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Performance of a Set of Tomato Parental Lines and their Hybrids for Quality and Yield under Conditions of Bengaluru, India

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ABSTRACT

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Hybrids in tomato are of great practical importance nowadays owing to their early and high yields in addition to the improved disease resistance and quality characters. Nine parental lines were crossed to obtain 18 F₁ hybrids, which were evaluated along with their parents and 2 commercial check hybrids to know their performance under the conditions of Bengaluru, which is the major tomato production hub of India. Among parents IIHR 2853, IIHR 2852 and IIHR 2892 with the yield of 3.31 kg/plant, 3.19 kg/plant and 2.86 kg/plant, respectively were found to be better yielders coupled with admirable quantity of carotenoids and lycopene. However, none of the hybrids was found to be best performer for all the traits under the study, but IIHR 1816 x IIHR 2852, IIHR 1816 x IIHR 2853, IIHR 1816 x IIHR 2890, IIHR 2850 x IIHR 2852, IIHR 2891 x IIHR 2853, IIHR 2892 x IIHR 2852 and IIHR 2892 x IIHR 2890 were best performing in maximum number of quality and yield attributing traits like vitamin C, carotenoids, lycopene, pericarp thickness, average fruit weight and yield/plant, hence they can be further evaluated and used for cultivation in Bengaluru's condition since their performance is on par with that of standard check hybrids in many of the characters.

Introduction

Tomato, being the most widely used and nutritive vegetable has a special importance in Indian subcontinent due to its inevitable use in almost all the dishes, processed products like pickle, jam, ketchup and also as a delicious salad vegetable. Tomato (*Solanum lycopersicum* L.) belongs to the family solanaceae with chromosome number 2n=24 and is a native of Peru, Ecuador region (Rick, 1969) and alleged to have been carried to India during the 16th century through far eastern countries. Although, tomato does not rank high in nutritional value, by virtue of

volume consumed, it contributes significantly to the dietary intake of vitamins A and C, as well as essential minerals and other nutrients. Fresh and processed tomatoes are the lushest sources of the dietary antioxidant lycopene, which possibly protects cells from oxidants that have been associated with cancer (Rao and Rao, 2007). It is also a source of other compounds with antioxidant activities, including chlorogenic acid, plastoquinones, rutin, tocopherol and xanthophylls (Leonardi *et al.*, 2000). It is a warm season crop reasonably resistant to heat and drought and

grows under wide range of soil and climatic conditions.

Since tomato is a very good source of income to small and marginal farmers in India, it ranks third in area immediately after potato and onion crop and second in production immediately after the potato Crop (Anon., 2016). Even though India is the second largest tomato producer in the world next to China, the productivity lies large below the average productivity of many small countries due to number of reasons ranging from climatic conditions to technology employed in management of crop, but most importantly the poor selection of varieties suitable to a particular region. Seed source or the variety is the cheapest input in crop production, yet the most important and yield deciding factor in the course. Commercially grown varieties are low yielder as compared to hybrid tomatoes which have advantages of uniformity in shape and size, increased vigor, early maturity, high yield and resistance to specific pests and pathogens. Hence the present experiment was designed to evaluate the 18 tomato hybrids developed by 9 diverse parents for quality and yield components under the conditions of Bengaluru (Karnataka).

Materials and Methods

Present investigation was carried out at Experimental plot of Division of vegetable crops, Indian Institute of Horticultural Research (IIHR), Bengaluru, Karnataka. The experimental field was located at an altitude of 890 meters above MSL 130.58° N latitude and 770.37° E longitude.

