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Transplanting time and mulching impact on yield and quality of tomato (*Solanum lycopersicum* L.) cv. Hisar Arun

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Abstract

The experiment comprising of five transplanting time *viz*., 15th December, 30th December, 15th January, 30th January and 15th February and three mulching materials, i.e. black polyethylene, wheat straw and control, was conducted at Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during *Rabi* season of 2014. The transplanting times showed significant effect on all the parameters. Mulching materials also showed significant effect on all the traits except TSS and acidity. The minimum intensity (6.8 and 12.0) and dry weight (8.2 and 17.2 g) of weeds at 45 and 60 days after transplanting were recorded when the crop was planted on 15th December under black polyethylene mulch, respectively. The TSS in tomato fruit were estimated significantly higher (5.7%) when the transplanting was done on 15th December but mulching had no significant effect on TSS. Ascorbic acid content decreased significantly with delayed transplanting. The maximum ascorbic acid content and titratable acidity was estimated 27.6 mg/100 g and 0.48%, respectively when the tomato seedlings were transplanted on 15th December under black polyethylene mulch. It can be concluded that the crop planted on 30th December under black polyethylene mulch had less weeds' population and produced better yield and quality of tomato with benefit to cost ratio Rs 3.12.

Keywords: Tomato, transplanting dates, mulching, weed intensity, yield and quality

Introduction

Tomato (*Solanum lycopersicum* L.), belonging to Solanaceae family, is grown widely all over the world. A large portion of total tomato production is processed into value added durable products, thus, it ranks first in the list of canned and processed products. It is also added in soups and vegetable curries to improve taste and flavour. It has high nutritive value, especially in terms of vitamin C, A and minerals. Both, its pulp and juice are intestinal antiseptic, blood purifier, mild appetizer and promoter of gastric secretion. It removes constipation, keeps the intestine smooth, stimulates torpid liver and is good in chronic dyspepsia. It is a powerhouse of curative properties and a most important protective food due to the presence of lycopene pigment, which acts as a potent antioxidant, inhibiting oxidation of low-density lipoprotein, thus, it is associated with low risk of cardiovascular diseases. In India, numerous tomato processing varieties are available but the information regarding optimum transplanting time and suitable mulching material under different climatic conditions is meager. In North India, tomato is usually transplanted from November to February but occurrence of frost during this period is a great bottleneck in getting early crop. The crop management practices like mulching with crop residues and plastic mulches help in conserving soil moisture (Singh 2011). Therefore, the experiment was conducted to find out the suitable transplanting time and mulch.

Materials and Methods

The study was carried out at Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during *Rabi* season of 2014 to find out the optimum transplanting time and suitable mulching material. The treatments were laid out in split plot design keeping the date of transplanting *viz*., 15th December, 30th December, 15th January, 30th January and 15th February in main plot and mulching material *i.e.*, black polyethylene (20 µm thickness), wheat straw (5 cm thickness) and control (no mulch) in sub-plot with three replications. Soil of the experimental plot was poor in organic carbon and available nitrogen, medium in phosphorus and high in potash with having high pH. The 45 days old healthy seedlings of tomato cv. Hisar Arun raised in plastic pro-trays were transplanted at a

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spacing of 60×45 cm in the plots of 3.60×2.70 m size. All the recommended cultural practices and plant protection measures were followed to raise a healthy crop. The data were recorded on intensity and dry weight of weeds (g/m^2) at 45 and 60 DAT, yield (q/ha), total soluble solids (TSS, %), acidity (%) and ascorbic acid (mg/100 g) and were subjected to statistical analysis (Panse and Sukhatme 1967).

Results and Discussion

Effect of date of transplanting on weed intensity: The data presented in Table 1 show that different dates of transplanting and mulching materials significantly influenced the weed intensity at 45 and 60 days after transplanting. Weed intensity increased with the delay in transplanting, which might be due to increased soil temperature and less coverage of land surface area by the crop plants canopy. These results are in line with those of Zafar *et al*. (2010) who reported that there was an increase in weed population and biomass with the increase of weed-crop competition period. Ghosheh *et al*. (2010) also reported that weed biomass was much higher in weedy plots. Amare *et al*. (2015) recorded the lowest weed density in plot kept weed free up to harvest and not weeded up to 15 DAT (0.0 and 0.0 m^2), whereas the highest weed density was recorded in weedy check plot up to harvest (146.51, 161.33 m^2).

