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Extending harvest duration in tomato (*Solanum lycopersicum* L.) with a combination of varieties, row spacings and planting systems

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Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crop grown throughout the world not only in terms of hectarage, but also in terms of its versatility for adoption under wide range of agroclimatic conditions and crop growing situations. It is one of the most popular cash earning vegetable crops for marginal farmers of India. There is an urgent need to increase the production and productivity of tomato in the country and the state as well. The return from this crop has reduced gradually because of poor farmers practices with respect to plant population and selection of varieties. Generally the farmers are cultivating one type of variety at a time i.e. either determinate or indeterminate and creates gluts in the markets. The demand for semi-indeterminate to indeterminate varieties of tomato is increasing among farmers for extending harvesting period, but growing of such varieties require distant spacings and training that involves high cost of production which is a limiting factor. Therefore, there is need to standardize row spacing and combine of varieties for better utilization of available soil, water and atmospheric resources to enhance productivity and quality of tomato for regulating market and fetching better price by marginal farmer.

The experiment was conducted on tomato cv. Krish (indeterminate) and Shivalika (determinate) with four row spacings i.e. 60 cm (L_1), 80 cm (L_2), 100 cm (L_3) and 120 cm (L_4) and three planting systems *viz.*, 100 % Krish (T_1), 100 % Shivalika (T_2) and 50 % Krish + 50 % Shivalika (T_3) during Sept. 2011 to Feb.2012 at the Hi-Tech Horticulture unit, Department of Horticulture, Rajasthan College of Agriculture, Udaipur. The trial was laid out using Randomized Block Design (Factorial) with three replications and comprised of total twelve treatment combinations. All crop operations stacking, training, intercultural operations, fertilizer, irrigation and plant protection measures were carried out as and when required. For recording different growth, yield and physio-chemical characters; ten plants were randomly selected in each plot and were tagged (while in mixed plot 5 plant of each variety). All observations were recorded and analysed as per standard methodology (A.O.A.C., 1995).

Growth, yield and physico-chemical attributes of tomato varieties were influenced by row spacings and planting systems (Table-1, 2 & 4). Among row spacings, 60 cm gave maximum plant height (118.56 cm) and LAI (2.73) (Table-1). It may probably due to closer spacing create competition for availability of space, water and nutrition for the growing plants. Results of present study are supported by finding of Nargis and Mathew (2000) in tomato. Further, row spacing had significant effect on number of flower clusters plant^{-1}, flower clusters^{-1} and fruit set (Table-1). The maximum number of flower clusters per plant (12.21), flowers clusters^{-1} (5.83) and fruit set (58.06 %) was noticed in L_4 (120 cm) treatment. This might be due to availability of more space which provides better aeration, light interception and nutrition to the plant and the results are in accordance with finding of Mantur and Patil (2008) in wider row spacing.

The data harvesting to physico-chemical characteristic showed that the highest fruit volume (69.32 cc), pulp recovery (60.70%) and TSS (6.20 ^{O}B) was recorded in wider row spacing L_4 (120 cm). Closer row spacing of 60 cm gave higher self life of fruit (6.66 days) and lycopene (3.89 mg/100g) than the wider spacing of 120 cm in tomato (Table-4).

Among the various planting systems, T_1 (100 % Krish) treatment on tomato crop adequately sustained favourable vegetative and reproductive growth as compared to T_2 (100 % Shivalika) treatment due to

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varietal characteristic (Table 1). T_1 treatment gave maximum plant height (143.75 cm at 90 DAT), and LAI (2.78). Present results are supported by Bahadur and Singh (2005) that plant height and LAI was highest in sole planting of indeterminate variety in tomato. Further, planting systems had significant effect on number of flower clusters plant^{-1}, number of flowers cluster^{-1} and fruit set. The maximum number of flower clusters plant^{-1} (14.67) and number of flowers cluster^{-1} (5.68) were recorded in T_1 (Sole Krish), while maximum fruit set (57.54 %) was observed in T_2 (Sole Shivalika). This may be due to genetic characteristics of cultivar (Table 1). Similar results were reported by Singh, (2005) and Muhammad *et al*., (1996). T_2 (Sole Shivalika) resulted highest fruit volume (69.56 cc), pulp recovery (58.40%), TSS (6.70 ^{O}B) and lycopene (3.59 mg/100g) due to varietal characteristics of determinate tomato (Table 4). Maximum self life (6.53 days) of fruit was observed in sole planting of Krish. The present results are confirmed by the earlier reports of Carvalho *et al.,* (2005) and Singh (2003) in tomato.

The interaction effect of row spacings and planting systems (Table 3) showed significant influence on different attributes of tomato (Table-3). It is clearly indicated that wider row spacing (120 cm i.e., L_4) and planting systems T_1 (100 % Krish) exhibited maximum number of fruits plant^{-1} (120). Further, maximum fruit weight (85.83 g) was observed in wider row spacing and sole planting system of Shivalika (L_4T_2). In closer row spacing (60 cm) and mixed planting system (50 % Krish + 50% Shivalika) i.e., L_1T_3 maximum harvest duration (90 day), yield plot^{-1} (70 kg) and yield ha^{-1} (771.02 q) were observed. This might be due to highest number of plant plot^{-1}. These results are supported by the reports of Jang *et al.,* (2000) in tomato.

