General Impact Factor (GIF): 0.875
Scientific Journal Impact Factor: 1.205

e- ISSN: 2394-5532
p- ISSN: 2394-823X

International Journal of Applied And Pure Science and Agriculture

www.ijapsa.com

Evaluation of tomato hybrids for fruit, yield and quality traits under polyhouse conditions

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Abstract

Protected cultivation is gaining momentum in India since it offers protection from adverse climate and weather, which ultimately influences the overall productivity and quality of vegetables. Tomato is a premier vegetable crop of round the year and one of the prominent eco-industrial crops of India generating sizeable employment. The present investigation was conducted at Department of Olericulture, College of Agriculture, Vellayani, Kerala. Twelve tomato hybrids were obtained from public and private sectors and grown under polyhouse conditions. The analysis of variance revealed significant variation among the hybrids for all the characters. Ample variability was observed for vegetative characters as obvious from the wide range obtained for the different characters. INDAM 9802 was the earliest to flower (26.27 days) among the hybrids. Tomato F1 T30 had the potential of setting maximum fruits per plant (35.66) followed by Tomato F1 Queen (35.55). INDAM 9802 recorded the maximum yield of 1444.40 g followed by Tomato F1 T 30 (1412.22) and have the potential to be cultivated under protected conditions of Kerala. A wide range of variation was observed for the biochemical constituents of the fruits. Polyhouse tomatoes had better colour and appearance than those from the field. It has been observed that polyhouse grown tomatoes have potential for better performance and higher fruit yield than open field conditions.

Key Words : Tomato, polyhouse, shade, yield, hybrids.

I. INTRODUCTION

Protected cultivation is a unique and specialized form of agriculture in which the microclimate surrounding the plant is controlled partially or fully, as per the requirement of the plant species grown during their growth period (Mishra *et al*., 2010). The intent is to grow crops where otherwise they could not survive by modifying the natural environment to prolong the harvest period often with earlier maturity, to increase yield, improve quality, enhance the stability of production and make commodities available when there is no outdoor production. The principal vegetable crops, produced under protected conditions in India are tomato, cucumber, muskmelon, capsicum, lettuce and cauliflower. Many greenhouses in southern and western states are specialized in the production of vegetable transplants, particularly tomato, lettuce, sweet pepper, eggplant, cabbage, broccoli and cauliflower.Tomato (*Solanum lycopersicum* L.) is a warm season crop and requires a relatively long growing season and moderately high temperature (20-28°C). The optimum fruit setting is at night temperature and the optimum range is 15°-20°C. Tomato, the globally leading popular vegetable belonging to Solanaceae family is being extensively cultivated under protected conditions and gives higher returns. Protected cultivation of tomato offers distinct advantages of earliness, higher productivity and quality particularly pesticide residue free produce, besides higher returns to growers. Being an important vegetable crop, research on every aspect of tomato cultivation to improve the productivity becomes essential. India has entered into the area of greenhouse vegetable cultivation more recently only. India being a vast country with diverse

and extreme agro-climatic conditions, the protected vegetable cultivation technology can be utilized for year round and off-season production of high value, low volume vegetables, production of virus free quality seedlings, quality hybrid seed production and as a tool for disease resistance breeding programs (Wani *et al.,* 2011). In the present scenario of perpetual demand of vegetables and drastically shrinking land holdings in the country, it is the best alternative and drudgery less approach for using land and other resources more efficiently. In Kerala, the thrust is now being given for protected cultivation using hybrids. This is so more in the case of tomato, especially indeterminate types. Keeping these in view, the present project is undertaken to identify superior and promising tomato hybrids with respect to yield, disease resistance and quality of the produce under protected conditions in Kerala.

II. MATERIALS AND METHODS

The present investigation was conducted at the Department of Olericulture, College of Agriculture, Vellayani during November 2013 to May 2014 to identify superior tomato hybrids for polyhouse cultivation. Twelve tomato hybrids were obtained from public and private sectors for this study. Seedlings were raised in portrays filled with potting mixture The tomato hybrids used for this experiment were laid out in RBD with three replications. The experiment was conducted in saw tooth type naturally ventilated polyhouse of gutter height of 5m, gutter slop of 2% and size 1000 m^2 (50 m x 20 m) located in Instructional farm, Vellayani. The framework is made of GI pipes of 76mm ID, 2-3 mm thickness. The roof is made of 200 micron UV stabilised polyethylene sheet and the sides made of 25% shade net. The poly house is provided with fogger unit to control temperature. Seedlings were raised in portrays filled with potting mixture. Transplanting was done at a spacing of 75 x 60 cm in raised beds. Plants were supported with stakes and trained to grow vertically upwards along a polythene twine which is tied at gutter height of 3m. Periodic pruning the plants helped to facilitate easy training operation, but also permit closer planting, early ripening of fruits and get higher yields of larger sized fruits. Five plants were randomly selected per accession per replication for recording observations and the mean worked out. Analysis of variance was done based on RBD as suggested by Panse and Sukhatme (1985) for each of the characters separately.

