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Influence of weed management practices and dates of transplanting in tomato (*Solanum lycopersicum*)

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ABSTRACT

The field experiment was conducted during two consecutive years 2016–17 and 2017–18 to find out the influence of weed management practices and dates of transplanting on weed, fruit yield and profitability of tomato (*Solanum lycopersicum* L.) at Vegetable Research Farm of Chandra Shekhar Azad University of Agricultural and Technology, Kanpur. The experiment was laid out in factorial randomized block design (FRBD) with four different dates of transplanting, viz. 15 October, 31 October, 15 November and 30 November and four type of mulches, viz. black polyethylene, white polyethylene, bio-mulch (paddy straw) and control (without mulch) replicated thrice. Tomato cultivar Azad T-6 was used in experiment. Results of the experiment revealed that the minimum weed population (4.43 and 4.26/m^2) and weeds fresh weight (9.52 and 9.15 g/m^2) and significantly highest marketable yield (30610 and 31418 kg/ha) and net returns (₹ 241460.50 and 249538.00/ha) were recorded in crop transplanted on 30 October. In case of mulching, application of bio-mulch (paddy straw) recorded minimum weed population (4.88 and 4.76/m^2) and weeds fresh weight (10.48 and 10.28 g/m^2) and significantly highest marketable yield (29569 and 30354 kg/ha) and net returns (₹ 231050.50 and 238905.50/ha). Transplanting on 30 October and application of bio-mulch (paddy straw) proved to be the best treatment combination for effective weed management and enhancing productivity and profitability of tomato. Therefore, this practice may be recommended to exploit the better economic yield of tomato under central plain zone of Uttar Pradesh.

Keywords: Dates of transplanting, Profitability, Tomato, Weed management, Yield

Tomato (*Solanum lycopersicum* L.) is an important fruit vegetable of solanaceous family. It is a rich source of vitamins like A and B and iron. It is grown for fresh market and tops the list of canned vegetables. It is day neutral, self pollinated and annual fruit vegetable crop which is extensively grown in Asian and European countries. Globally, the production share of tomato of India is 10.4% with second rank next to China. In India, area under tomato crop is 789 thousand ha with the production of 19759 thousand MT (DACFW 2018). Tomato can be planted from November to February. Due to day neutral behaviour of tomato plant, many varieties are planted round the year. Among various cultural practices followed during tomato cultivation, transplanting time is considered one of the most important practices that greatly influence growth and yield of the crop. There is a wide range of transplanting time, which may affect its yield and quality due to varying climatic conditions at different stages of crop.

Mulching is the most valuable practice to conserve the soil moisture, organic matter and reduced weed intensity. When straw from plants is left in the field as mulch, it reduces soil erosion, the biological activity of the soil microbes increases and soil physical and chemical properties are also improved, which efficiently inhibit the growth of weeds (Ramakrishna *et al.* 2006). Organic mulch reduces the weed seed germination and growth of weeds through the less light penetration into the soil (Anyszka and Dobrzanski 2008). Weeds reduce crop productivity by interfering with crop growth. Besides reduction of crop yield, weeds also contaminate and taint farm product which ultimately reduce their market values and change their end use. Therefore, it was considered enviable to find out a suitable date of transplanting and the best mulching material to obtain maximum crop growth and yield. Keeping this in view the present study was undertaken.

MATERIALS AND METHODS

The field experiment was conducted at Vegetable Research Farm of Chandra Shekhar Azad University of Agricultural and Technology, Kanpur during the two

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consecutive years *rabi* 2016–17 and 2017–18. The soil is sandy loam in texture and soil *p*H was 7.8, which showed slightly alkaline reaction. The soil was low in organic carbon 0.36%, low in available N 148.0 kg/ha, medium in available P 14.0 kg/ha and low in available K 174.0 kg/ha at initiation of experiment. Geographically, the experimental site falls under Upper Gangetic Plains of Uttar Pradesh. The climatic condition of Kanpur region consisted three distinct seasons, viz. rainy or wet, winter and summer or hot. The rainy season starts from the end of June and goes up to the last week of September or some time extends up to mid October with average annual rainfall of 1200 mm. Sporadic rains also occurs during winter. The winter season starts from November and continues up to the first week of March with mean temperature ranging from 15–25ºC. The experiment was laid out in factorial randomized block design (FRBD) with four different dates of transplanting, viz. 15 October, 31 October, 15 November and 30 November and four type of mulches, viz. black polyethylene, white polyethylene, bio-mulch (paddy straw) and control (without mulch) replicated thrice. Tomato cultivar Azad T-6 was used in experiment and transplanted at 50 cm × 50 cm spacing. Recommended package of practices for the region was followed except treatments. The observations were taken on their weed population, weed biomass, yield and yield attributes of tomato and subjected to analysis of variance with mean comparison of 5% level of significance. On the basis of total variable cost and gross return and net return were calculated as per methods suggested by Devasenapathy *et al.* (2008).