Effect of date of transplanting on weed dry weight: The different transplanting dates and mulching materials influenced weed dry weight significantly (Table 1). The weed dry weight (g/m^2) was greater in late-planted crop as compared to crop transplanted early. The maximum (77.6 and 88.8 g) and the minimum (47.2 and 59.7 g) weed dry weight (g/m^2) at 45 and 60 days after transplanting were recorded with 15th February and 15th December planted crop, respectively. The minimum weed dry weight in crop planted at early stage might be due to prevailing low temperature for longer period, which checked the weed seeds to germinate but the summer weed seeds did germinate with the delay in transplanting due to increased soil temperature. Amare *et al*. (2015) recorded lowest weed dry weight in weed free and not weeded up to 15 DAT (0.0 and 0.0 g/m^2) and highest in weedy check up to harvest (1127.2 and 1093.2 g/m^2) in 2013 and 2014, respectively.

Effect of date of transplanting on fruit yield: The data pertaining to fruit yield per plot and per hectare

Table 1: Effect of transplanting time and mulching materials on yield and quality parameters of tomato

Treatments		Weed Intensity/m^2 45DAT	Weed Intensity/ m^2 60DAT	Weed dry weight/ m^2 45DAT	Weed dry weight/ m^2 60DAT	Total yield (q/ha)	Total soluble solids (%)	Acidity (%)	Ascorbic acid content (%)
S_1	M_1	6.8	8.2	12.0	17.2	324.8	5.7	0.48	27.6
	M_2	30.4	40.8	49.1	57.2	257.3	5.4	0.51	25.7
	M_3	88.2	91.2	80.5	104.6	176.6	5.3	0.48	24.7
	Mean	41.8	46.7	47.2	59.7	252.9	5.5	0.49	26.0
S_2	M_1	8.4	13.5	14.1	19.0	352.6	5.6	0.42	24.5
	M_2	36.5	46.4	54.0	62.4	288.4	5.3	0.45	24.3
	M_3	90.7	108.6	95.7	109.9	199.9	5.2	0.39	23.9
	Mean	45.2	56.2	54.6	63.8	280.3	5.4	0.42	24.2
S_3	M_1	10.4	15.4	16.5	20.9	331.5	5.4	0.38	22.2
	M_2	42.8	52.6	58.8	67.6	272.5	4.8	0.35	21.8
	M_3	96.2	119.1	110.0	118.2	184.4	4.5	0.31	22.6
	Mean	49.8	62.3	61.8	68.9	262.8	4.9	0.35	22.2
S_4	M_1	13.7	16.3	19.2	26.8	281.5	4.8	0.34	21.6
	M_2	50.3	59.3	64.2	79.3	220.6	4.5	0.31	21.5
	M_3	101.2	128.2	124.8	133.3	141.0	4.4	0.36	20.2
	Mean	55.0	67.9	69.4	79.8	214.4	4.6	0.33	21.1
S_5	M_1	15.0	18.9	24.1	28.6	235.2	4.7	0.23	20.9
	M_2	62.1	66.8	69.2	93.0	178.8	4.4	0.22	20.7
	M_3	116.3	140.3	139.4	144.9	105.5	4.2	0.19	18.9
	Mean	64.5	75.3	77.6	88.8	173.2	4.4	0.21	20.2
Overall mulching mean	M_1	10.9	14.4	17.2	22.5	305.1	5.2	0.37	23.4
	M_2	44.5	53.2	59.1	71.9	243.5	4.8	0.37	22.8
	M_3	98.5	117.5	110.1	122.2	161.5	4.7	0.35	22.1
Date of Sowing		9.7	1.4	1.8	1.0	9.2	0.6	0.03	0.8
Mulching		7.8	1.2	1.1	1.0	7.1	NS	NS	0.7
Date at same level of mulching		1.7	2.7	2.7	2.1	NS	NS	NS	NS
Mulching at same level of date		1.8	2.9	2.6	2.3	NS	NS	NS	NS

M_1= Black polyethylene mulch; M_2= Wheat straw, M_3= No mulch and S_1= 15th December, S_2= 30th December, S_3= 15th January, S_4= 30th January and S_5= 15th February

show that date of transplanting significantly influenced fruit yield of tomato crop. The crop transplanted on 30th December gave maximum fruit yield per plot (28.9 kg) and per hectare (280.3 q) as compared to late planted crop, which might be due to the availability of more time for vegetative as well as reproductive phase in early planted crop since the plants accumulated more assimilates. In late transplanted crop, the temperature at flowering stage exceeded to 35 ºC, which impaired fruit set in tomato due to the elongation of style, poor and sterile pollen and ovule production, poor pollen germination, slow pollen tube growth, lack of anther dehiscence due to the absence of endothecium layer, and lack of pollination and fertilization which led to poor fruit set and finally lower fruit yield. The results of present study confirm the findings of Amador *et al*. (2005) and Hossain *et al*. (2013 and 2014) who recorded the inverse relationship between tomato yield and weed dry weight.

