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Identification of tomato (*Solanum lycopersicum*) genotype for organic cultivation and better shelf life under North Indian plain condition

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ABSTRACT

A field experiment was laid out in RBD having three replications to investigate the morphological performance, yield and shelf life of five different tomato (*Solanum lycopersicum* L.) varieties under organic and inorganic ambient. The different tomato varieties behaved significantly different from each other for various growth parameters. The organic ambient grown tomato var. Angoorlata gave the highest plant height, number of branches, leaves and flowers; the variety Pusa Sheetal recorded highest fruit length, fruit diameter, fruit shelf life and fruit yield. The var. Pusa Sheetal also grown inorganic ambient gave highest performance for number of fruits, fruit diameter, fruit weight, shelf life at room temperature and yield production. The potential of the variety Pusa Sheetal for accumulation of higher concentration of soluble solids such as sugars, Vitamin C, polyphenols and best performance for yield contributing attributes as well as highest shelf life at refrigerated condition in organic ambience reflects that it is an eco-health friendly genotype for organic tomato and longer shelf life. This novel finding reported for the first time for the variety Pusa Sheetal opens a new avenue for its larger scientific and practical utility for breeding of new genotypes suitable for organic farming with enhanced shelf life to meet out the increasing fondness and requirement of future consumers.

Key words: Organic arming, Tomato, Traditional farming, Shelf Life, Yield components

Tomato (*Solanum lycopersicum* L.) crop requires certain nutrients that are essential for fruit growth and quality. For improving plant growth and development, use of organic and inorganic fertilizer is essential. (Csplittstoesser 1990). The use of organic fertilizers plays a major role to ensure the sustainability of production, allowing preservation of natural resources for present and future generations, while providing a high quality and long shelf life of the product (Rembiałkowska 2007). Addition of organic manure to soil enhances microbial activity and increases their ability to conserve fertilizer and consequently increasing their fertility and fertilizer use efficiency as a final goal (Nanwai *et al.* 1998). Large quantities of organic wastes such as farmyard manure, poultry wastes and compost are available and it should be considered as complementary and cheap source of fertilizers. In addition, organic fertilizers may act as an energy source for microorganisms in the soil, which can improve soil structure and plant growth. The present study was undertaken to assess the effect of organic and inorganic nutrient sources along with the assessment of different tomato varieties for various parameters of the production and shelf life.

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MATERIALS AND METHODS

The experimental field is located at 28.53^0 North latitude and 77.39^0 east longitude at an elevation of 202 m above the sea level. The soil of the experimental site was sandy loam with low organic carbon content and alkaline in nature. The soil was free from chemical fertilizers and insecticide and pesticides. The organic farm has been maintained for the past 10 years. The experiment, comprising three diverse nutritional ambient (T_1- Organic; T_2 – Inorganic, T_3 – Control (no fertilizers)) and five tomato varieties of varying growth habit namely Angoorlata (Indeterminate), Avinash-3 (semi determinate), Swaraksha (semi determinate), Pusa Sheetal (semi determinate) and Pusa Rohini (determinate) was conducted in a Randomized Block Design with three replications during Rabi 2017-18. Each plot consisted of 4 × 4m size. Nursery was grown on raised bed and seedling was transplanted after four weeks when the seedlings were 9 to 12 cm in height having 4 to 7 compound leaves. Plants were transplanted keeping plant to plant and row to row distance of 45 cm and 90 cm respectively. The organic supplement comprised farmyard manures, vermicompost @ 15 to 20 t/ha at the time of final ploughing and as green manures dhaincha (*Sesbania aculeata* L.) crop was incorporated in

the plot. Inorganic fertilizers; 100 to 125 kg N (Urea), 60 to 80 kg P_2O_5 (Single super phosphate) and 40 to 50 kg K_2O (Muriate of potash) was applied. 1/3 N, full P_2O_5 and K_2O was incorporated at the time of transplanting and remaining N (Urea) after 45 days. The growth and yield parameters, viz plant height at various stages, number of branches plant^{-1}, number of leaves plant^{-1}, number of flowers plant^{-1}, number of fruits plant^{-1}, fruit length (cm), fruit diameter (cm), weight of individual fruit (g), fruit yield plot^{-1}, fruit yield per ha, shelf life of the fruit at room temperature and refrigerated conditions were recorded.

