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Performance evaluation of natural dwarf mutant tomato suitable for vertical gardening

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ABSTRACT

A dwarf mutant genotype Selection-24 (Seln-24) was identified and stabilized from a segregating population of tomato variety Pusa Gaurav. Performance of Seln-24 was compared with six genotypes of tomato, including parental line for resistance to insect vectors, *Tomato leaf curl virus* and for different horticultural traits. Seln-24 plants were of compact-miniature type and recorded significantly less height (41.53 cm) compared to parent Pusa Gaurav (134.62cm). Fruits are bullet shaped with bright deep red color. Each fruits weighs around 55g. The fruits are firm with thick pericarp (0.5 cm) with two well filled locules which facilitates good shelf -life. It is highly rich in vitamin C and was found tolerant to whiteflies and *leaf curl virus*. Due to its compact and dwarf nature, Seln-24 requires minimum staking and training. The line is very useful for vertical gardening or container gardening in multistoried buildings in urban setup.

Key words: Dwarf tomato, vertical gardening, Selection-24, whiteflies, *Tomato leaf curl virus*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is one of the important and nutritious vegetable crops in the world as it is a rich source of antioxidants. It is most frequently consumed as a fresh vegetable and also used for preparation of variety of processed products such as juice, ketchup, sauce, canned fruits, puree, paste, etc. Tomatoes are good source of phyto-nutrients and chemo-protective compounds (Ranieri *et al.*, 12). The area under tomato production has been increasing in the country due to the increased demand. The crop is susceptible to many biotic and abiotic factors which are major constraints of production. Among the biotic constraints, whiteflies transmitting tomato leaf curl virus is one of the limiting factors causing significant yield loss under acute conditions. Injudicious use of pesticides in tomato by farmers to control pests and diseases has led to serious threats to our life and potential of pest emergence/resurgence.

Resources like soil and water being finite in comparison to the ever increasing population of the world. The diversion of agricultural land for the human activities in urban areas and the global climate change has become challenging for maintaining sustainability of food production. Under such circumstances, maintaining environmental sustainability, water conservation and healthy open green space are becoming strenuous. Alternatively, vertical farming can be one of the sustainable options for food production with minimum land use. Vertical farming systems can be practiced in multilevel buildings, public housing or settlements (Utami *et al*., 15). This gardening system can substitute for the ordinary horizontal gardens. The crop yield per unit area is much higher in the vertical farming system. Several vegetables can be grown successfully in such vertical system. Such gardening is helpful to old age people who may find difficulty to bend for doing intercultural operations while growing veggies in normal kitchen gardens. Before going to this type of farming we need to have varieties suitable for container gardening which can easily grow in high-rise as well as multistoried building to provide the daily vegetable needs of the family. Tomato is one such vegetable, which is daily required in almost all Indian culinary. Therefore developing tomato varieties for such cultivation is of prime importance in the present scenario. The present study identified and stabilized a natural dwarf tomato line that is useful for growing in pots and for vertical gardening in high-rise buildings. It will act both as an ornamental as well as serve the daily needs. Additionally, the line shows tolerance to the leaf curl virus, insect vector and has good horticultural traits at the same time.

MATERIALS AND METHODS

A unique looking natural dwarf mutant was observed in the variety Pusa Gaurav during varietal trial for virus resistance at the IARI Regional Station, Pune. The dwarf plant was selfed and fruits harvested separately. Seeds from individual fruits were grown

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as separate lines in the subsequent generations. All the plants of individual fruit lines of Selection-24 were found uniform and hence all the seeds were bulked and designated as Selection-24 (Seln-24). The plants were grown continuously for five generation and stabilized. After 5th generation, Seln-24 was evaluated for different quantitative and qualitative traits at IARI, Regional Station in comparison with parental line Pusa Gaurav, released varieties Pusa Rohini and standard leaf curl resistant check Arka Rakshak, as well as laboratory resistant check line Seln-29 and Seln-33, during *rabi* season of 2020. The lines were sown in the month of October and transplanted in November 2019 in randomized block design in three replications Observations were recorded on plant characters, fruit characters and incidence of whiteflies, thrips and leaf curl disease. Morphological data of plants were taken from time to time. Fruit quality was assessed after harvesting of ripened fruits..