Hybrid seed production

Nine diverse genotypes, namely IIHR 977, IIHR 1816, IIHR 2848, IIHR 2850, IIHR 2891, IIHR 2892 as female parents (Lines) and IIHR 2852, IIHR 2853, IIHR 2890 as

male parents (Testers) were crossed in Line × Tester fashion during *rabi* 2013-14 to obtain 18 hybrids. Healthy flower buds in a cyme preferably of the first flush which were expected to open in the next day were selected for emasculation and pollination. The selected buds were emasculated by hand using forceps in the evening hours between 4.00 pm to 6.00 pm and were covered with butter paper bags to avoid contamination. The pollination of emasculated flowers was done next day morning during anthesis time (7.00 am to 10.30 am). Well opened flowers with dehisced anthers were collected from the male parents, the butter paper bag was removed carefully and stigma was brought in contact with dehisced anthers of male flowers. The female flower was covered with white coloured butter paper bag immediately after crossing for easy identification and to avoid the contamination from other pollen. The pedicel of each pollinated flowers was tied with label bearing information of female and male parents and date of crossing for identification. The ripe fruits were harvested and the seeds were extracted by fermentation method. Simultaneously, some flowers in each of these genotypes were selfed by covering the flowers with butter paper bags.

Nursery Raising and Cultivation

The seeds of 18 hybrids along with their parents and standard checks (ArkaRakshak and Abhinava) were sown during first week of January 2014 in the plug trays of 98 cells and named accordingly. They were managed well by watering under the protected structure and seedlings reached optimum stage for transplanting in four weeks after sowing. The experimental plot was ploughed repeatedly and brought to a fine filth and FYM was applied at the rate of 25t per ha at the time of land preparation before transplanting of seedlings and ridges were made, polythene mulch was used to avert weeds and to

preserve the root zone moisture. The crop was facilitated with inline dripper through which the irrigation and recommended nutrition was provided for tomato plants as per package of practices recommended by IIHR for tomato crop. The entire plot was divided into subplots all 29 entries (9 parents, 18 hybrids and 2 commercial checks) were assigned to different sub-plots in all replications using random table. Seedlings were transplanted in randomized block design with three replications during February 2014. Each entry was represented by 40 plants in each replication at spacing of 100 cm between rows and 45 cm within row. Seedlings transplanted and were trained using jute twines on to a metal wire that is supported by the wooden stakes fixed at every 5m along the row. Each branch of the plant are tied on to the metal wire as and when they start flowering using separate twines, this supports the fruits to stay high and to avoid touching to the ground. Additionally, spray of *vegetable special*, a micronutrient mixture developed at IIHR was sprayed on plants at flowering and thereafter at every harvest that helps in better plant growth, flowering and yield. Observations on five randomly selected plants were recorded for various growth, yield and quality attributing traits to understand the performance of tomato hybrids and check varieties.

Results and Discussion

The mean performance of the parents and hybrids for various characters under investigation are presented in Table 1 and Table 2, respectively and the results are presented under various sub-headings as follows.

Morphological traits: A range of variation for plant height was observed among the parents and hybrids with IIHR 1816 being the shortest (63.42 cm) to IIHR 2853 (89.54 cm)

being the tallest. Among the F₁'s, the lowest plant height of 73.67 cm was recorded in IIHR 1816 x IIHR 2890 and the highest (91.08 cm) in IIHR 2848 x IIHR 2853. IIHR 2853 (5.33) had least number of branches whereas IIHR 2890 (6.87) had highest number of branches followed by IIHR 2848 (6.61). Amongst the hybrids, IIHR 977 x IIHR 2890 (7.2) was observed to have most branches, whereas IIHR 2850 x IIHR 2890 (5.00) had minimum number of branches per plant. Number of branches decides the production of leaves that decides the efficiency of photosynthesis and number of flowers per plant which may contribute towards better yield, the results were in approval with the work of Arun *et al.*, (2004).