Effect of date of transplanting on quality: Quality of the tomato fruit is determined by total soluble solids, which help in the recovery of processed products. Acidity is considered ideal for processing and high ascorbic acid helps in better retention of red colour and flavour of the processed products. The quality parameters *viz*., total soluble solids and acidity, were influenced significantly (Table 1) due to the dates of transplanting but not due to mulching materials, while ascorbic acid was influenced by different transplanting dates and mulching materials. The maximum total soluble solids, ascorbic acid and acidity was recorded when the seedlings were transplanted on 15th December (5.5%, 0.49% and 26.0 mg/100 g pulp) followed by 30th December (5.4%, 0.42% and 24.2 mg/100 g pulp, respectively), whereas, the minimum total soluble solids, acidity and ascorbic acid was recorded under 15th February transplanting date (4.4%, 0.21% and 20.2 mg/100 g pulp, respectively). The findings of present investigation agree with the findings of Madhumathi and Sadarunnisa (2013) also reported that the tomato fruits harvested from early planted crop had significantly higher ascorbic acid (20.81 mg/100 g pulp) than the fruits obtained from late planted crop, while Singh *et al*. (2015) estimated more total soluble solids (5.55%) in tomato fruits harvested from early-planted crop as compared to fruits obtained from late-planted crop.

Effect of mulching on weed intensity: The minimum number of weeds at 45 and 60 days after transplanting was recorded when the crop was planted on 15th December (41.8 and 46.7, respectively), which might be due to low temperature longer period in early planted crop but the weed seeds germination increased with too much delay in transplanting, which might be due to the increase in soil temperature. The present results are in agreement with the findings of Grassbaugh *et al*. (2004) who reported 80% reduction in weed biomass under black plastic mulch, Ngouajio and Ernest (2004) reported the highest and lowest weed biomass under white and black plastic mulches, respectively and Rajablariani *et al*. (2012) reported that the silver/black and black plastic mulch blocked the weed seed germination, except a few, which emerged through the transplanting holes. Amare *et al*. (2015) recorded that mulching with black polyethylene suppressed the weed intensity to a minimum level but the wheat straw did not affect the weeds population much.

Effect of mulching on weed dry weight (g/m^2): Among the mulch treatments, the minimum weed dry weight (g/m^2) was recorded under black polyethylene mulch (17.2 and 22.5 g/m^2) followed by wheat straw mulch (59.1 and 71.9 g/m^2) and the maximum weed dry weight (g/m^2) at 45 and 60 days after transplanting was recorded under no mulch treatment (110.1 and 122.2 g/m^2), respectively. This might be because of the inhibition of sunlight transmission by the black polyethylene, as light is an integral part of photosynthesis essentially required for the growth of weed plants. The results of present study are in agreement with the findings of Chakraborty and Sadhu (1994) who reported polyethylene mulch irrespective of colour superior to rice straw or water hyacinth mulch in suppressing weed growth significantly. Polyethylene and biodegradable plastic mulch resisted most of the weeds well, except for purple nut sedge, which was able to pierce the plastics in tomato. Most weed species were controlled by using mulching materials in tomato except purple nut sedge, which was controlled only by paper mulch, and the best weed control and the lowest weed biomass were achieved by paper mulch followed by polyethylene

Table 2: Total fruit yield, net monetary returns and B:C ratio as influenced by different transplanting time and mulching material in tomato

Sr. No.	Treatments	Variable cost (Rs./ha)	Treatment cost (Rs./ha)	Total cost (Rs./ha)	Yield (q/ha)	Gross return (Rs./ha)	Net return (Rs./ha)	B:C ratio
1.	Control	60018	0.0	60018	161.5	161500	101482	1.69
2.	Wheat Straw	60018	4500	64518	243.5	243500	178982	2.77
3.	Black polyethylene sheet	60018	14000	74018	305.1	305100	231082	3.12

Price of tomato fruit= Rs. 1000/quintal, Wheat Straw=500/q, Black Polyethylene sheet= 170 rs./kilo

and biodegradable plastic mulch (Anzalone *et al*. 2010).

Effect of mulching on fruit yield: Among mulch treatments, it is apparent from the data that all the mulch treatments increased tomato fruit yield per hectare as compared to control. The maximum fruit yield per plot and hectare was recorded under black polyethylene mulch (25.7 kg and 305.1 q) and minimum under no mulch treatment (15.9 kg and 161.5 q). Organic mulching significantly increases the plant height, leaf area, leaf weight, fruit weight, fruit yield, fruit density, post-harvest shelf-life and TSS of tomato (Singh et al. (2013). Nagalakshmi *et al*. (2002) obtained the maximum fruit yield of chilli with the application of black LLDPE mulch (8.60 t/ha) compared to organic and no mulch. Whereas Gandhi and Bains (2006) reported that the crop planted under straw mulch produced higher number of branches (8.7), fruit weight (28.08 g) and total yield (49.63 t/ha) as compared to no mulch (8.1, 27.86 g and 47.85 t/ha, respectively) in tomato.