Plant height was measured from the five sample plants in centimeters from the ground level to the tip of the stem at 60 DAT (days after transplanting) and mean was calculated. Branches plant^{-1} was recorded under each treatment at 60 days after transplanting from selected five plants and average was calculated. Flower plant^{-1} was recorded under each treatment at 60 days after transplanting of selected plants. Equatorial diameter of the fruit was measured with the help Vernier Caliper and expressed in cm. Fruit weight was measured on a semi-analytical scale as whole fruits and individually weighed and results were expressed in grams (g). The yield in q/ha was calculated by taking the total yield plant^{-1} under each treatment and then converted into per ha.

Shelf life

Shelf life was calculated as the period of time between harvesting and period of start of rotting of fruits. Parameters measured were number of days for fruits to wrinkle and number of days to watery (Mondal 2000). The harvested ripe five fruits were placed on a clean table in a store at room temperature (24 to 30^{0}C) for observing the changes critically on daily basis. Signs of wrinkles were observed and the number of days it took to wrinkle. The number of days it took to watery was also noted for each treatment samples taken.

Analysis of soil used in the experiment

Sample soils were analyzed for nutrients at soil laboratory, KVK Ghaziabad. Organic carbon was estimated by the method of Olsen *et al.* (1954), available nitrogen (kg/ha) as per Subbian and Asija (1956), available phosphorus (kg/ha) as per Walkley and Black (1934), available potassium (kg/ha) as per Perur *et al.* (1973) and pH of the soil as per Jackson (1973). The composition of soil analysis is presented in Table 1.

Statistical analysis

The collected data were subjected to standard statistical analysis as per Douglas and Bland (2005) and Lindgren (1960) for ANOVA.

RESULTS AND DISCUSSION

Plant height (cm)

Data depicted in ANOVA Table 2 indicates that varietal differences, application of organic and inorganic nutrient sources significantly affected the height of the plant and even interaction between variety and treatments was also found to be significant. The trends of plant height at 90 DAT have been presented in Table 3. It was observed that three tomato varieties Avinash-3, Pusa Rohini and Swaraksha showed significant increase in plant height with application of inorganic fertilizers and maximum plant height (56.33 cm) was recorded in Pusa Rohini showing an increase of 40% over the control.

Table 1 Chemical analysis of experimental soil

Analysis	Organic nutrient source (T_1)	Inorganic nutrient source (T_2)	Control (T_3)
Soil pH	7.89	7.61	8.4
Electrical conductivity ds/m)	0.528	0.423	0.319
Organic carbon (%)	0.58	0.85	0.36
Available nitrogen N (kg/ha)	263.2	330	178
Available phosphorus P_2O_5 (kg/ha)	25.9	33.9	20.7
Available potassium K_2O (kg/ha)	332.8	438.4	265.9

Tomato varieties Angoorlata and Pusa Sheetal showed significant increase for the plant height, when grown in organic ambience. Maximum height (51.66 cm) was attained by Angoorlata showing an increase of 13.12% over the control. Similar findings have also been reported by Awad et al. (2002), who have reported that organic fertilizers might contain high level of absorbable nutrients which influenced the growth and germination of the plants (Table 3).

Number of branches per plant

Number of branches per plant was significantly affected by varietal differences due to diverse growth habits as well as interaction between varieties and treatments (Table 2). The tomato variety Angoorlata exhibited higher number of branches with organic manure in comparison to the plants grown in application with inorganic fertilizer source. Other experimental varieties like Pusa Sheetal, Avinash-3 and Swaraksha showed different trends and maximum number of branches were reported for Avinash-3 with the application of inorganic fertilizers (Table 3). However, the tomato *var.* Angoorlata exhibited highest number of branches (39) with organic nutrient (T_1) with an increase of 40.79% over the control. Avinash-3 exhibited highest (22.33) no of branches under inorganic application of fertilizers showing an increase of 33.5% over the control (Table 3).

The findings are in agreement with several other previous reports. Among the sources of available organic manures, vermicompost contains a higher percentage of nutrients necessary for plant growth in readily available forms, increase the number of secondary branches and increases macro pore space resulting in improved air-water relationship in the soil, which favorably affects plant growth (Theunissen *et al.* 2010; Bhat and Limaye 2012).