Earliness

The hybrid that flowers or fruits earlier is known to add additional income by exploiting the market demand in the early days of the season, and hence the need is for hybrid with early bearing. Among the parents, IIHR 2892 was found to be earliest to flower (28 days after transplanting) followed by IIHR 1816, IIHR 2852 and IIHR 2848 (28.33 DAT). IIHR 2891 x IIHR 2852 was earliest to flower (26.33 DAT) among the hybrids, while IIHR 1816 x IIHR 2852, IIHR 1816 x IIHR 2853 and IIHR 2891 x IIHR 2853 took 27.33 days after transplanting for 50 per cent flowering, which are comparatively earlier than checks Arka Rakshak (31 DAT) and Abhinava (29 DAT). Lekshmi and Celine (2015) also revealed that the flowering of tomato hybrids was ranged between 26.27 days 29 days after transplanting under polyhouse conditions of Vellayani, Kerala. IIHR 977 and IIHR 2890 (56.33 days) were early to attain fruit maturity among parents, while IIHR 2848 (64.33 days) was late. Arka Rakshak (62.33 DAT) and Abhinava (60 DAT) were bit late to attain fruit maturity. Among the hybrids, IIHR 977 x IIHR 2890 (56.33 days) took minimum days

to attain first fruit maturity, whereas IIHR 2848 x IIHR 2853 and IIHR 2848 x IIHR 2890 (62.33 days) took more number of days.

Quality traits

Firmness of fruit is most important trait since it influences the shipping ability and keeping quality of fruit. Parent IIHR 2853 had firm fruits (8.37 kg/cm²), followed by IIHR 2850 (8.14 kg/cm²), IIHR 2852 (7.42 kg/cm²) and IIHR 2890 (7.36 kg/cm²). The firmness of the hybrids ranged from 5.02 kg/cm² to 8.78 kg/cm² with the hybrids IIHR 1816 x IIHR 2890 and IIHR 2891 x IIHR 2890 having least firm fruits with *per se* firmness of 5.02 kg/cm² and 5.85 kg/cm², respectively. The hybrids IIHR 2892 x IIHR 2852 and IIHR 977 x IIHR 2852 were more firm with a mean value of 8.78 kg/cm² and 7.46 kg/cm², respectively. Fruits with more number of locules found to be having more juice content in them, whereas fruits with lesser number of locules are said to be physically firmer. IIHR2891 (2.44) had minimum number of locules per fruits and hence better firmness, while IIHR 2853 (6.33) showed the maximum number of locules per fruit and hence more juice content in it. Lower number of locules per fruit was noticed in the hybrids IIHR 2891 x IIHR 2852 (3) and IIHR 977 x IIHR 2852 (3.11). Higher number of locules per plant was registered in the hybrids IIHR 1816 x IIHR 2853 (6.28) and in IIHR 2850 x IIHR 2853 (5.89). Arka Rakshak was found to have firmer fruits (8.47 kg/cm²) than any of the other hybrids under study and the variations obtained for fruit firmness and number of locules is in accordance with the findings of Truong *et al.*, 2015. Pericarp thickness of the fruit also contributes to the shipping and keeping quality of fruit by providing thick physical barrier against external stresses. Pericarp thickness of parents ranged from 5.55mm (IIHR 2890) to 9.12mm (IIHR 977) similarly, hybrids too displayed wide range of

variation from 5.11mm (IIHR 2892 x IIHR 2853) to 9.22mm (IIHR 2848 x IIHR 2852) and these results were similar to the findings of Hazarika and Phookan (2005) and Renuka *et al.*, 2014.

High total soluble solids (TSS) and low acidity are the major factors well thought-out for manufacture of processed products. One per cent increase in TSS content of fruits result in 20% increase in recovery of processed product (Berry *et al.*, 1988 and Shivanand, 2008). Among the parents, IIHR 2890 showed the highest value for TSS (5.17 °B) followed by IIHR 2848 (4.85 °B), IIHR 1816 (4.82 °B), IIHR 2891 (4.71 °B), IIHR 2852 (4.55 °B) and IIHR 2853 (3.83 °B). Check hybrid Abhinava had highest TSS of 5.03 °B, followed by IIHR 2850 x IIHR 2852 (4.84 °B) and IIHR 2848 x IIHR 2890 (4.72 °B) in contrast to IIHR 2892 x IIHR 2853 (3.90 °B) and in IIHR 2892 x IIHR 2852 (3.94 °B) and this is in consonance with the experiments conducted by Suchindra *et al.*, (2012) and Cheema *et al.*, (2013). High ascorbic acid (Vitamin C) content was found in IIHR 1816 (20.06mg/100g), followed by IIHR 2848 (18.46mg/100g) and IIHR 2892 (12.30mg/100g). Among hybrids, low vitamin C content was observed in Abhinava (7.81mg), IIHR 2850 x IIHR 2852 (8.06mg/100g) and IIHR 2891 x IIHR 2852 (9.4mg/100g), whereas highest vitamin C is recorded in IIHR 977 x IIHR 2853 (18.21mg/100 g) and IIHR 1816 x IIHR 2890 (17.51mg/100 g). Similar variation for TSS has been recorded by Renuka *et al.*, 2014.

