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Effect of low plastic tunnels, transplanting dates and mulching on quality of tomato (*Solanum lycopersicum*)

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ABSTRACT

The present experiment was conducted at Research Farm and in Laboratory of the CCS Haryana Agricultural University, Hisar during spring summer 2014–15 and 2015–16 to study the influence of low plastic tunnels, transplanting dates and mulching on quality characteristics of tomato (*Solanum lycopersicum* L.). The treatments comprise two types tunnels, three transplanting dates and three types mulching materials which were laid out in factorial RBD design with three replications. Results of the study showed that pericarp thickness (3.02 mm), acidity (0.48%), ascorbic acid (26.61 mg/100 g) and TSS (5.68%) content in tomato fruits were recorded significantly higher when seedlings were transplanted under low plastic tunnel on 30 November using black polyethylene as mulch materials compared to other treatments. Moreover fruit firmness (4.66 kg/cm) was recorded significantly higher value when seedlings were transplanted under plastic low tunnel on 20 December with black polyethylene mulch during both the years.

Keywords: Low tunnels, Mulch, Tomato, Transplanting, Quality parameters

Tomato (*Solanum lycopersicum* L.) is an economically important and most popular vegetable crop grown in tropical and subtropical regions of the world. It is the second most widely consumed vegetable after the potato (Gastelum *et al.* 2011). Tomato has many uses in both fresh and processed forms in the human diet (Kacjan *et al.* 2005) because it's an important source of micronutrients, notably lycopene, α-tocopherol, phenolic compounds, different acids like ascorbic, citric, fumaric and oxalic acids (Hernandez Suarez *et al.* 2008). Kanase *et al.* (2018) stated that transplanting time plays a very important role in increasing the yield potential of vegetable crops. Protected cultivation could allow farmers to obtain year around vegetables (Schreinemachers *et al.* 2016). Hisar has extreme low temperature in winter season touching 0°C and high as 45ºC in summer. The tomato grown and produced in plastic tunnels are sold as off-season product fetching higher prices. In general, low tunnels allow shortwave solar radiation to pass through it during the day and the plastic material slows long wave radiation from the surface at night (Snyder and Abreu 2005). These tunnels facilitate the entrapment of carbon dioxide, thereby enhancing the photosynthetic activity of the plants and hence increased the yield. These structures also protect the plants from the high winds, rain, frost and snow (Kumar *et al.* 2015).

To address the adverse impacts of climate change on productivity and quality of horticultural crops we need to develop sound adaptation strategies. Strategies like changing sowing or transplanting dates to struggle the expected increase in temperature and water stress periods during the crop-growing period. Plastic mulches are used in many horticultural crops to suppress weed growth, conserve soil moisture and to alter temperature in the rhizosphere. Rohila *et al.* (2018) also concluded that there is an immense need to motivate and encourage the farmers to adopt smart agriculture practices (SAPs). Keeping in view that present study was carried out with the objective to find out the effect of plastic low tunnels, transplanting dates and mulching on quality of tomato.

MATERIALS AND METHODS

The experiment was conducted at Research Farm and Biochemistry Laboratory of the CCS Haryana Agricultural University, Hisar during spring summer 2014–15 and 2015–16. It is situated in south west zone at latitude 29º.10' N, longitude 75º.46' E at an altitude of 215.2 m above mean sea level. The weekly soil temperature data of tomato crop growing period is presented in Table 1.The treatments comprising of two tunnels (with low tunnel and open field condition) three transplanting dates (30 November, 20 December and 10 January of 2014–15 and 2015–16) and three mulching materials (black polythene, white polythene and without mulch) and were laid out in Factorial RBD

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Table 1 Weekly pooled mean soil temperature under poly-tunnel and open field from 1 December 2014 to 15 February 2015 and 1 December 2015 to 15 February 2016

Week	Mean soil temperature (^{0}C)			
	Under poly-tunnel		Open field	
	Min.	Max.	Min.	Max.
01-07 December	15.2	30.8	9.0	18.9
08-14 December	14.3	29.4	7.7	16.4
15-21 December	12.5	28.0	6.5	13.3
22-28 December	11.0	26.1	5.2	12.6
29 December–4 January	11.6	25.7	5.8	13.4
05-11 January	12.0	24.4	4.6	13.0
12-18 January	11.7	23.0	4.4	13.7
19-25 January	12.4	25.3	6.0	12.9
26 January–01 February	13.1	26.6	6.7	14.6
02-08 February	14.8	28.0	8.0	16.0
09-15 February	15.3	28.7	9.1	18.7

