Positive heterosis over better parent for average fruit weight was also reported by Hussain *et al.*, (2001) and Singh *et al.*, (2005). In the present investigation the yield q/ha increased mainly due to increase in average fruit weight and number of fruits per plant.

Statically highest significant standard heterosis for fruit length was expressed by hybrid EC-552141 × Hisar Arun (56.18 %) over check parent.

Table.1 Heterosis over standard check for growth and yield (DVRT-1) of different characters in tomato

S.NO	Character	Standard heterosis over check	
		Superior hybrids	**(%)**
1.	Plant height (cm)	EC-273966 × EC-520058	19.43
		EC-620536 × EC-520058	16.27
		EC-620520 × EC-520058	15.78
2.	Daysto50 %flowering	EC- 620500× Hisar Arun	-29.82
		EC-538405×EC-520061	-13.06
		EC-538405 × Hisar Arun	-16.26
3.	Number of primary branches per plant	EC-570028 × EC-520058	251.93
		EC-570028 × Hisar Arun	250.80
		EC-570028 × EC-520061	187.73
4.	Number of fruits per cluster	EC-620494 × Hisar Arun	80.93
		EC-552141 × Hisar Arun	75.90
		EC-620500 × Hisar Arun	75.34
5.	Average fruit weight	EC-273966 × EC-520061	209.53
		EC-570028 × EC-520061	195.45
		EC-538405 × Hisar Arun	195.18
6.	Fruit length (cm)	EC-552141 × Hisar Arun	56.18
		EC-570028 × Hisar Arun	55.25
		EC-552141 × EC-520061	45.69
7.	Fruit width (cm)	EC-620421 × EC-520058	23.94
		EC-620494 × EC-520061	23.70
		EC-620500 × Hisar Arun	22.87
8.	Number of fruits per plant	EC-620421 × Hisar Arun	84.85
		EC-620520 × EC-520058	78.51
		EC-552141 × EC-520058	77.29
9.	Fruit yield (q/ha)	EC-570028 × EC-520061	99.76
		EC-552141 × EC-520061	96.57
		EC-552141 × Hisar Arun	96.43

Fruit length is one of the most necessary characters for breeding big size tomato for commercial purpose. Fruit width was observed maximum in the hybrid EC-620421 × EC-520058 (23.94 %). Fruit width is one of the most important characters for breeding big size tomato for commercial purpose. These results are in line with the reports from, Islam *et al*., (2012) and Aisyah *et al*., (2016). The hybridEC-620421 × Hisar Arun showed statistically "highest significant standard heterosis" for number of fruits per plant over check parent**.** Major yield contributing character is the number of fruits per plant. These results are online with Prashant (2004); Kulkarni (2003); Joshi and Thakur (2003); and Sharma and Thakur (2008). Significant result has been also found for number of fruits per plant by Saleem *et al.,* (2009). These results are also on line with the results of Mirshamssi *et al*., (2006); Rani and Veeraragavathatham (2008); Kumar *et al.*, (2016b), Pattnaik *et al.*, (2020a); and Pattnaik *et al.,* (2020b). Fruit yield was recorded statistically "significant maximum standard heterosis" in hybrid EC-570028 × EC-520061(99.76 %) over check parent. Similar results were also reported by Wagh *et al*., (2004); Harer *et al.,* (2006); and Sharma and Thakur (2008). Yield is a composite character, evidences suggest that heterosis of such a compound character is much regulated by the vigour expressed by its component character (Sinha and Khanna, 1975) such as average fruit weight, no. of number of fruits' per plant, fruits per' cluster, and fruit yield q/ha. These findings were similar with the findings of Kulkarni (2003); Prashant (2004); Kumar *et al.,* (2013); Kumar *et al.*, (2016 b), Pattnaik *et al.,* (2020a); and Pattnaik *et al.*, (2020b).

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