With growing health concerns round the globe, tomato provides an option in the form of dietary antioxidants, carotenoids and lycopene that are known to avoid many types of cancer. Additionally, lycopene also provides attractive red colour to the fruit and hence its content in the fruit is a matter of concern.

Table.1 Per se performance of tomato parental lines for quality and yield traits

Hybrid	Days to 50% flowering	Days to first fruit maturity	Plant height (cm)	Number of branches	Fruit firmness (kg/cm ²)	Number of locules	TSS (B)	Pericarp thickness (mm)	Vitamin C (mg/100g)	Total carotenoids (mg/100g)	Lycopene (mg /100g)	Fruits per cluster	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight	Yield/ plant (kg)
IIHR977	29	56.33	71.13	5.66	6.93	2.66	4.21	9.12	9.18	13.41	7.92	2.73	7.11	4.96	126.32	1.68
IIHR1816	28.33	59.33	63.42	5.57	6.47	4	4.82	8.39	20.06	6.61	3.68	3.13	6.16	6.51	136.9	2.69
IIHR2848	28.33	64.33	73.33	6.61	6.67	3.33	4.85	8.77	18.46	7.74	4.46	2.47	6.66	7.27	197.62	1.98
IIHR2850	31.67	62.67	73.24	5.8	8.14	3.89	4.52	7.87	14	5.34	2.92	2.07	6.33	7.42	177.75	2.17
IIHR2891	31.33	59.33	82.93	6.27	6.93	2.44	4.71	7.44	6.73	8.95	5.05	3.27	5.86	4.97	75.09	2.08
IIHR2892	28	62	74.9	5.8	6.89	3.89	4.18	6.55	12.3	11.3	6.18	2.73	5.24	5.38	120.37	2.86
IIHR2852	28.33	59.33	79.08	5.6	7.42	2.89	4.25	7.33	9.5	11.94	7.26	3.2	6.65	4.71	91.41	3.19
IIHR2853	29.67	57.67	89.54	5.33	8.37	6.33	4.05	6.61	9.4	13.09	7.51	2.53	6.38	7.4	144.82	3.31
IIHR2590	29.33	56.33	70.17	6.87	7.36	5.55	4.29	5.55	8.43	16.78	9.61	2.6	4.63	5.26	69.05	2.52

Table.2 Per se performance of tomato hybrids and checks for quality and yield traits