III. RESULTS AND DISCUSSION

Analysis of variance revealed significant differences among the 12 hybrids of tomato under polyhouse condition for all the characters studied *viz.*, plant height (cm), height at flowering (cm), node to first inflorescence, internodal length(cm), leaf length (cm), leaf width (cm), days to first flowering, days to fruit set, flowers per cluster, inflorescence per plant, fruit set (%), pollen viability (%), fruits per plant, truss per plant, fruits per truss, fruit length (cm), fruit girth (cm), fruit weight (g), yield /plant (g), TSS, beta carotene, lycopene and ascorbic acid. Mean sum of squares were found significant for all treatment because all genotypes are genetically different from each other and showed significant variation among each other. Mean sum of squares of replication was not significant because among replication there is no significant difference within genotypes.

In the present study remarkable variation in the mean performance of hybrids was observed for vegetative characters like plant height, leaf length, leaf width etc. The observations recorded on plant height in different tomato hybrids grown under polyhouse ranged from 1.17 m to 2.80 m. The results indicated that under the polyhouse conditions tomato hybrid Naveen was the tallest with a height of 2.80 m which was on par with Rakshitha (2.79m). The accession INDAM 9802 recorded the minimum height (1.17m) among the hybrids. The plants received comparatively lower light intensity than the open condition there by facilitating cell elongation and increased intermodal length leading to an increase in

plant height. Ganesan (2001) revealed that Pusa Ruby attained maximum plant height (2.11m) under greenhouse conditions. However, as per the studies of Cheema *et al*. (2013), tomato hybrids grown in open field conditions show ranges in between the 81 to 181cm. Rakshitha had maximum height at flowering (87.74 cm) while grown under protected conditions. INDAM 9802 had minimum height at flowering (59.09 cm) and was on par with Indam Ruchi (59.26 cm). Polyhouse tomato plants had better plant height and leaf size as compared to open cultivation. Optimum temperature, increased carbon dioxide concentration, better light distribution etc might have contributed to the better crop growth. This agree with the results of Smitha (2002), Kumar and Arumugam (2010) and Reddy *et al*. (2013). The hybrid Rakshitha had maximum leaf length (36.72 cm) which was on par with Naveen (36.47 cm). Leaf width was also high in Rakshitha (26.51 cm) and Naveen (26.16 cm). The shaded plants had large leaves with long petioles resulting in more area for better light interception thereby increased the light harvesting efficiency of the plants. This is how plants under shade tend to adjust the specific environment without compromising the yield potential. This finding is in line with Smitha (2002). A higher concentration of carbon dioxide results in greater leaf expansion and larger canopy as reported by Suseela (2013).

The present study revealed that hybrids showed early flowering under poly house conditions. INDAM 9802 was the earliest to flower (26.27 days) and Rakshitha was the latest to flower (29 days) under polyhouse conditions. Commencement of flowering with minimum number of days is a desirable character since it denotes earliness. This is in agreement with the investigation in tomato by Kumar and Arumugam (2010). The hybrids showed a variation of 9.93 (INDAM 3004) to 14.33 (Rakshitha) for node to first flower.

There was a significant difference in the number of flowers per cluster in different tomato hybrids grown under polyhouse (5.65-7.16). Gavrish *et al*. (1998) revealed that tomato hybrid Malyshock produced 6-7 flowers per inflorescence under plastic green house and Cheema *et al*. (2013) reported a range of 5.00 to 10.00 for flowers per cluster under net house conditions. The inflorescence per plant is an important character which influence the total yield of the plant. Maximum number of inflorescence per plant was recorded in Tomato F1 T 30 (29.80). Though the plants may produce a lot of inflorescence all of them may not bear fruits. Truss per plant ranged from 10.87 in INDAM Ruchi to 24.20 in Tomato F1 T 30 with a mean of 15.39. This is in accordance of the results of Singh *et al*. (2005) and Cheema *et al.* (2013).

