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Effect of drip fertigation and plastic mulching on growth and yield of tomato

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Abstract

A study was conducted to assess the effect of drip fertigation and plastic mulching on tomato at Precision Farming Development Centre farm, Tamil Nadu Agricultural University, Coimbatore. The experiment was laid out in a randomized block design with 9 treatments and 3 replications. The treatments consisted of 3 mulching levels of black plastic mulch of 50 micron thickness, 25 micron thickness and no mulch, and 3 fertilizer levels of 80, 100 and 120 % of Recommended Dose of Fertilizers (RDF). The results of the study showed that the different levels of drip irrigation and plastic mulching significantly influenced the plant growth parameters of tomato. Among the various treatments, black plastic mulch of 25 micron thickness and drip fertigation with 120 % RDF (240:300:300 kg of NPK/ ha) recorded maximum plant height (112 cm), earlier flowering, and fruit set and highest yield (67.41 t/ha). The highest net income and benefit cost ratio of Rs. 4,18,911/ ha and 3.66, respectively was also recorded in the black plastic mulch of 25 micron thickness along with fertigation @ 120 % RDF compared to other treatments.

Key words: Plastic mulch, drip irrigation, fertigation, tomato.

Introduction

Global fresh water resources constitute about 2.5 per cent of the total volume of water on Earth, and a considerably small fraction of less than 1 per cent of this resource is the usable fresh water supply for ecosystems and human utilization (UNEP, 2008). Available fresh water resources, however, are not evenly distributed, and are already scarce in many parts of the world, affecting almost every continent. Generally, water scarcity arises when the demand for water gets close to or exceeds its availability. In order to satisfy growing food demands, related rises in agricultural water use are expected to increase the severity of water scarcity even further. Agriculture is by far the largest consumer of fresh water resources, currently accounting for over 70 per cent of global withdrawals and 86 per cent of the world's total fresh water consumption (FAO, 2012). Under limited water supply condition, proper utilization of water is very essential for successful agriculture. This can be achieved by increasing water use efficiency of a crop by adopting different water conservation measures.

The existing methods of irrigation and the available facilities are fore fronted with many problems regarding soil and water. The water loss takes place in nature due to evaporation, transpiration and percolation. The percolation losses can be avoided by applying water to the root zone of plants through drip irrigation systems. The evaporation losses can be minimized by the use of mulches such as crop wastes and polyethylene plastics. Now a days, black plastic is the predominate mulch utilized for vegetable production. It requires higher cost per acre compared to other mulches. However, black plastic mulch also effectively warms the soil, improving early crop production and eliminates most in-row weed growth. The use of black plastic mulches typically results in higher yields and quality in vegetable crops enhancing profitability for the grower. A large number of experiments have been conducted to study the effect of drip irrigation and plastic mulch on yield improvement of many crops in different agro-climatic region and soil condition. About 20-60 % higher yields were obtained with drip irrigation in some studies (Sivanappan *et al.,* 1974), while in other studies yield was reported to be slightly lower or equal to that of conventional irrigation along with reduction in irrigation requirement of 30-60 %.

Fertigation is a new concept, recently practiced in several parts of the world in horticultural crops. It offers the best solution for intensive and economical crop production where both water and fertilizers are delivered to the crop through drip system. It provides essential elements directly to active root zone thus minimize losses of expensive fertilizer which ensures higher and quality yield along with saving in time and labour (Patel and Rajput, 2005). Experiments have already indicated that through fertigation 40 to 50 per cent of nutrient could be saved. Hebbar *et al.* (2004) reported that fruit yield of tomato was increased to a range of 20-30 % in drip fertigation over furrow irrigation.

Tomato (*Lycopersicon esculentum* Mill.) is one of the most common crop belonging to the nightshade family, Solanaceae. Tomato is a popular vegetable in India. The fruit is consumed in diverse ways, including raw, as an ingredient in many dishes, sauces, and in drinks. Tomatoes are rich in Vitamins A and B, and iron. Moreover, tomatoes are rich sources of lycopene, which is a very powerful antioxidant and helps prevent the development of many forms of cancer (You and Barker, 2004). Hence, this vegetable is gaining importance in both developing and developed countries, and efforts are being made to improve the quality and quantity of tomato production (Zhao *et al.,* 2012). Of course, water supply is important for tomato yield quantity and quality. Increasing the water supply increases fruit yield but significantly reduces the quality and the ascorbic acid and lycopene contents of fruits is significantly higher under optimum water supply conditions (Favati *et al.,* 2009). Water stress is one of the most important environmental factors that regulate plant growth and development and limit plant production (Gulen and Eris, 2004). Tomato also responds well to fertilizer application and is reported to be a heavy feeder of nitrogen, phosphorus and potassium fertilizer (Hebbar *et al.,* 2004). To obtain high yields and maximum profits in commercial tomato production, the optimal management of both fertilizer and water is imperative. Therefore, the study was made to explore the effect of different levels of drip fertigation and plastic mulching on growth and yield of tomato.