with three replications. Fruits were harvested at maturity to find out the effect of all these above mentioned factors on different quality parameters like fruit firmness (kg/cm), pericarp thickness (mm), titratable acidity (%), ascorbic acid (mg/100 g) and TSS (%) of (cv. Hisar Arun Sel-7). The fresh ripe fruits were harvested at marketable stages with a uniform size per plot from five randomly selected plants per treatment for recording fruit firmness (kg/cm), pericarp thickness (mm), titratable acidity (%), ascorbic acid (mg/100g) and TSS (%) of fruits. Fruit firmness was measured using penetrometer and pericarp (epicarp + mesocarp) thickness was measured with verniercaliper by dissecting at equatorial position. Fresh fruits harvested at marketable stages with a uniform size per plot were sampled so as to avoid variation in firmness due to size. Three readings were taken from each sample and their average value was taken as the firmness. The effect of the skin on destructive firmness measurement of texture by using force/deformation test was investigated. Fruits were cut from middle into two pieces and juice was directly dropped on the glass of hand refractometer and reading on scale was recorded as per cent total soluble solids. Ascorbic acid and acidity was estimated by using the procedure given in AOAC (1990). All the statistical analysis was carried out by using OPSTAT statistical software.

RESULTS AND DISCUSSION

The data presented in Tables 2 reveals that fruit firmness (kg/cm), pericarp thickness (mm), titratable acidity (%), ascorbic acid (mg/100 g) and TSS (%) content of tomato fruits significantly influenced by low plastic tunnels, transplanting dates and mulching. The results obtained on fruit quality (Table 2) showed significant individual effects of low tunnels, transplanting dates and mulches. In individual effect, pooled data of both the years shows that tomato under low tunnel (T_1) had maximum fruit firmness (4.21 kg/cm^2), pericarp thickness (2.62 mm), ascorbic acid (23.20 mg/100 g) and TSS (5.32%) while maximum acidity (0.41%) was recorded with sample without using low tunnel (T_2), irrespective of transplanting dates and mulching. Thus, the lower acidity of the fruits grown in a protected environment may be a result of the lower photosynthetic activity of the plant in this environment, and consequently a lower carbohydrate accumulation in the fruits. Similarly, Ashrafuzzaman *et al*. (2011) stated that mature green stage, the chilli fruits grown with black-plastic mulch had the highest 119 vitamin C content. The highest total soluble solids content (6.67%) was estimated in tomato grown with rice husk than the control (Tipu *et al*. 2014). Ilic *et al.* (2017) reported total acid (TA) content was 0.19 in the control and 0.25 in pepper fruits grown under red nets. The highest concentration of vitamin C was detected in peppers grown in plastic tunnels integrated with red coloured nets (175.77 mg 100/g) in sweet pepper.

Among transplanting dates, on 30 November (D_1) recorded maximum pericarp thickness (2.84 mm), acidity (0.47%), ascorbic acid (24.29 mg/100 g) and TSS (5.38 %) while fruit firmness (4.18 kg/cm^2) was recorded highest on December 20 D_2, irrespective of tunnels and mulching. With regards to different mulches, M_1 (Black polyethylene) showed maximum fruit firmness 4.31 kg/cm^2, pericarp thickness (2.61 mm), TSS (4.33%), ascorbic acid (23.78 mg/100 g) and titrable acidity (0.42 %) and minimum (3.73 kg/cm^2, 2.50 mm, 5.01%, 21.67 mg/100 g and 0.37%, receptively) in M_3 in treatment (without mulch), irrespective of tunnels and transplanting dates. The data revealed that in the interaction between tunnels and transplanting dates, treatment combination T_1D_2 recorded highest fruit firmness (4.42 kg/cm^2) while highest pericarp thickness (2.94 mm) was recorded with T_1D_1. The effect of these treatment combinations on fruit acidity, ascorbic acid and TSS were non-significant. Further effect of treatment combinations, tunnels and mulches (T × M) on fruit firmness, pericarp thickness, acidity, ascorbic acid and TSS were non-significant.