Incidence of whiteflies was estimated by counting number of whiteflies per leaf selected at bottom, middle and top portion of plants. Ten plants were counted for each replication. Similarly, the thrips population was estimated for ten plants in each replication by beat cup method, which involved gently beating of plants against thermocol cup and counting their numbers (Chavan *et al*., 2). Incidence of leaf curl disease was estimated by observing the number of plants showing disease symptoms in each replication against the total number of plants. However, for confirmation few diseased plants showing typical symptoms of leaf curl, total genomic DNA was extracted (DNAeasy Plant Kit, Qiagen, Amph, Germany) and the presence of begomovirus was confirmed by PCR using degenerate primers (Deng *et al*., 4). PCR was performed in 20µl PCR mixture using 2µl of template containing ~50 ηg/µl of genomic DNA and annealing temperature of 58 °C for 45 sec.

Total Soluble Solids (TSS) of fruits was measured by hand-held digital refractometer. Fresh tomato samples were washed and wiped with tissue paper to remove water. The fruits were cut into two halves, the juice was taken with a dropper and then TSS measured with refractometer. Ascorbic acid content in fruits was estimated using 2, 6-dichlorophenol indophenol visual titration method (Ranganna, 11). Data were analysed using analyis of variance (ANOVA) technique at P values ≤ 0.5. Pearson correlation was used to measure association between quantitative and qualitative characters.

RESULTS AND DISCUSSION

The selected dwarf mutant plants (Seln-24) from Pusa Gaurav were grown continuously for five generation for stabilization. During first three generations, few wild type looking plants similar to parent line Pusa Gaurav were observed which were weeded out. Wild type was not observed on 4th generation onwards. Hence, it was assumed that line has stabilized after 5th generation. The average plant height during stabilization generations 1-5 (2015-2019) was 43.2±2.5, 40.0±3.0, 41.4±2.3, 43.4±3.0 and 42.8±1.6, respectively and percent disease incidence recorded from the generation 3-5 was 7.4±1.2, 2.10±1.96 and 6.68±1.0 respectively.

Significant, reduction in plant height was recorded in stabilized Seln-24 which was about 3.24 times less compared to parental line Pusa Gaurav (134.62 cm). Maximum plant height was recorded in Seln-29 (241.3 cm) and the mean of plant height was 158 cm (Table 1). Similar variation in plant height was reported in several studies (Parajapati *et al.,* 9). Average plant height observed for Seln-24 is the most suitable for pot culture as well as high density planting (Fig. 1). Huge cost is involved in staking sticks/stumps, steel wires, gunny twine/rope and labour for twining tomato plants. The cost involved in this activity varies from 7 to 11% (Chandraprabha, 1). Until now, not many varieties exist that do not require staking. Use of dwarf determinate variety Seln-24 may lead to savings in cost of cultivation for the staking in tomato.

Number of branches per plant, number of flowers/truss and number of fruits per cluster did not show any significant variation amongst genotypes. Number of flowers per truss was minimum in Pusa Gaurav (4.26) while Seln-29 recorded maximum (7.40). Variety Pusa Rohini (6.27) recorded maximum number of fruits per cluster, while Seln-24 recorded the least (5.40). Number of fruits per plant showed significant difference among the lines ranging from 47.70 (Seln-33) to 85.10 (Pusa Rohini) with a mean of 64.66.

The yield and yield components of tomato fruits are most important from the production point of view. It is the prime concern of the plant breeder and is the final factor on which selection programs are most times envisaged. Mean fruit yield per plant showed highly significant (p≤ 0.01) differences among the tomato genotypes. The highest fruit yield per plant was observed in Arka Rakshak (3.31 kg) and the minimum in Seln-29 (1.18 kg). Fruit yield per plant in tomato genotypes is attributed to the differences in plants ability to produce and retain number of flowers that developed into fruits. High yielding genotypes retain higher number of flowers successfully developing into fruits due to genetic components. Clark *et al.* (3) ascribed differences in crop yield and its components among crop genotypes to variations in genetic structure, mineral concentration and

Fig. 1. A- Growth pattern of parental line Pusa Gaurav and Seln-24 grown in pots; B- Seln-24 grown in containers for vertical gardening; C-Seln-24 grown in field; D&E- Heavy fruiting of Seln-24; F- Red ripe tomato of Seln-24

absorption in addition to the abilities of carrying photosynthetic materials within plants. Individual fruit weight also showed highly significant difference ($p<0.001$). Average fruit weight maximum in Arka Rakshak (81.53g) whereas Seln-29 recorded the minimum (34.78g). Seln-24 showed average fruit weight of 53.58 g. Variability in fruit weight among genotypes was reported by Kanneh *et al.* (5). Fruit size influences fruit weight and thus determines the consumer preference in tomato crop.