Hybrid	Days to 50% flowering	Days to first fruit maturity	Plant height (cm)	Number of branches	Fruit firmness (kg/Cm2)	Number of locules	TSS (B)	Pericarp thickness (mm)	Vitamin C (mg/100g)	Total carotenoids (mg/100g)	Lycopene (mg/100g)	Fruits per cluster	Fruit length (cm)	Fruit breadth (cm)	Average fruit weight	Yield/ plant (kg)
PIHR977 x PIHR2852	27.67	59.33	84.17	6.43	7.46	3.11	4.25	7.03	13.92	20.62	12.75	3.15	6.39	5.43	100.67	2.73
PIHR977 x PIHR2853	31.33	57.67	90.58	6.67	6.63	3.77	4.05	6.22	18.21	13.5	8.04	3.33	5.75	5.36	109	3.88
PIHR977 x PIHR2890	29	56.33	76.17	7.2	6.92	4.11	4.29	7.11	11.75	8.45	4.69	3.27	5.48	5.72	80.3	3.23
PIHR1816 x PIHR2852	27.33	57.33	84.58	6.2	6.49	4.11	4.12	7.6	10.18	18.52	11.8	2.47	6.04	5.31	120.37	3.19
PIHR1816 x PIHR2853	27.33	57.33	79.75	5.33	6.64	6.28	4.06	7.05	9.95	20.96	13.3	2.87	6.08	6.87	140.19	3.66
PIHR1816 x PIHR2890	27.67	58.67	73.67	6.07	5.02	4.5	4.27	6.32	17.51	12.22	7.55	2.47	5.19	5.85	155.95	3.29
PIHR2848 x PIHR2852	28.33	59.67	84.83	6	8.14	4.33	4.65	9.22	11.06	9.17	5.51	2.33	6.08	6.82	128.55	2.71
PIHR2848 x PIHR2853	28.67	62.33	91.08	5.2	7.01	4.78	4.22	8.44	10.28	13.8	8.59	2.13	7.5	6.85	194.44	3.67
PIHR2848 x PIHR2890	28.67	62.33	84.58	6.77	6.73	5.22	4.72	8.44	10.18	8.9	5.11	2.55	5.75	6.67	104.37	2.96
PIHR2850 x PIHR2852	27.67	61.33	88.58	5.93	6.51	4.94	4.84	7.77	8.06	13.04	8.08	2.6	6.34	6.51	140.21	4.07
PIHR2850 x PIHR2853	28.33	61.67	80.58	5.83	7.11	5.89	4.4	7.44	10.98	12.54	7.63	2.2	6.42	7.55	132.24	3.67
PIHR2850 x PIHR2890	29	57.33	76.5	5	7.27	4.22	4.62	7	9.74	6.34	3.75	2.67	5.21	5.85	76.77	3.25
PIHR2891 x PIHR2852	26.33	57.67	86.08	5.92	6.95	3	4.47	6.22	9.4	9.8	5.85	3.08	6.64	5.43	88.89	3.26
PIHR2891 x PIHR2853	27.33	56.67	87.33	6.53	7.11	4	4.71	6.44	13.25	21.19	13.49	2.47	6.28	5.75	96.01	3.02
PIHR2891 x PIHR2890	28.67	58	80.75	5.2	5.85	5.33	4.53	5.99	10.15	13.54	8.31	2.8	5.15	5.84	91.41	3
PIHR2892 x PIHR2852	27.67	58	86.33	5.87	8.78	5.33	3.94	6.61	12.64	24.17	15.11	2.8	5.62	6.67	117.06	3.19
PIHR2892 x PIHR2853	30.33	57.67	80.33	5.8	7.09	4.33	3.9	5.11	12.85	11.66	7.01	2.6	5.37	6.39	116.67	3.22
PIHR2892 x PIHR2890	28.67	58	76.17	6.1	5.97	4.33	4.45	5.77	13.54	9.48	5.41	2.87	4.84	5.69	104.34	2.88
Arka Rakshak	31	62.33	83.75	5.67	8.47	3.22	4.39	7.83	12	12.96	8.02	3.47	6.54	5.25	103.7	4.55
Abhinava	29.67	60.33	89.42	5.43	6.72	2.67	5.03	6.11	7.81	20.43	12.9	3.47	6.37	5.09	85.85	3.47

Table.3 Best performing hybrids in relation to commercial checks

Hybrids	Yield/plant	Average fruit weight	Vitamin C	Carotenoids	Lycopene	Pericarp thickness
IIHR1816 x IIHR2852	3.19	120.37	10.18	18.52	11.8	7.6
IIHR1816 x IIHR2853	3.66	140.19	9.95	20.96	13.3	7.05
IIHR1816 x IIHR2890	3.29	155.95	17.51	12.22	7.55	6.32
IIHR2850 x IIHR2852	4.07	140.21	8.06	13.04	8.08	7.77
IIHR2891 x IIHR2853	3.02	96.01	13.25	21.19	13.49	6.44
IIHR2892 x IIHR2852	3.19	117.06	12.64	24.17	15.11	6.61
IIHR2892 x IIHR2890	2.88	104.34	13.54	9.48	5.41	5.77
ArkaRakshak	4.55	103.70	12.00	12.96	8.02	7.83
Abhinava	3.47	85.85	7.81	20.43	12.90	6.11