Table 2 ANOVA for various agronomic characters of tomato

Source	DF	Plant height (cm)	No. of branches	No. of leaves	No of flowers	No. of fruits plant^{-1}	Fruit weight (g)	Fruit length (cm)	Fruit diameter (cm)	Shelf life room temperature (d)	Shelf life refrigerated (d)	Yield (tonnes)/ha
Variety	4	59.91**	264.08**	6002.00**	1180.90**	82.14	558.60**	11.61**	9.75**	13.17**	68.53**	1,704.91**
Treatment	2	222.29**	26.47	2708.00	535.20	22.96	259.80	8.59**	0.92	1.27**	7.62	606.23**
Replications	2	-	-	-	-	-	-	-	-	-	-	-
Variety × Treatment	8	25.09*	73.91*	1946.00*	270.40	11.84	113.40	1.77**	0.18	0.60	1.07**	155.06**
Error	28	7.57	18.09	416.57	156.61	57.91	45.13	0.28	0.18	0.35	0.35	5.37
Total	44	25.98	51.71	1390.00	297.70	63.71	113.40	1.98	1.15	1.59	7.21	214.27

<0.05* Significance level at 5%, <0.01* *Significance level at 1%

Number of leaves per plant

The number of leaves per plant was significantly influenced by varieties as well as interaction between varieties and treatments (Table 2). The experimental varieties Angoorlata, expressed maximum number of leaves per plant (195.00) with organic manure having an increase of 69.56% over control and Avinash-3 expressed highest number of leaves (112.00) with inorganic fertilizer dose having an increase of 45.45% over the control (Table 3). However, Angoorlata was over all best performer on average basis across all the treatments.

The growth parameter higher number of leaves plant^{-1} is supposed to have positive correlation with higher production and yield that might be due to more availability of nutrients as FYM and vermicompost are considered the store house of plant nutrients including micronutrients and beneficial microbial activities with improved physical properties of the soil which ultimately increased the number of leaves and vegetative growth. The findings are in agreement with the results obtained by Brown (1995).

Number of flowers per plant

A significant variation in the number of flowers was observed due to varietal differences (Table 2). The highest performing tomato varieties Pusa Rohini in inorganic ambience and Angoorlata in organic ambience were having an increase of 29.36% and 51.99% respectively over the controls (Table 3).

The increase in number of fruit inflorescence in organic ambience might be due to organic manure providing macro and micronutrient to tomato plant specially potassium in optimum level and temperature which also contributed in the formation of a greater number of fruit inflorescence as well as more flowers for fruit set. The findings are in conformity with several others (Suleiman and Rabbani 2006; Adekiya and Agbede 2009).

Number of fruits per plant

As per ANOVA the variation for number of fruits was found to be non-significant (Table 2). However, the tomato Angoorlata demonstrated better in control and organic ambience in comparison to inorganic ambience.

The number of fruits may increase due to the greater number of flowers remained on the plant and increase the chances to form more fruits by the plants treated with organic manures as made from animal excreta or other agricultural wastes and improve the structure and physical stability of the soil. High fruit yield and nutrient contents of plants nourished with organic fertilizer could be due to the fact that the nutrients are slowly released to the plants. The findings are supported by several others (Ibrar Ali *et al.* 2015; Mukta *et al.* 2015).

Fruit weight (g)

Statistical analysis of data revealed that fruits weight was significantly affected by different varieties. Maximum fruit weight was gained by Avinash-3 plants grown under

Table 3 Various morphological, fruiting and yield traits of different tomato varieties with different treatments (T1 – Organic, T2 – Inorganic and T3 – Control)