In the interaction between transplanting dates and mulches, treatment combination D_1M_1 recorded maximum pericarp thickness (2.94 mm) and TSS (5.57%). The effect of these treatment combinations on fruit firmness, acidity and ascorbic acid was non-significant. The second order interaction between low tunnels, transplanting dates and mulches recorded non-significant for fruit firmness, pericarp thickness, acidity, ascorbic acid and TSS. Ali and Gaur (2007) reported possible reason for improvement of fruit quality attributes with black polythene mulch might be that black-polythene mulch provided favourable condition for growth and development of plants by conservation of moisture, optimum temperature and least weed growth. Madhumathi and Sadarunnisa (2013) also reported significantly higher (20.81 mg/100 g pulp) ascorbic acid in tomato fruits harvested from early transplanted crop than the

Table 2 Effect of low tunnel, transplanting date and mulching on fruit firmness (kg cm^{-2}), pericarp thickness (mm), acidity (%), ascorbic acid (mg/100 g) and total soluble solids (%) in tomato (based on pooled data)

		Fruit firmness (kg cm^{-2})				Pericarp thickness (mm)				Acidity (%)				Ascorbic acid (mg/100 g)				Total soluble solids (%)			
		D_1	D_2	D_3	Mean (T)	D_1	D_2	D_3	Mean (T)	D_1	D_2	D_3	Mean (T)	D_1	D_2	D_3	Mean (T)	D_1	D_2	D_3	Mean (T)
T × D	T_1	4.19	4.42	4.03	4.21	2.93	2.71	2.24	2.62	0.46	0.37	0.31	0.38	24.93	23.13	21.53	23.20	5.47	5.40	5.08	5.32
	T_2	3.83	3.95	3.78	3.86	2.75	2.57	2.15	2.49	0.48	0.40	0.35	0.41	23.65	22.51	20.72	22.29	5.28	5.18	4.81	5.09
	Mean (D)	4.01	4.18	3.90		2.84	2.64	2.20		0.47	0.39	0.33		24.29	22.82	21.13		5.38	5.29	4.95	
T × M		M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3		M_1	M_2	M_3	
	T_1	4.49	4.26	3.88	4.21	2.68	2.63	2.57	2.62	0.40	0.38	0.36	0.38	24.38	23.27	21.94	23.20	5.55	5.28	5.12	5.32
	T_2	4.14	3.85	3.58	3.86	2.55	2.49	2.43	2.49	0.43	0.41	0.39	0.41	23.17	22.31	21.40	22.29	5.30	5.08	4.89	5.09
	Mean (D)	4.31	4.06	3.73		2.61	2.56	2.50		0.42	0.40	0.37		23.78	22.79	21.67		5.43	5.18	5.01	
D × M	D_1	4.29	4.01	3.73	4.01	2.94	2.84	2.74	2.84	0.50	0.46	0.45	0.47	25.65	24.16	23.07	24.29	5.57	5.36	5.20	5.38
	D_2	4.45	4.24	3.86	4.18	2.68	2.64	2.60	2.64	0.40	0.39	0.37	0.39	23.73	22.92	21.81	22.82	5.42	5.32	5.13	5.29
	D_3	4.19	3.92	3.59	3.90	2.23	2.2	2.16	2.20	0.36	0.34	0.30	0.33	21.95	21.29	20.14	21.13	5.29	4.86	4.69	4.95
	Mean (M)	4.31	4.06	3.73		2.61	2.56	2.50		0.42	0.40	0.37		23.78	22.79	21.67		5.43	5.18	5.01	
CD (P = 0.05)	T – 0.04 T × D - 0.07 D – 0.05 T × M - NS M – 0.05 D × M - NS					T – 0.017 T × D - 0.029 D – 0.021 T × M - NS M – 0.021 D × M – 0.036				T - 0.010 T × D - NS D - 0.012 T × M - NS M - 0.012 D × M - NS				T – 0.25 T × D - NS D – 0.30 T × M - NS M – 0.30 D × M - NS				T – 0.04 T × D - NS D – 0.05 T × M - NS M – 0.05 D × M – 0.08			

T_1, Low tunnels; T_2, Without low tunnels; Transplanting dates D_1 (30 November), D_2 (20 December), D_3 (10 January); M_1, Black-polyethylene mulch; M_2, White-polyethylene mulch; M_3, No mulch.

fruits obtained from late planted crop. Singh *et al*. (2015) also estimated more total soluble solids (5.55%) in tomato fruits harvested from early-planted crop as compared to fruits obtained from late-planted crop. Singh *et. al.* (2017) observed M_2 (Black polythene) showed maximum fruit TSS (4.78 °Brix), ascorbic acid (32.77 mg/100 g) and lycopene content (2.67 mg/100 g) while M0 recorded maximum titratable acidity (0.48%).

The present study concluded that use of low plastic tunnels, mulching and dates of transplanting had a significant effect on quality of tomato. Moreover, sowing on 20 December with black polyethylene mulch under low plastic tunnel gave the highest yield and B: C ratio.

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