Maximum fruit length was recorded in Seln-24 (5.48cm) followed by Arka Rakshak (5.31 cm) while Seln-29 recorded least length (4.16 cm). The maximum fruit diameter was recorded in Pusa Rohini (5.15cm) and minimum in Seln-33 (3.93cm). The differences expressed among tomato genotypes with respect to fruit length and fruit diameter which might be a consequence of a combination of factors including plant health, fruit shape (spherical, elongated, flat or pear-like) and ability of plant to absorb and utilize existing moisture and nutrients. Kanneh *et al.* (5) also reported significant variability among tomato genotypes for these characters. The variations observed among tomato genotypes with respect to fruit length might be associated with genetic differences. No significant differences were observed in fruit flesh thickness or the pericarp thickness among tomato genotypes which varied from 0.51cm to 0.65cm. The variations in fruit flesh thickness among genotypes could be ascribed to fruit firmness and possibly genetic differential for the trait. Significant differences observed for the fruit cavity character among the genotypes. Pusa Rohini recorded the maximum fruit cavity (4.16 cm) while Seln-33 was the least (2.86 cm). Fruit cavity in Seln-24 was 3.06 cm.

TSS is a key trait, as it influences final product flavor and consistency, and ultimately determines the final yield after processing. TSS ranged from 2.73 to 3.60 ºBrix (Table 1). Highest TSS was recorded in Pusa Gaurav (3.60) and lowest in Seln-29 (2.73) with a mean of 3.20 ºBrix. Seln-24 showed average TSS of 2.93 ºBrix. The observed variations in TSS among genotypes may be attributed to genetic makeup that might have influenced the performance of these genotypes for the trait. The findings are in close conformity with reported results of Kumar *et al.* (8). Ascorbic acid is of much importance from nutrition point of view due to its antioxidant property. The ascorbic acid content among lines ranged from 14.78 to 43.88 mg/100g. Maximum ascorbic acid content was observed in Seln-24, which was at par with Pusa Gaurav (40.47mg/100 g). Seln-33 reported the minimum ascorbic acid content. This variation in ascorbic acid may be due to varietal characteristics of the fruit. These observations are in accordance with the findings of Trivedi *et al*. (14).

Simple correlations were done for all the twelve characters. Significant positive correlation was observed for plant height with number of branches/

Table 1. Mean performance of yield, and quality traits of various tomato genotypes

S. No.	Accessions	Plant height (cm)	No of branches/ plant	No of flowers/ truss	No of fruits/ cluster	No of fruits/ plant	Yield/ plant (kg)	Yield (t/ha)	IFW(g)	FL (cm)	FD (cm)	PT (cm)	FC (cm)	TSS ° Brix	Vitamin C (mg/100g FW)
1	Arka Rakshak	201.84	5.93	6.40	5.93	81.8	3.31	81.90	81.53	5.31	4.88	0.60	3.91	3.40	19.38
2	Pusa Rohini	165.10	6.73	6.46	6.27	85.1	1.86	45.94	71.25	4.45	5.15	0.65	4.16	3.45	28.63
3	Pusa Gaurav	134.62	7.33	4.26	5.67	64.6	2.29	56.76	48.11	4.9	4.51	0.55	3.50	3.60	40.47
4	Seln-29	241.30	8.13	7.40	5.53	53.27	1.81	44.78	34.78	4.16	3.98	0.51	3.00	2.73	21.62
5	Seln-33	164.08	7.93	6.13	6.20	47.7	2.05	50.69	35.41	4.48	3.93	0.55	2.86	3.13	14.78
6	Seln-24	41.53	7.13	6.40	5.40	55.5	1.18	29.33	53.58	5.48	4.13	0.56	3.06	2.93	43.88
	Mean	158.07	7.19	6.17	5.83	64.66	2.08	51.56	54.11	4.79	4.43	0.57	3.41	3.20	28.12
	CD (5%)	23.58	NS	NS	NS	12.56	0.75	18.70	6.18	0.43	0.4	NS	0.29	NS	4.98
	CV	8.20	15.85	16.75	18.53	21.58	40.25	40.26	6.28	5.02	5.06	13.69	4.71	12.03	9.74