RESULTS AND DISCUSSION

Effect of transplanting date on weed population and weed biomass: Number of weeds and weed biomass in tomato were influenced significantly by different transplanting date during both years (Table 1). Data (Table 1) revealed that the significantly lowest numbers of weeds (4.43 and 4.26/m^2) were recorded in crop transplanted on 30 October while crop transplanted on 15 November observed weed population of 5.31 and 5.15/m^2 during first and second year, respectively. The maximum numbers of weeds were found in crop transplanted on 30 November (7.52 and 7.36/m^2) during both the years of experimentation. In case of weed biomass, the maximum fresh weight of weeds was recorded in crop transplanted on 30 November (16.12 and 15.79 g/m^2) followed by crop transplanted on 15 October (14.26 and 13.99 g/m^2). On the other hand, the minimum values of fresh weight were recorded with crop transplanted on 30 October (9.52 and 9.15 g/m^2). Similar trend was also observed in case of dry weight and minimum dry weight of weeds (5.25 and 5.04 g/m^2) was recorded in crop transplanted on 30 October.

As far as individual weed species is concern, the different individual weeds in tomato were influenced significantly by different transplanting date during both years (Table 2). The minimum weed population of *Cyperus rotundus, Phalaris minor, Parthenium hysterophorus, Rumex dentatus,*

Table 1 Effect of weed management practices on number of weeds, weed biomass, fruit yield and economics of tomato

Treatment	No. of weeds/m^2 at harvest		Weed biomass/m^2 at harvest				Fruit yield (kg/ha)						Net income (₹/ha)		B:C ratio	
			Fresh weight (g)		Dry weight (g)		Marketable		Unmarketable		Total					
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Date of transplanting																
15 October	6.65	6.52	14.26	13.99	7.83	7.66	25929.0	26617.0	2880.0	2960.0	28810.0	295740	194655.5	201535.5	3.01	3.11
30 October	4.43	4.26	09.52	09.15	5.25	5.04	30610.0	31418.0	3400.0	3490.0	34011.0	34908.0	241460.5	249538.0	3.73	3.86
15 November	5.31	5.15	10.36	11.06	5.71	6.09	28402.0	29170.0	3155.0	2140.0	31558.0	31310.0	219385.5	207060.5	3.39	3.51
30 November	7.52	7.36	16.12	15.79	8.85	8.67	24236.0	24890.0	2692.0	2765.0	26928.0	27655.0	177717.8	183760.5	2.75	2.85
SE (d)	0.28	0.27	0.68	0.64	0.44	0.39	383.0	509.0	078.0	093.0	418.0	553.0	2207.64	2403.31	0.17	0.19
CD (P = 0.05)	0.58	0.56	1.40	1.30	0.91	0.80	783.0	1040.0	161.0	191.0	854.0	1131.0	4509.86	4909.58	0.34	0.39
Mulching																
Black polyethylene	5.59	5.41	10.95	11.62	6.03	6.39	27901.0	28640.0	3099.0	3185.0	31001.0	31822.0	213875.5	220762.5	3.28	3.39
White polyethylene	6.30	6.11	13.50	13.12	7.42	7.21	26691.0	27408.0	2965.0	3045.0	29656.0	30453.0	201773.0	208940.5	3.09	3.20
Bio-mulch (paddy straw)	4.88	4.76	10.48	10.28	5.77	5.63	29569.0	30354.0	3285.0	3372.0	32854.0	33726.0	231050.5	238905.5	3.57	3.69
Control (No mulching)	7.15	7.01	15.32	15.03	8.42	8.25	25016.0	25692.0	2779.0	2854.0	27795.0	28546.0	186520.5	193285.5	2.93	3.03
SE (d)	0.28	0.27	0.68	0.64	0.44	0.39	383.0	509.0	078.0	093.0	418.0	553.0	2207.64	2403.31	0.17	0.19
CD (P = 0.05)	0.58	0.56	1.40	1.30	0.91	0.80	783.0	1040.0	161.0	191.0	854.0	1131.0	4509.86	4909.58	0.34	0.39