The number of fruits per truss is a genetic character and is also governed by the micro climatic condition surrounding the tomato plant under the polyhouse conditions. Tomato F1 Queen recorded maximum number of fruits per truss (3.49) among the 12 hybrids. Tomato crop grown under polyhouse conditions produced higher number of fruits per cluster than in the open field conditions because, better environmental conditions under polyhouse helped in better pollination which leads to more fruit setting as revealed by Gavrish *et al*. (1988) and Cheema *et al*. (2013). INDAM 3004 registered minimum number of fruits per truss (2.01). Reduced number of fruits per truss in tomato hybrids might be due to excessive style elongation and exertion of the stigma through the mouth of the antheridial cone. Pollen viability is one of the essential requirements for good fruitset. Pollen viability was maximum in INDAM 3001 (50.16) and minimum in Tomato F1 Queen (40.16). Maximum fruit set percentage was recorded in Arka Rakshak (53.0) whereas INDAM 3004 recorded the minimum fruitset (33.78). Cheema *et al.* (2002), and Arora *et al.* (2006) reported variations in fruits setting percentage due to variation in pollen release under fluctuating heat stress environment. Fruit length was maximum in Rakshitha (6.74 cm) and minimum in INDAM Ruchi (5.49 cm). Fruits of INDAM 3001 recorded maximum girth of 6.61 cm and

fruits of INDAM 3004 recorded minimum girth of 4.68 cm. The observations recorded on average fruit weight in different tomato hybrids grown under polyhouse conditions indicated that tomato hybrid, INDAM 3001 had maximum average fruit weight (102.19 g) whereas, INDAM Ruchi had the minimum average fruit weight (41.81g). Arora *et al*. (2006) and Cheema *et al.* (2013) reported similar variations for fruit characters under protected cultivation.

As far as number of fruits per plant are concerned, the result indicated that under polyhouse Tomato F1 T 30 had the potential of setting maximum fruits per plant (35.66) which was on par with Tomato F1 Queen (35.55). Tomato varieties varied in their reaction under polyhouse conditions than in open field conditions, as supported by the experiment conducted by Singh *et al* (2005) and Cheema *et al*., (2013). The genetic make up of the plantdecides its yield potential. But the expression of the yield is influenced by the environmental factors in which plant grows. In the present study yield per plant (g) showed a wide variation from 841.77 in INDAM 3004 to 1444.44 in INDAM 9802 which was on par with Tomato F1 T 30 (1412.22) with a mean of 1128.28. Maximum fruit yield per plant of tomato hybrids was due to higher fruit set and higher retention of matured fruits/plant. High yield recorded by INDAM 9802 might be due to the genetic potential of plant to produce fruits in less number but larger in size. Genotypic combination plays an important role in the development of fruit size and weight. Similar results were reported by the Mangal and Jasim (1987) in plastic house, Papadopoulos and Ormrod (1991) in green house, Munshi and Kumar (2000) under greenhouse conditions and Choudhury and Bhuyan (1992) in shade house. Chandra *et al.* (2000) found that tomato hybrid Naveen performed better under green house. Hazarika and Phookan (2005), Singh *et al* (2005) and Cheema *et al*. (2013) reported similar results under polyhouse conditions. For better utilization of light and temperature, the compensation point between photosynthesis and respiration in relation to light intensity and temperature is important. The light intensity and temperature at which photosynthesis and respiration are exactly balanced are important to make a better use of both these climatic parameters under protected conditions. A genotype exhibiting a compensation point at low light intensity and temperature may have a high photosynthetic efficiency and such genotypes perform better under shade.

Quality characters are very important in any crop especially in vegetables like tomato because they impart nutritional quality of the produce as well as processing quality. In the present study, different hybrids showed variation in quality characters like ascorbic acid, lycopene, TSS and vitamin A. Fruits of INDAM 3003 recorded the highest TSS of 5.36 degree Brix which was on par with Rakshitha (5.35). A low TSS of 5.15 was recorded by NS 2535. The results indicated that under the net house conditions tomato hybrid Naveen recorded maximum ascorbic acid content (25.46mg) whereas, minimum ascorbic acid content (20.64 mg) was recorded in INDAM Ruchi. Increased ascorbic acid content of tomato under shading was also reported by Smitha (2002). Tomato is a rich source of Bbeta carotene. In the present study beta carotene exhibited a range of 145.75 in Arka Rakshak Tomato to 171.30 in F1 T 30. Polyhouse tomato fruits exhibited a higher content of lycopene. Fruits of INDAM 9802 recorded the maximum lycopene content of 11.94 which was on par with INDAM 3003 (11.34) and Arka Samrat exhibited a minimum lycopene content of 5.97. This is in consonance with the experiments conducted by Singh *et al*., (2005) and Suchindra *et al.* (2012), Cheema *et al*., (2013). An additional advantage of improved fruit appearance was noticed under the polyhouse tomato fruits. Fruits under shade were uniformly red coloured with very good appearance.

In this study, crop inside poly house was comparatively free from pest and disease incidence. Increased fruit yield per plant under polyhouse condition compared to open field condition due to minimum incidence of pest and insects under polyhouse was reported by Singh *et al*. (2012) in tomato

and capsicum. Influence of shade on disease incidence on tomato was reported by Kittas *et al*. (2009). Similar results was reported by Monica *et al*. (2014) and Shah and Shukla (2014).