Materials and methods

A field experiment was conducted to evaluate the effect of drip fertigation and plastic mulching on plant growth and yield of tomato at Farms of Precision Farming Development Centre, Department of Soil and Water Conservation Engineering, Tamil Nadu Agricultural University, Coimbatore. The soil of the experimental field was categorized as clay loam. The soil was neutral in reaction with low in organic carbon, available nitrogen and phosphorus and medium in available potassium. Normal weather conditions prevailed during the crop growth period. The experiment was laid out in a factorial randomized block design with 9 treatments and 3 replications. The treatments consisted of 3 mulching levels of black plastic mulch of 50 micron thickness, 25 micron thickness and no mulch, and 3 fertilizer levels of 80, 100 and 120 % of Recommended Dose of Fertilizers (RDF).

The experimental plot was thoroughly ploughed with disc plough and repeatedly tilled with cultivator to bring optimum soil tilth. Then the layout was taken up forming 27 raised beds of 1.2 x 4.5 m size and drip system was installed. The treatments were allocated to each plot by following random principle. The laterals were laid in each bed. On line drippers of 4 L h^{-1} were used at a spacing of 60 cm. Over the drip line according to the treatment mulching sheets were spread in each plot and holes were punched where seedlings were to be established. Both ends of the plastic sheet were buried into the soil upto a depth of 10cm. After that 25 days old healthy seedlings of tomato F1 hybrid Jeevan were planted in raised beds with a spacing of 60 cm between rows and 45 cm within row as paired row geometry. Other management practices like gap filling, weeding, propping and plant protection measures were carried out according to the recommended package of practices. The various growth, yield and quality parameters were recorded at appropriate stages by selecting five plants randomly in the net plot area of individual treatments and fruit yield of tomato was recorded from the net plot area and its mean yield was multiplied to one hectare area.

Treatments details
T_1: Plastic mulch @ 25 micron & 80 % RDF
T_2: Plastic mulch @ 25 micron & 100 % RDF
T_3: Plastic mulch @ 25 micron & 120 % RDF
T_4: Plastic mulch @ 50 micron & 80 % RDF
T_5: Plastic mulch @ 50 micron & 100 % RDF
T_6: Plastic mulch @ 50 micron & 120 % RDF
T_7: No mulch with 80 % RDF
T_8: No mulch with 100 % RDF
T_9: No mulch with 120 % RDF

RDF: 200: 250: 250 kg of NPK ha^{-1}

Results and discussion

The results of the study showed that the different levels of drip irrigation and plastic mulching significantly influenced the plant growth parameters of tomato. Among the various treatments, black plastic mulch of 25 micron thickness with 120 % RDF drip fertigation (240:300:300 kg of NPK/ ha) (T_3) recorded maximum plant height (112 cm) and the minimum height (93 cm) was recorded in no mulch plot with 80 % RDF. The earliest flowering of 28 days after transplanting (DAT) was recorded in T3, *i.e.*, 25 micron thickness plastic mulch with 120 % RDF followed by T_6 (50 micron thickness plastic mulch with 120 % RDF) (29 DAT). Whereas, the no mulch treatments took higher number of days (35 days after transplanting) for first flowering. The fruit set was also earlier in 25 micron thickness plastic mulch with 120 % RDF (T_3) (36 DAT) and it took more time in no mulch treatments (45 DAT). Similarly, Yaghi *et al.* (2013) obtained faster crop development and earlier yields in cucumber with the application of plastic mulching. The early flowering and fruit setting in

Table 1. Effect of drip fertigation and plastic mulching on plant height at various stages, days to first flowering and days to first fruit set in tomato

Treatments	Plant height (cm)					Days to first flowering (DAT)	Days to first fruit set (DAT)
	15 DAT	30 DAT	45 DAT	60 DAT	90 DAT		
T_1: Plastic mulch @ 25 micron & 80 % RDF	28	56	84	96	103	31	39
T_2: Plastic mulch @ 25 micron & 100 % RDF	31	61	87	99	108	30	38
T_3: Plastic mulch @ 25 micron & 120 % RDF	33	60	89	103	112	28	36
T_4: Plastic mulch @ 50 micron & 80 % RDF	25	53	79	88	97	31	41
T_5: Plastic mulch @ 50 micron & 100 % RDF	27	55	81	93	100	30	40
T_6: Plastic mulch @ 50 micron & 120 % RDF	28	58	84	95	108	29	38
T_7: No mulch with 80 % RDF	20	48	72	84	93	35	45
T_8: No mulch with 100 % RDF	23	52	77	87	96	34	42
T_9: No mulch with 120 % RDF	26	55	80	92	100	35	43
LSD (P=0.05)	1.66	2.09	2.64	4.07	3.69	4.69	6.74

Table 2. Effect of drip fertigation and plastic mulching on yield attributes and fruit yield of tomato