Melilotus alba, Artabotrys odoratissimus, *Cynodon dactylon* and *Chenopodium album* were 1.79, 1.76, 1.43, 1.48, 1.58, 1.63, 1.48 and 2.40/m^2, respectively in crop transplanted on 30 October during first year. Whereas, the maximum weed population of *Cyperus rotundus* (2.86)*, Phalaris minor* (2.81)*, Parthenium hysterophorus* (2.23)*, Rumex dentatus* (2.32), *Melilotus alba* (2.50)*, Artabotrys odoratissimus* (2.60), *Cynodon dactylon* (2.32) and *Chenopodium album* (3.95) were recorded in crop transplanted on 30 November. Similar trend was also observed in second year of experiment and minimum weed population of *Cyperus rotundus, Phalaris minor, Parthenium hysterophorus, Rumex dentatus*, *Melilotus alba, Artabotrys odoratissimus*, *Cynodon dactylon* and *Chenopodium album* were 1.71, 1.71, 1.39, 1.43, 1.53, 1.58, 1.43 and 2.32/m^2, respectively in crop transplanted on 30 October. Rajiv and Singh (2018) and Tomar *et al.* (2019) also reported similar findings.

Effect of mulching on weed population and weed biomass: Different mulches during both years (Table 1) influenced number of weeds and weed biomass in tomato significantly. Based on data, application of bio-mulch (paddy straw) recorded significantly lowest numbers of weeds (4.88 and 4.76/m^2). It was second lowest with black polythene mulch (5.59 and 5.41/m^2). The maximum weed population (7.15 and 7.01 m/^{2}) was found under control treatment (without mulch) during both the years of investigation. In case of weed biomass, application of bio-mulch (paddy straw) recorded minimum fresh weight (10.48 and 10.28 g/m^2) of weeds. Whereas, the maximum fresh weight (15.32 and 15.03 g/m^2) of weeds was recorded in control (without mulch). Similar trend was also observed in case of dry weight of weeds and minimum dry weight (5.77 and 5.63 g/m^2) of weeds was observed with application of bio-mulch (paddy straw).

Different mulches influenced individual weed species in tomato significantly during both years (Table 2). Application of bio-mulch (paddy straw) reduced significantly individual weed species and the minimum values of 1.93, 1.92, 1.55, 1.60, 1.71, 1.78, 1.60, 2.63 /m^2 were recorded for *Cyperus rotundus, Phalaris minor, Parthenium hysterophorus, Rumex dentatus, Melilotus alba, Artabotrys odoratissimus, Cynodon dactylon* and *Chenopodium album,* respectively during first year of experiment. The maximum weed population of *Cyperus rotundus* (2.73)*, Phalaris minor* (2.69)*, Parthenium hysterophorus* (2.13)*, Rumex dentatus* (2.21), *Melilotus alba* (2.39)*, Artabotrys odoratissimus* (2.48), *Cynodon dactylon* (2.13) and *Chenopodium album* (3.76) was found under control treatment (without mulch). Similar trend was also observed in second year of experiment and minimum weed population values of 1.89, 1.88, 1.52, 1.57, 1.68, 1.74, 1.56 and 2.57 of *Cyperus rotundus, Phalaris minor, Parthenium hysterophorus, Rumex dentatus*, *Melilotus alba, Artabotrys odoratissimus*, *Cynodon dactylon* and *Chenopodium album*, respectively were found with the application of bio-mulch (paddy straw). Results of the experiment revealed that the application of different mulches significantly influenced weed population and weed biomass. The present results are