Variety	Plant height (cm)			Branches plant^{-1}			Leaves plant^{-1}			Flowers plant^{-1}			Fruits plant^{-1}			Fruit weight (g)			Fruit length (cm)			Fruit diameter (cm)		
	T_1	T2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3	T_1	T_2	T_3
V1	51.7 (+13.12%)	50.7 (+50.7)	45.7	39.0 (+40.7)	20.0 (27.7)	27.7	195.0 (+69.56)	100.0 (13.1)	115.0	95.3 (+51.99)	71.7 (+14.3)	62.7	25.0 (+7.3)	22.0 (5.5)	23.3	19.7 (+81.3)	14.7 (+37.3)	10.7	3.0 (+50)	2.4 (+20)	2.0	2.8 (+21.7)	2.7 (+17.3)	2.3
V2	43.7 (-1.35)	52.0 (+17.3)	44.3	16.0 (-0.41)	22.3 (+33.5)	16.7	80.0 (+3.89)	112.0 (+45.4)	77.0	47.3 (-2.8)	69.3 (+42.2)	48.7	22.7 (-6.58)	27.7 (+14)	24.3	49.7 (+95.2)	29.7 (+17.3)	25.3	4.2 (+27.27)	4.1 (+24.2)	3.3	4.7 (+11.9)	4.9 (+16.6)	4.2
V3	47.3 (+10.0)	56.3 (+40)	43.0	16.3 (-14.2)	18.0 (-5.2)	19.0	81.7 (+63.4)	90.7 (+81.4)	50.0	66.7 (+8.80)	79.3 (+29.3)	61.3	30.7 (+1.52)	28.3 (0.0	28.3	19.0 (0.00)	28.3 (+48.9)	19.0	4.1 (+7.8)	6.8 (+86.8)	3.8	3.9 (-9.3)	4.6 (+6.9)	4.3
V4	51.3 (6.87)	49.3 (+2.7)	48.0	19.0 (+16.56)	18.3 (+12.2)	16.3	95.0 (+20.25)	91.7 (+15.6)	79.0	72.3 (+3.73)	71.3 (+2.2)	69.7	26.7 (+1.53)	31.3 (+19)	26.3	34.0 (+18.4)	30.7 (+6.9)	28.7	5.3 (+29.26)	6.8 (+65.8)	4.1	5.3 (+12.7)	5.4 (+14.8)	4.7
V5	41.3 (+4.03)	49.3 (+24.1)	39.7	15.0 (+4.89)	15.0 (+4.8)	14.3	75.0 (+4.60)	75.0 (+4.6)	71.7	51.7 (+14.22)	51.7 (14.8)	45.0	23.0 (+15)	24.0 (+20)	20.0	28.0 (+8.9)	32.7 (+27.2)	25.7	3.6 (-2.7)	4.2 (+13.5)	3.7	2.9 (-6.4)	3.5 (+12.9)	3.1
CD at 5% for varieties	2.67			4.128			19.81			12.146			N/A			6.521			0.512			0.509		
CD at 5% for Treatment	2.068			N/A			15.345			9.409			N/A			5.051			0.397			0.394		
CV (%)	5.781			21.774			22.052			19.472			29.752			25.468			13.027			10.419		

*Percentage Increase/decrease in T1 (organic Treatment) and T2 (Inorganic Treatment) over control is shown in parenthesis. V1: Angoorlata V2: Avinash3 V3: Pusa Rohini V4: Pusa Sheetal V5: Swaraksha

organic ambience. Angoorlata and Pusa Sheetal exhibited higher fruit weight under organic application. In case of inorganic fertilizer, the maximum fruit weight was recorded for Swaraksha followed by Pusa Sheetal (Table 3). However, the variety Pusa Sheetal gave best fruit weight as control.

The almost static performance of Pusa Sheetal fruit weight may be due to genetic attributes of the variety. The increase in fruit weight may be due to slow decomposition of organic residues, nutrient release pattern, carbon-nitrogen ratio and physiological fitness. This is in conformity of Masarirambi *et al.* (2009).

Fruit length (cm)

The differences in fruit length due to different nutrient treatment were significant. The maximum tomato fruit length (6.83 cm & 6.82 cm) were observed in tomato *var.* Pusa Sheetal and Pusa Rohini respectively with application of inorganic fertilizer and Pusa Sheetal performed best across the diverse ambience (Table 3). This is in conformity of the Mukta *et al*. (2015).

Fruit diameter (cm)

The variation in the diameter of the fruit due to varieties was found to be statistically significant, while their interaction was non-significant (Table 2). Tomato *Var.* Angoorlata and Pusa Sheetal are the only varieties showing higher diameter of fruit with the application of organic nutrient manure in comparison to application with the inorganic nutrient source and other three genotypes performed better in inorganic ambience. However, amongst the all varieties Pusa Sheetal was the overall best performer across the diverse ambient (Table 3).