Effect of mulching on quality: The various mulching treatments had no significant effect on total soluble solids and acidity but had significant effect on ascorbic acid content. The maximum ascorbic acid content was recorded under black polyethylene mulch (23.4 mg/100 g), whereas, the minimum ascorbic acid content was recorded under control treatment (22.1 mg/100 g) at same level of no mulch treatment. The findings of present study are in line with the findings of Ashrafuzzaman *et al*. (2011) found higher vitamin C content in chilli fruits harvested from the plants raised under black polyethylene mulch. Tipu *et al*. (2014) estimated the highest total soluble solids (6.67%) in tomato grown with rice husk as compared to fruits of control treatment.

Interactive effect of time of transplanting and mulching: The interactional effect of different transplanting dates and mulching materials on intensity and dry weight of weeds per square meter was found significant. The minimum intensity (6.8 and 8.2/m^2) and dry weight of weeds (12.0 and 17.2 g/m^2) at 45 and 60 days after transplanting was found under 15th December transplanting date in combination with black polyethylene mulch closely followed by 30th December (8.4 and 13.5/m^2) and (14.1 and 19.0 g/m^2) at same level of mulch. The interactional effects of different transplanting dates and mulching at same level of mulch and mulching and transplanting dates at same level of date were found non-significant with respect to total fruit yield per hectare. The interactional effects of different transplanting dates and mulching at same level of mulch, and mulching and transplanting dates at same level of transplanting date were found non-significant with respect to fruit quality parameters.

Economics: The benefit: cost ratio (Table 2) indicates that among the various mulching treatments, the highest benefit: cost ratio (Rs. 3.12:1.00) was registered with black polyethylene mulch followed by wheat straw mulch (Rs. 2.77:1.00), whereas, the minimum benefit: cost ratio was registered with control (no mulch) treatment (Rs. 1.69:1). These findings are in close agreement with the results of More *et al*. (2014) who achieved the highest marketable fruit yield and benefit to cost ratio with crop transplanted early (5th November) and mulched with black polythene (49.65 t/ha and 2.05: 1.00) closely followed by crop planted on 5th November and mulched with sugarcane tress (43.08 t/ha and 1.87:1.00), respectively.

It is concluded that tomato crop planted on 30th December under black polyethylene mulch was found economically best for obtaining minimum weed intensity and dry weight and maximum fruit yield with better quality parameters. The highest benefit cost ratio (Rs. 3.12:1.00) was recorded under black polyethylene mulch and lowest with control treatment (Rs.1.69:1.00).

सारांश

टमाटर में 5 पौध रोपड़ समय अर्थात् 15 दिसम्बर, 30 दिसम्बर, 15 जनवरी, 30 जनवरी तथा 15 फरवरी एवं तीन पलवार पदार्थ जैसे–काली पाली इथायलिन, गेहूँ का भूसा, व नियन्त्रक सहित वर्ष 2014 में शोध प्रक्षेत्र, सब्जी विज्ञान विभाग, चौधरी चरण सिंह हरियाणा कृषि विश्वविद्यालय हिसार (हरियाणा) में शोध किया गया। रोपड़ का सार्थक प्रभाव सभी गुणों पर पाया गया। पलावर पदार्थों का भी कुल विलेय ठोस तथा अम्लता को छोड़कर सार्थक प्रभाव पाया गया। खरपतवार की सबसे कम सघनता (6.8 एवं 12.0) शुष्क भार (8.2 व 17.2 ग्राम) पौध रोपड़ के 45 एवं 60 दिन बाद पालीथीन पलवार के तहत 15 दिसम्बर को रोपड़ पर पाया गया। पौध रोपड़, 15 दिसम्बर को किया गया तो फलों कुल विलेय ठोस की सबसे अधिक (5.7 प्रतिशत) पाया गया जबकि पलवार का कोई सार्थक प्रभाव कुल ठोस विलेय पर नहीं था। देर से पौध रोपड़ करने पर एस्कार्विक एसीड की मात्रा में सार्थक गिरावट दर्ज की गयी। 15 दिसम्बर को काली पालीइथायालिन पलवार का प्रयोग कर पौध रोपड़ किया गया तब अधिकतम एसीड व मापन अम्लता का मूल्य क्रमशः 27.6 मिग्रा/100 ग्राम व 0.48 प्रतिशत पाया गया। इससे निष्कर्ष निकलता है कि 30 दिसम्बर को काली पालीइथायलिन पलवार के साथ पौध रोपड़ करते हैं तो खरपतवार की संख्या कम तथा उपज ज्यादा मिलती है जिनमें लाभ लागत अनुपात 3.12 रहा।

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