Table 2 Effect of weed management practices on individual weed species

Treatment	Individual weed species/m^2 at harvest															
	Cyperus rotundus		*Phalaris minor*		*Parthenium hysterophorus*		*Rumex dentatus*		*Melilotus alba*		*Artabotrys odoratissimus*		*Cynodon dactylon*		*Chenopodium album*	
	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18	2016-17	2017-18
Date of transplanting																
15 October	2.55	2.50	2.54	2.47	1.99	1.96	2.08	2.04	2.23	2.19	2.33	2.29	1.91	2.04	3.50	3.45
30 October	1.79	1.71	1.76	1.71	1.43	1.39	1.48	1.43	1.58	1.53	1.63	1.58	1.48	1.43	2.40	2.32
15 November	2.08	2.02	2.05	2.01	1.66	1.62	1.72	1.67	1.84	1.78	1.91	1.85	1.63	1.66	2.84	2.77
30 November	2.86	2.80	2.81	2.76	2.23	2.19	2.32	2.28	2.50	2.44	2.60	2.55	2.32	2.28	3.95	3.87
SE (d)	0.26	0.20	0.25	0.22	0.18	0.17	0.20	0.15	0.20	0.19	0.23	0.19	0.17	0.17	0.11	0.10
CD (P = 0.05)	0.54	0.41	0.51	046	0.37	0.35	0.41	0.31	0.42	0.38	0.48	0.40	0.36	0.36	0.23	0.21
Mulching																
Black polyethylene	2.19	2.12	2.15	2.09	1.73	1.68	1.80	1.75	1.93	1.87	2.00	1.94	1.63	1.75	2.97	2.90
White polyethylene	2.43	2.35	2.39	2.34	1.91	1.86	1.98	1.93	2.13	2.07	2.21	2.16	1.98	1.93	3.33	3.25
Bio-mulch (paddy straw)	1.93	1.89	1.92	1.88	1.55	1.52	1.60	1.57	1.71	1.68	1.78	1.74	1.60	1.56	2.63	2.57
Control (No mulching)	2.73	2.67	2.69	2.64	2.13	2.10	2.21	2.18	2.39	2.34	2.48	2.44	2.13	2.18	3.76	3.70
SE (d)	0.26	0.20	0.25	0.22	0.18	0.17	0.20	0.15	0.20	0.19	0.23	0.19	0.17	0.17	0.11	0.10
CD (P = 0.05)	0.54	0.41	0.51	0.46	0.37	0.35	0.41	0.31	0.42	0.38	0.48	0.40	0.36	0.36	0.23	0.21

in agreement with the findings of Grassbaugh *et al*. (2004) who reported 80% reduction in weed biomass under black plastic mulch. Rajablariani *et al*. (2012) and Anzalone *et al*. (2010) also reported similar findings.

Effect of transplanting date and mulching on fruit yield: Tomato fruit yield was influenced significantly by different transplanting dates and mulching during both years (Table 1). As compared to late planted crop, the crop transplanted on 30 October produced significantly highest marketable fruit yield (30610 and 31418 kg/ha), un-marketable fruit yield (3400 and 3490 kg/ha) and total yield (34011 and 34908 kg/ha). It might be due to the availability of long period for vegetative growth and reproduction and plants accumulated more assimilates. In late transplanted crop, the temperature at flowering stage exceeded 35ºC, which impaired fruit set in tomato due to elongation of style, poor pollen production, poor pollen germination, slow pollen tube growth, lack of anthers dehiscence due to absence of endothesium 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 earlier researchers (Singh and Kumar 2005 and Hossain *et al*. 2014).

As far as mulching is concern, the crop grown with bio-mulch produced significantly highest marketable fruit yield (29569 and 30354 kg/ha), un-marketable fruit yield (3285 and 3372 kg/ha) and total yield (32854 and 33726 kg/ha). The increased fruit yield with the application of bio-mulch was probably associated with conservation of moisture and improved microclimate both below and above the soil surface. The suitable condition enhanced the plant growth and development and increased fruit bearing nodes thereby, resulting in more fruits per plant. Gandhi and Bains (2006) reported that higher tomato fruit weight under straw mulch as compared to no mulch treatment. Norman *et al*. (2011) recorded the higher fruit weight of okra under dry grass mulch and the maximum fruit weight of pepper under sawdust mulch than the control. Straw mulch increased the fruit yield in both pepper and tomato as reported by Dzomeku *et al*. (2009).

Effect of transplanting date and mulching on economics: The economics of crop was affected by different transplanting dates and mulching (Table 1). Net returns were worked out significantly highest with crop transplanted on 30 October (₹ 241460.50 and 249538.00/ha) and application of bio-mulch (₹ 231050.50 and 238905.50/ha). Whereas, the minimum net returns were found in crop transplanted on 30 November (₹ 177717.83 and 183760.50/ha) and grown without mulch (₹ 186520.50 and 193285.50/ha). Similar to net returns, the B:C ratios were also higher in crop transplanted on 30 October (3.73 and 3.86) and with application of bio-mulch (3.57 and 3.69). Choudhary and Bhambri (2012) and More *et al*. (2014) also reported similar findings.

From the above said findings, it can be concluded that the practice of crop transplanting on 30 October and application of bio-mulch are effective in weed management, higher fruit yield and profitable in tomato under Kanpur condition. Hence, it may be recommended to exploit the better economic yield of tomato.

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