Yield (t ha^{-1})

The yield was significantly influenced by varieties, ambience along with interactions between varieties and ambience. Mean value depicted that maximum yield 64.01 t ha^{-1} was recorded in tomato *var* Pusa Rohini, grown under inorganic ambience. Angoorlata and Pusa Sheetal showed better performance with application of organic nutrients in comparison to inorganic nutrients (Fig 1). However, the varieties Avinash-3, Pusa Rohini and Swarakksha gave best yield in inorganic ambience. The increase and decrease in tomato yield may be due to the genetic potential of each variety and positive changes in the total yield by supplementing the essential elements for tomato plants brought about through different nutrient sources.

The findings are in the conformity of several others (Abduli *et al.* 2013; Pradeep Kumar *et al.* 2017).

Shelf life

The shelf life of tomato fruit at room temperature was significantly influenced by varieties as well as treatments as organic and inorganic manures. The genotypes Pusa Sheetal (7.67), Pusa Rohini (7.00), Angoorlata (6.66) and Avinash-3 (4.66) gave maximum shelf life days respectively grown in organic ambient. The hybrid Swarakksha did not express any differential behavior for shelf life in relation to organic and inorganic ambience. Over all organic ambience gave better shelf life at room temperature.The shelf life of tomato fruit at refrigerated condition was significantly influenced by varieties as well as interactions between varieties and treatments as organic and inorganic manures. The shelf life was higher in organic nutrient ambience than in the inorganic ambience for all the genotypes. Maximum shelf life of 15.33 days was recorded in tomato *var* Pusa Sheetal followed by Angoorlata and Pusa Rohini (Fig 2). The best shelf life of tomato in refrigerated condition is conformity of Hasanuzzaman Akand *et al* (2015).

Several studies confirm that tomatoes coming from organic ambience present higher vitamin C content than fruits from inorganic cultivation as organic farming doesn't use nitrogenous fertilizers, as a result, plants respond by activating their own defense mechanisms, increasing the levels of all antioxidants. Stressed plants produce more polyphenols giving oxidative stress and the accumulation of higher concentration of soluble solids such as sugars and other compounds contributing to fruit nutritional quality such as Vitamin C and polyphenol compounds. A non-significant difference in the days to fruit rotting under storage could as well be ascribed to the no variation in the chemical composition of the different treatments and the possible reason for better shelf life may be attributed to better growth resulting into firm fruits with more pericarp thickness, on account of proper and adequate availability of all macro and micro nutrients (Laxmi *et al.* 2015; Abolusoro *et al.* (2017).

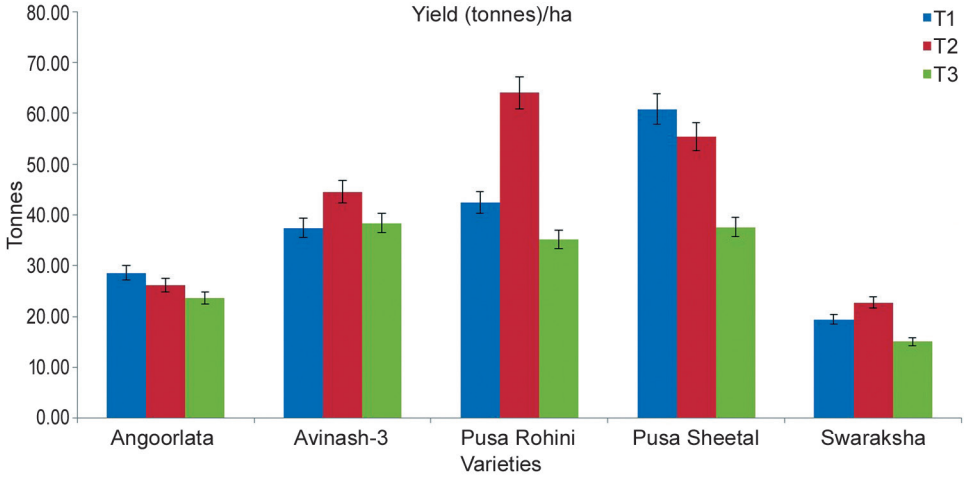

Fig 1 Yield of tomato crop in t/ha of different tomato varieties with different treatments (T1- Organic, T2- Inorganic and T3- Control).