Treatments	Fruit diameter (cm)	Fruit weight (g)	Fruit yield per plant (kg)	Number of fruits/ plant	Fruit yield (t/ha)
T_1: Plastic mulch @ 25 micron & 80 % RDF	5.10	71.47	1.52	37	56.30
T_2: Plastic mulch @ 25 micron & 100 % RDF	5.90	80.41	1.70	45	62.96
T_3: Plastic mulch @ 25 micron & 120 % RDF	6.67	82.32	1.80	48	67.41
T_4: Plastic mulch @ 50 micron & 80 % RDF	4.90	60.12	1.46	30	54.07
T_5: Plastic mulch @ 50 micron & 100 % RDF	5.85	69.41	1.63	33	60.37
T_6: Plastic mulch @ 50 micron & 120 % RDF	6.20	77.86	1.75	36	64.81
T_7: No mulch with 80 % RDF	4.00	48.00	1.18	27	43.70
T_8: No mulch with 100 % RDF	4.60	54.25	1.30	27	48.15
T_9: No mulch with 120 % RDF	4.90	59.00	1.35	30	50.00
LSD (P=0.05)	1.90	10.00	0.49	11.99	4.44

Table 3. Effect of drip fertigation and plastic mulching on nutrient use efficiency in tomato

Treatments	Nitrogen use efficiency (kg/ha kg of N)	Phosphorus use efficiency (kg/ha kg of P)	Potassium use efficiency (kg/ha kg of K)
T_1: Plastic mulch @ 25 micron & 80 % RDF	352	281	281
T_2: Plastic mulch @ 25 micron & 100 % RDF	315	252	252
T_3: Plastic mulch @ 25 micron & 120 % RDF	278	222	222
T_4: Plastic mulch @ 50 micron & 80 % RDF	338	270	270
T_5: Plastic mulch @ 50 micron & 100 % RDF	302	241	241
T_6: Plastic mulch @ 50 micron & 120 % RDF	270	216	216
T_7: No mulch with 80 % RDF	273	219	219
T_8: No mulch with 100 % RDF	241	193	193
T_9: No mulch with 120 % RDF	208	167	167
LSD (P=0.05)	88.4	61.0	65.1

mulched treatments might be due to rise in soil temperature in the planting bed by plastic mulches, which promotes faster crop development and earlier yields.

Black plastic mulching stimulated the plant growth and hastened the flowering in tomato resulted enhanced yield attributes in tomato. Black plastic mulching produced maximum yield attributes compared to no mulching. This increase in the yield attributes was probably associated with the conservation of moisture and improved microclimate both beneath and above the soil surface which was maintained throughout the life period of crop in plastic mulching and drip fertigation @ 120 % RDF. A maximum of 48 numbers of fruits per plant were obtained for the treatment T_3 and 27 number of fruits per plant for the control (no mulch). The maximum yield was observed in the treatment T_3 (1.80 kg) followed by T_6 (1.75 kg) and T_2 (1.70 kg). The maximum fruit diameter of 6.67 cm was recorded in T_3, *i.e.*, 25 micron thickness plastic mulch with 120 % RDF followed by T_6 (6.20 cm). Whereas, in the control treatment fruits recorded less diameter of 4.0 cm. Fruit weight had significant effect of plastic mulching and fertigation treatments. The maximum fruit weight was observed in the treatment T_3 (82.32 g) followed by T_2 (80.41 g) and T_6 (77.86 g).

The highest fruit yield of 67.41 t/ha was recorded in the black plastic mulch of 25 micron thickness along with fertigation @ 120 % RDF (240:300:300 kg of NPK/ ha) (T_3). It was followed by T_6 (64.81 t/ha) and T_2 (62.96 t/ha) and lowest yield of 43.70 t/ha was recorded in no-mulch treatment with 80 % RDF (T_7). Increased yield in mulched plots could be largely attributed to the increase in soil temperature and due to application of plastic mulch which resulted in an enhancement of soil environment around roots of tomato plants, which led to increasing plant growth and, hence, increasing nutrients uptake. Hence, earlier production and higher total yield was obtained. These results were in line with the findings of Kadam and Karthikeyan (2006) and Ashrafuzzaman *et al.* (2011). The results of this study was also supported by the findings of Anderson *et al.* (1995) who recorded highest yield of tomato in black polyethylene mulches. Similarly Yaghi *et al.* (2013) obtained much better yield of cucumber with plastic mulches. Ramakrishna *et al.* (2006) also reported that the polythene mulched plots produced 94.5 % of more nuts yield over to unmulched plots in groundnut. The response of tomato F_1 hybrid Jeevan on black plastic mulch with drip fertigation was found to have higher moisture conservation, high yield, maximum water use efficiency, maximum fertilizer use efficiency and higher weed control. The economics worked out for different treatment combinations of tomato showed that the highest net income was recorded in plastic mulched treatments than in non-mulched treatments. Among the treatments, black plastic mulch of 25 micron thickness along with fertigation @ 120 % RDF (240:300:300 kg of NPK/ ha) (T_3) recorded the highest net income and benefit cost ratio of Rs. 4,18,911/ ha and 3.66, respectively.

The result of the present study revealed that the plant growth parameters, yield attributes and fruit yield of tomato were enhanced by the combined effect of drip fertigation at 120 % RDF (240:300:300 kg of NPK/ ha) along with 25 micron thick black plastic mulching. Hence, the present study recommends the 120

% RDF drip fertigation with 25 micron black plastic mulching to maximize the yield of tomato crop with effective utilization of water and nutrients.

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