(FL-Fruit length, FD- Fruit Diameter, PT- Pericarp Thickness, FC- Fruit Cavity, IFW- Individual Fruit Weight, TSS- Total Soluble Solids)

plant, number of flowers/truss, number of fruits/ cluster, number of fruits/plant, yield/plant, yield, fruit cavity. Fruits per plant was positively correlated with plant height, number of fruits/cluster, yield/plant, fruit length, TSS, and Vitamin C. Number of fruits per plant is the most important trait which is directly related to increased fruit yield per plant. Individual fruit weight was positively correlated with fruits/cluster, yield/ plant, yield, fruit length, TSS and Vitamin C. Number of fruits per plant and fruit width showed significant positive correlation with fruit yield per plant. The results are in accordance with Kumar *et al*. (7), for number of fruits per plant, Singh (13) for fruit width. Number of primary branches per plant and number of flowers per cluster or truss had significantly positive correlation with plant height. Similar results reported by Prashanth *et al*. (10). Fruit length had highly significant positive correlation with fruit weight and TSS. Fruit width had highly significant positive correlation with fruit weight. Fruit weight had positive correlation with TSS. Ascorbic acid had positive association with TSS. Results are in accordance with Kumar and Dudi (6) for fruit weight and TSS. Fruit length had highly significant positive correlation with fruit weight and TSS. Negative correlation was observed with individual fruit weight, fruit length, fruit diameter, pericarp thickness, TSS, and Vitamin C for plant height (Table 2). Fruits per plant had negative correlation with flowers/truss. Number of fruits per cluster and ascorbic acid content showed significantly negative association with number of branches per plant. Generally, association of characters indicated that fruit yield per plant, number of fruits per plant and number of fruit clusters per plant are the most important fruit yield components which contributes more to highest fruit yield per hectare. Therefore, to improve fruit yield, selection based on these characters is important.

Data revealed that some of the characters of Seln-24 like number of fruits per cluster, individual fruit weight, pericarp thickness, fruit cavity, fruit diameter and vitamin C content were very close to the parental line Pusa Gaurav. Disease and pest occurrence on tomato genotypes like incidence of thrips per sample was maximum in Seln-29 and minimum in Seln-33 (Fig. 2). Whitefly vector of leaf curl virus disease was highest in Arka Rakshak and lowest in Seln-24. Leaf curl disease was negligible in Seln-33 followed by Seln-24. PCR of all the tested symptomatic samples showed 520 bp amplicons with degenerate primers confirming virus presence. The disease incidence was recorded maximum in Pusa Rohini. Genotypes Seln-33 and Seln-24 were found to be tolerant to leaf curl disease and pests. However, all the symptomatic plants showed virus presence in PCR.

Table 2. Correlation coefficients between different quantitative and qualitative characters of tomato

	a	b	c	d	e	f	g	h	i	j	k	l	m	n
a	1.000	0.102	0.376	0.317	0.173	0.541	0.538	-0.031	-0.659	0.102	-0.147	0.157	-0.061	-0.779
b	0.102	**1.000**	0.101	-0.231	-0.855	-0.577	-0.577	-0.982	-0.639	-0.818	-0.761	-0.809	-0.584	-0.093
c	0.376	0.101	**1.000**	-0.014	-0.068	-0.197	-0.200	-0.004	-0.293	-0.170	-0.022	-0.146	-0.741	-0.479
d	0.317	-0.231	-0.014	**1.000**	0.423	0.356	0.352	0.304	-0.361	0.474	0.615	0.458	0.495	-0.586
e	0.173	-0.855	-0.068	0.423	**1.000**	0.517	0.516	0.921	0.198	0.988	0.850	0.993	0.672	0.017
f	0.541	-0.577	-0.197	0.356	0.517	**1.000**	1.000	0.521	0.160	0.460	0.203	0.486	0.547	-0.487
g	0.538	-0.577	-0.200	0.352	0.516	1.000	**1.000**	0.521	0.164	0.459	0.201	0.485	0.548	-0.484
h	-0.031	-0.982	-0.004	0.304	0.921	0.521	0.521	**1.000**	0.511	0.886	0.838	0.879	0.563	0.055
i	-0.659	-0.639	-0.293	-0.361	0.198	0.160	0.164	0.511	**1.000**	0.174	0.222	0.145	0.222	0.510
j	0.102	-0.818	-0.170	0.474	0.988	0.460	0.459	0.886	0.174	**1.000**	0.881	0.998	0.746	0.077
k	-0.147	-0.761	-0.022	0.615	0.850	0.203	0.201	0.838	0.222	0.881	**1.000**	0.854	0.597	0.049
l	0.157	-0.809	-0.146	0.458	0.993	0.486	0.485	0.879	0.145	0.998	0.854	**1.000**	0.729	0.051
m	-0.061	-0.584	-0.741	0.495	0.672	0.547	0.548	0.563	0.222	0.746	0.597	0.729	**1.000**	0.154
n	-0.779	-0.093	-0.479	-0.585	0.017	-0.487	-0.484	0.055	0.510	0.077	0.049	0.051	0.154	**1.000**