Total carotenoids content oscillated from 11.94mg/100g (IIHR 2852) to 16.78mg/100g (IIHR 2890) among parents. The F₁'s showed wider range of variation from 6.34mg/100g (IIHR 2850 x IIHR 2890) to 24.17mg/100g (IIHR 2892 x IIHR 2852) with checks, Arka Rakshak and Abhinava recording 12.96mg/100g and 20.43mg/100g, respectively. A greater range of variation was observed among the parents (2.92mg to 9.61mg/100g) for lycopene content similar to that of the hybrids, ranging between 3.75mg/100g (IIHR 2850 x IIHR 2890) and 15.11mg/100g (IIHR 2892 x IIHR 2852), however Arka Rakshak and Abhinava recorded 12.9mg/100g and 8.02mg/100g, respectively. Very good variation among hybrids for quality characters like ascorbic acid, lycopene and TSS was also observed by Lekshmi and Celine (2015).

Yield attributing traits

Number of fruits, fruit size and average fruit weight are the entities that directly contribute to the yield per plant and thereby to total yield per unit area. A wide range of variation was observed for fruits per cluster in hybrids with IIHR 2848 x IIHR 2853 (2.13) and IIHR 2850 x IIHR 2853 (2.22) having less number of

fruits per cluster and IIHR 977 x IIHR 2853 (3.33) and IIHR 977 x IIHR 2890 (3.27) having more number of fruits per cluster. Parental line, IIHR 2853 (3.33) had more number of fruits per cluster followed by IIHR 2890 (3.27), IIHR 2891 (3.27) and IIHR 2852 (3.15). Fruit length varied from 4.63cm (IIHR 2890) to 7.11cm (IIHR 977), whereas the mean value of hybrids was in range of 5.15cm (IIHR 2891 x IIHR 2890) to 7.50cm (IIHR 2848 x IIHR 2853). The fruit breadth of the parental lines varied from 4.71cm (IIHR 2852) to 7.42cm (IIHR 2850) with the hybrids ranging from 5.31cm (IIHR 1816 x IIHR 2852) to 7.55cm (IIHR 2850 x IIHR 2853). The magnitude of variation among the parents with respect to fruit weight varied from 69.05g in IIHR 2890 to 197.62g in IIHR 2848. IIHR 1816 x IIHR 2890 recorded the highest fruit weight of 155.95 g, while IIHR 2850 x IIHR 2890 displayed minimum fruit weight of 76.77 g. Among the parents, a range of variation from 1.68 kg (IIHR 977) to IIHR 2853 (3.31kg) while, the highest yield of 4.07 kg/plant was recorded by IIHR 2850 x IIHR 2852, which is comparatively higher than that of Abhinava (3.47kg) but low yielder than that of Arka Rakshak (4.55kg). Other best yielding hybrids include IIHR 977 x IIHR 2853 (3.88 kg), IIHR 2848 x IIHR 2853 and

IIHR 2850 x IIHR 2853 (3.67kg). Results obtained by Ali *et al.*, (2012), Shresta and Sah (2014), Lekshmi and Celine (2015), for fruit length, fruit diameter, average fruit weight and yield per plant also shown similar pattern as of in this experiment. None of the hybrids was found to be superior for all the characters under the study, whereas hybrids like IIHR1816 x IIHR2852, IIHR1816 x IIHR2853, IIHR1816 x IIHR2890, IIHR2850 x IIHR2852, IIHR2891 x IIHR2853, IIHR2892 x IIHR2852 and IIHR2892 x IIHR2890 were found to be embedded with most of the quality and yield traits in them (Table 3), which can be used for cultivation under the conditions of Bengaluru after further necessary evaluations.

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