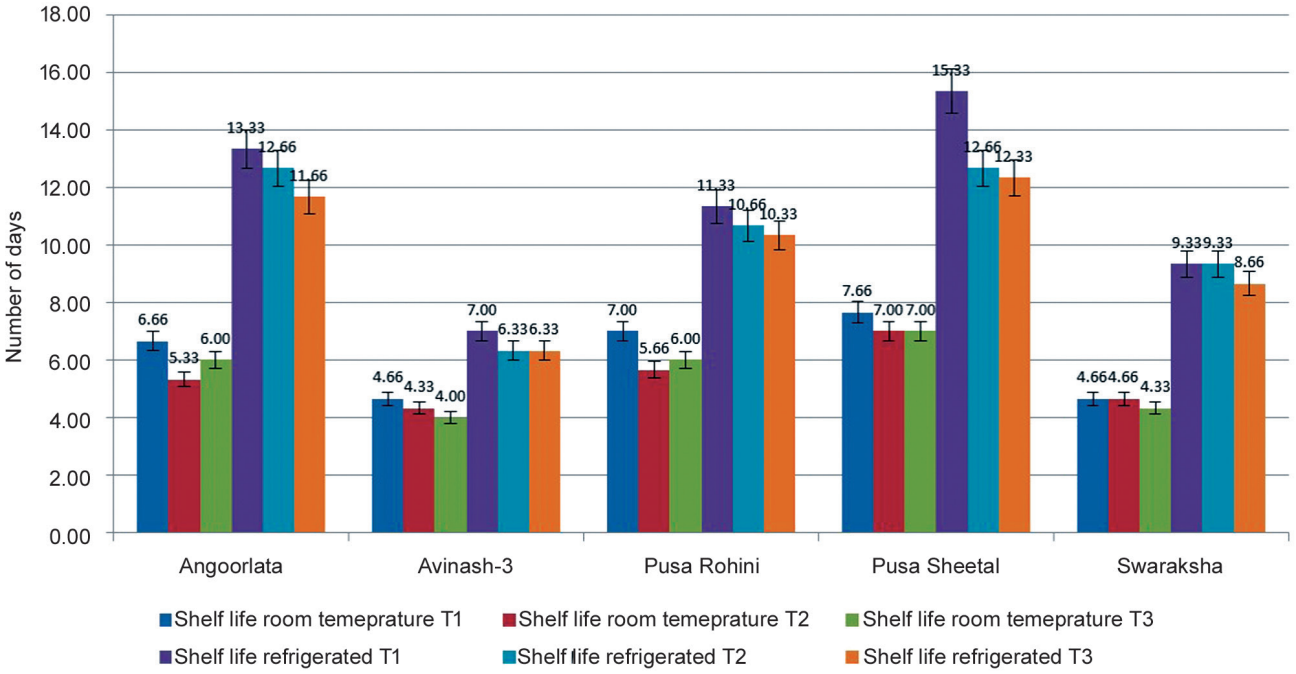

Fig 2 Shelf life observations of different tomato varieties with different treatments (T1 – Organic, T2 – Inorganic and T3 – Control).

It is concluded that different tomato varieties behaved significantly different from each other concerning various parameters. Amongst the tomato varieties grown in organic ambience Angoorlata gave best performance for the plant height, number of branches, number of leaves and number of flowers; the hybrid Avinash-3 gave best fruit weight; Pusa Rohini have highest number of fruits; Pusa Sheetal maximum fruit length, fruit diameter, yield, and shelf life at both room and refrigerated conditions. Amongst the tomato varieties grown in inorganic ambience the Pusa Rohini gave best performance for plant height, flowers/plant and yield; Avinash-3 gave highest number of leaves; Pusa Sheetal gave best performance for fruits/plant, fruit length, fruit diameter and shelf life at both room and refrigerated conditions. However, Swaraksha gave highest fruit weight. Amongst the tomato varieties grown in controlled ambience best performers were the Angoorlata for number of branches and number of leaves; the Pusa Rohini for number of fruits; Pusa Sheetal for plant height, number of flowers, number of fruits, fruit weight, fruit length, fruit diameter, yield and shelf life at both room and refrigerated conditions. Thus, the variety Pusa Sheetal gave best performance for yield contributing attributes as well as highest shelf life at refrigerated condition in organic ambience, a novel finding reported first time may have a larger scientific and practical importance for breeding of new genotypes. Thus, to encourage organic farming due to various advantages such as food safety, free from any chemical fertilizers and eco and health friendly variety Pusa Sheetal should be promoted for production and utilization for further advancement in crop improvement programmes to breed newer genotypes with enhanced self-life and yield potentials.

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