(a-Plant height, b-No of branches/plant, c-No of flowers/truss, d-No of fruits/cluster, e-No of fruits/plant, f-Yield/plant, g-Yield, h-Individual Fruit Weight, i-Fruit length, j-Fruit Diameter, k-Pericarp thickness, l-Fruit Cavity, m-TSS, n-Vitamin C)

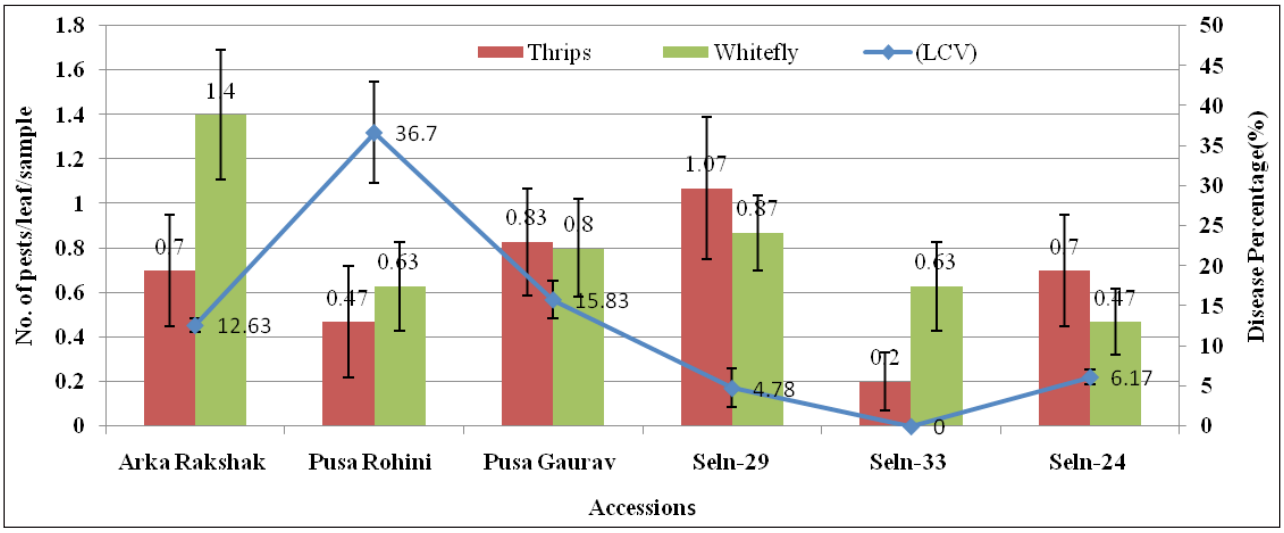

Fig. 2. Disease and pest surveillance in tomato genotypes. Disease represented as % incidence of leaf curl virus on Y_2 axis

Present study identified Seln-24 with a good plant architecture i.e., short stature, tolerance to leaf curl disease and their vectors and rich in vitamin C content. Henceforth, it can useful for vertical gardening and pot culture for high-rise buildings as well as for high density planting. Since no staking is required for this line, farmers can directly reduce their cost of cultivation by 7-11%. The present study also identified genotypes Seln-33 and Seln-29, which possess very high resistance to leaf curl disease. In addition to disease resistance, characters like fruit yield per plant, number of fruits per plant, yield per plant etc. are most important components for any commercial tomato variety. Breeders can make use of them in the production of cultivars with outstanding yield, quality and resistance attributes.

AUTHORS' CONTRIBUTION

Conceptualization of idea and designing of the field experiments (KC and SS); Disease data and virus detection (RJ and ST). All authors contributed for preparation of the manuscript.

DECLARATION

The authors declare that they do not have any conflict of interest.

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