IV. CONCLUSION

Under polyhouse conditions, tomato hybrids performed well for yield and quality characters because of favourable conditions which positively influenced the morpho-phenological and physiological events of tomato plants. The differential shade responses of different hybrids is due to the inherent variability that exists among them. It is concluded that INDAM 9802 and Tomato F1 T 30 were found to be the high yielding hybrids under polyhouse conditions for the area under consideration. The higher yields in these hybrids might be due to cumulative effects of early flowering, higher fruit set and higher retention of matured fruits per plant. The optimum temperature accompanied by low relative humidity inside polyhouse hasten crop development and early maturity, so growers are benefited by being able to produce higher and off-season tomato which fetched premium prices in the market.

V. ACKNOWLEDGEMENTS

One of the authors (Lekshmi S. L.) is grateful to the Kerala State Council for Science, Technology and Environment (KSCSTE), Kerala for the award of research fellowship programme.

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Table 1. Mean performance of 12 tomato hybrids

Character	Tomato F1 Queeen	Tomato F1 T 30	INDAM 3001	INDAM 3003	INDAM 3004	NS 2535	INDAM Ruchi	INDAM 9802	Arka Samrat	Arka Rakshak	Naveen	Rakshitha	CD (5%)
Plant height	2.15	2.65	1.67	1.51	1.39	1.34	1.36	1.17	2.37	2.46	2.80	2.79	0.14
Height at flowering	71.82	71.70	68.59	66.91	64.32	64.60	59.26	59.09	70.35	79.85	81.59	87.74	3.29
Node to first Inflorescence	11.13	11.33	10.53	10.87	9.93	12.67	12.13	11.27	12.47	12.13	14.20	14.33	0.72
Internodal length	9.86	9.53	8.35	8.23	8.96	8.38	8.57	8.33	8.69	9.17	10.95	11.18	0.47
Leaf length	24.13	28.54	21.75	24.14	27.34	20.73	21.69	23.35	28.54	28.82	36.47	36.72	1.73
Leaf width	15.91	19.02	18.65	19.46	21.17	17.05	12.33	16.03	21.37	25.01	26.16	26.51	1.27
Days to flowering	27.20	28.67	27.07	27.33	27.80	28.53	27.60	26.27	27.60	28.40	28.93	29.00	0.79
Days to fruitset	7.27	7.47	7.73	8.67	8.60	8.60	8.80	8.60	9.00	8.93	9.40	9.53	0.64
Flowers per cluster	7.00	7.16	5.99	6.00	5.96	6.05	6.33	5.65	6.13	6.00	6.67	6.40	0.58
Inflorescence per plant	27.07	29.80	25.73	17.33	15.20	14.40	12.73	12.60	17.00	17.33	17.53	18.07	1.56
Fruit set	50.14	44.08	46.69	50.25	33.78	42.24	44.42	45.03	51.82	53.00	51.62	51.91	8.51
Pollen viability	40.16	46.51	50.16	44.25	41.55	41.18	41.08	41.59	41.29	42.62	44.68	44.63	1.44
Fruits per plant	35.55	35.67	21.95	23.26	18.13	25.63	23.85	22.85	27.83	25.31	17.39	19.40	2.42
Truss per plant	23.13	24.20	18.00	14.73	12.00	11.33	10.87	11.60	13.73	14.07	15.27	15.80	1.19
Fruits per truss	3.49	3.16	2.80	3.01	2.01	2.56	2.82	2.53	3.16	3.18	3.42	3.32	0.47
Fruit length	5.67	5.88	5.84	5.50	5.55	6.01	5.49	5.53	5.54	5.57	6.34	6.74	0.23
Fruit girth	5.31	5.39	6.61	4.84	4.68	4.69	5.63	5.48	5.30	5.54	5.59	5.99	0.34
Fruit weight	85.54	87.81	102.19	79.33	86.44	67.79	41.81	77.19	48.86	57.07	61.84	61.83	3.01
Yield per plant	1324.75	1412.22	1082.67	1265.76	841.77	911.39	929.45	1444.44	928.47	1093.42	1210.37	1094.65	62.72
TSS	5.30	5.21	5.22	5.36	5.28	5.16	5.22	5.28	5.26	5.24	5.28	5.35	0.87
Beta carotene	145.97	171.30	151.29	161.98	156.33	161.46	161.96	153.48	147.18	145.75	167.89	169.83	5.34
Lycopene	11.03	10.33	9.81	11.34	10.82	10.06	11.14	11.94	5.97	9.46	10.35	11.38	1.22
Ascorbic acid	23.74	22.66	24.42	23.09	24.13	21.65	20.64	23.91	24.89	25.07	25.46	25.41	1.00