In conclusion, 60 cm row spacing (L_1) markedly enhanced plant height, LAI, yield, harvest duration, acidity, self-life and lycopene content. Similarly, 50 % Krish + 50 % Shivalika (T_3) planting system produced maximum harvest duration, pickings, and yield along with their combined interaction L_1T_3 (60 cm + mixed

Table 1: Effect of row spacings and planting systems on growth and flowering attributes of tomato cv. Krish and Shivalika.

Treatments	Plant height (cm)	LAI	Number of flower clusters per plant	Number of flower per clusters	Fruit set (%)
Row spacings					
L_1(60 cm)	118.56	2.73	10.22	5.14	51.34
L_2(80 cm)	105.06	2.51	10.82	5.32	54.21
L_3(100 cm)	101.67	2.19	11.44	5.59	55.74
L_4(120 cm)	97.61	1.78	12.21	5.83	58.06
SEm±	2.87	0.04	0.36	0.14	1.60
Planting systems					
T_1(100 % Krish)	143.75	2.78	14.67	5.68	51.68
T_2(100 % Shivalika)	69.33	1.81	7.84	5.23	57.54
T_3(50 % Krish + 50 % Shivalika)	104.08	2.33	11.02	5.50	55.30
SEm±	2.48	0.04	0.31	0.12	1.39

Table 2: Effects of row spacings and planting systems on yield attributes and yield of tomato cv. Krish and Shivalika.

Treatments	**Number of pickings**	**Number of fruits per plant**	**Fruit weight (g)**	**Harvest duration (days)**	**Fruit yield (kg/plot)**	**Fruit yield (q/ha)**
Row spacings						
L_1(60 cm)	5.69	94.59	70.00	58.89	58.78	637.78
L_2(80 cm)	6.03	96.84	73.33	56.44	51.89	559.22
L_3(100 cm)	6.14	100.48	77.00	52.00	44.61	521.56
L_4(120 cm)	6.50	105.87	81.06	45.28	41.17	486.67
SEm±	0.10	1.15	0.66	1.55	1.66	14.35
Planting systems						
T_1(100 % Krish)	6.22	116.83	69.42	53.17	52.25	608.83
T_2(100 % Shivalika)	5.21	80.26	82.54	27.25	36.08	394.58
T_3 (50 %Krish + 50 %Shivalika)	6.85	101.25	74.08	79.04	59.00	650.50
SEm±	0.08	0.99	0.57	1.34	1.44	12.42

Table 3: Interaction effect of row spacings and planting systems on growth and yield attributes of tomato cv. Krish and Shivalika.

Treatments	Plant height (cm)	LAI	Number of pickings	Number of fruits per plant	Fruit weight (g)	Harvest duration (days)	Fruit yield (kg/plot)	Fruit yield (q/ha)	B:C Ratio
L_1T_1	170.00	3.10	5.93	114.67	62.33	56.67	66.67	725.00	2.83
L_1T_2	77.17	2.30	4.43	74.20	79.33	30.00	39.67	417.33	2.62
L_1T_3	108.50	2.80	6.70	94.90	68.33	90.00	70.00	771.00	3.86
L_2T_1	143.50	3.00	6.00	115.83	65.67	55.00	54.00	615.67	2.27
L_2T_2	68.50	1.93	5.30	77.47	81.50	28.67	36.67	404.33	2.56
L_2T_3	104.00	2.60	6.80	97.23	72.83	85.67	65.00	657.67	3.20
L_3T_1	133.33	2.63	6.10	116.80	71.67	54.00	46.67	574.67	2.09
L_3T_2	67.67	1.53	5.43	84.37	83.50	27.00	34.50	383.33	2.44
L_3T_3	103.17	2.40	6.90	100.27	75.83	75.00	52.67	606.67	2.95
L_4T_1	128.17	2.37	6.83	120.00	78.00	47.00	41.67	520.00	1.91
L_4T_2	64.00	1.47	5.67	85.00	85.83	23.33	33.50	373.33	2.43
L_4T_3	100.67	1.50	7.00	112.60	80.00	65.50	48.33	566.67	2.72
SEm±	4.97	0.07	0.17	1.99	1.15	2.68	2.88	24.85	2.83

Table 4: Effect of row spacings and planting systems on Physico-chemical characteristic of tomato cv. Krish and Shivalika.

Treatments	Fruit volume (cc)	Self life of fruit (days)	Pulp recovery (%)	TSS (^{O}B)	Lycopene (mg/100g)
Row spacings					
L_1(60 cm)	62.02	6.66	51.93	5.76	3.89
L_2(80 cm)	64.23	6.32	55.59	5.88	3.54
L_3(100 cm)	65.11	5.98	56.53	6.02	3.30
L_4(120 cm)	69.32	5.47	60.70	6.20	3.09
SEm±	1.64	0.22	0.90	0.11	0.05
CD at 5%	4.80	0.66	2.65	NS	0.15
Planting systems					
T_1(100 % Krish)	59.68	6.53	53.44	5.32	3.33
T_2(100 % Shivalika)	69.56	5.74	58.40	6.70	3.59
T_3 (50 %Krish + 50 %Shivalika)	66.28	6.05	56.73	5.88	3.45
SEm±	1.42	0.19	0.78	0.10	0.05

planting) exhibited maximum harvest duration and yield with highest B: C ratio.

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