Original Research Article

EFFECT OF DIFFERENT MULCHING MATERIALS ON YIELD AND GROWTH PARAMETERS OF TOMATO CROP

ABSTRACT

The present investigation was carried out to study the performance of yield and growth parameters of tomato crop under different mulching materials. This experiment was conducted at Vikas College of Engineering and Technology, Nunna, Vijayawada during the period from Jan 2019 to April 2020. The experimental field has an area of 180 m^2 (15m × 12m) and divided into 4 plots i.e., Drip with plastic mulch (A), Drip with live mulch (coconut coir) (S), Drip without mulch (M) and Control (without mulch and without drip) (K). Growth parameters like plant height, number of leaves per plant, soil parameters like bulk density, soil temperature, soil moisture and yield were observed for each treatment. Crop water requirement was calculated using CROPWAT 8.0. The results showed that the bulk density has no effect between the treatment plots. The soil moisture in initial stage is more in K and least in S; in flowering stage, M was high and least in K and in harvesting stage, it is high in A. The soil temperature was high in K and least in A. The readings of number of leaves was observed high in A and least in K. It was observed that highest yield was obtained in A and least in K. The weed control efficiency was found to be highest in A (57%) followed by S (41.3%) and weed control efficiency was lowest in M (22.8%).

Keywords: Mulch, Crop water requirement, CROPWAT 8.0, Weed control efficiency

Introduction

Mulch is a layer of material applied to the surface of soil, which is used for conserving soil moisture, improving fertility and health of the soil, reducing weed growth and enhancing the visual appearance of the area. Mulching allows early seeding and transplanting of certain crops, and encourages faster growth. As the season progresses, it stabilizies the soil temperature and moisture, and prevent weed growth. Materials used as much includes coir, woodchips, papers, stones, plastic sheet, paddy straw etc. Mulching increased marketable yield relative to bare soil as the plants grown on silver/black plastic mulch indicated a 65% increasing in marketable mulch compared to control treatment. The plastic mulches resulted in an 84-98% reduction in weed biomass **(Reza *et al.*, 2012)**. The effect of mulching and amount of water on the yield of tomato under drip irrigation was studied and stated that micro irrigation system saves water about 30-70% in various orchard crops and 10-16% in vegetable crops (**Baye Berihun, 2013)**. The influence of organic mulches on soil properties and crop yield were studied and observed that soil moisture in mulched plots is not only higher but also more stable during the entire vegetation period which is an important factor for crops, and also highest soil moisture content was in plots which was mulched with coconut peat (2.6-7.3% units) with saw dust (3.8-6.1% units) compared with soil moisture in plots without mulch (**Pupalienė *et al.*, 2009)**. The soil moisture and yield of tomato in a plot with sugarcane trash mulch were more by 44% and 98%, respectively than those in a plot without mulch (**Firake *et al.*, 1987**). The inorganic mulches (CB and WPB), organic mulches (GWC and PB) and living mulch (TG) exhibited positive effect by elevating the soil moisture content **(Qu. B., et al., 2019)**. The effect of different mulches on growth, flowering and yield of tomato was studied at Abohar and it was observed that there is significantly higher plant height (79.4 cm), branches per plant (7.1), dry weight of plant (287 g), fruit per plant (37.2), fruit weight (85.2 g) and yield per hectare (54t/ha) in black polythene mulching, whereas days to flowering (45) and days taken for ripening were minimum in clear polythene mulching (**Rajbir singh, 2005)**. The increase in yield of black mulched was probably associated with the conservation of moisture, improved micro-climate both beneath and above the soil surface, light reflection and great weed control which reflected also in terms of higher return **(Kundu *et al.*, 2019)**. Mulching caused marked variations in number of leaves per plant, plant height, no. of shoots per plant, shoot length and plant spread **(Kumar *et al.*, 2019).** Average soil temperature was found to be higher by 2 to 5^0C under open field condition than inside the polyhouse. Among the mulches, highest soil temperatures were obtained under transparent mulch with a maximum difference of 10 0C from no mulch soil inside and outside the polyhouse during December to mid March **(Abhivyakti, 2016)**.

From the above studies it is clear that mulches plays a great role in conserving moisture and improving soil temperature and growth parameters of various crops. Keeping this in view, the experiment was planned to determine the effects of different mulches on soil properties, yield and growth parameters of tomato crop.

Material and Methods:

Study area:

The research farm was located at Vikas College of Engineering and Technology, Nunna with an area of 180 m^2 (15m × 12 m) and was divided into 4 plots namely A (plastic mulching with drip), S (coconut coir mulch with drip), M (without mulch with drip), K (control without mulch without drip). The soil in the study area was red sandy loam texture and the source of irrigation is tube well. The average annual temperature and rainfall is 28.5°C and 1067 mm respectively. The seedlings are transplanted with row to row spacing of 60 cm and plant to plant spacing of 40 cm in order to analyse the growth and yield characteristics of tomato crop grown under various mulching materials with drip and without drip and also control conditions.

Methodolgy:

Data collection:

Meteorological data are collected from online sources such as climatedata.org. The data such as Maximum & Minimum Temperatures (^oC), Mean Relative Humidity (%),Wind Speed (kmph) and Sunshine Hours (h). The Reference Crop Evapotranspiration (ET_o) - (mm/day) is calculated by Penman Method. **Table 1** Shows average Meteorological data for the Nunna region on daily data.

Table 1. Meteorogical Data of Nunna Station

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	18.9	30.1	92	4	7.5	16.9	3.02
February	20.1	32.8	92	4	7.3	18.2	3.5
March	22.6	35.4	78	6	8.4	21.4	4.29
April	25.8	37.5	76	8	8.4	22.4	4.83
May	27.9	39.6	65	9	8.9	23.2	5.17
June	27.4	37.5	64	9	8.9	23	5.08
July	25.4	32.9	69	9	9	23.1	4.79
August	25.2	32.4	73	8	8.8	22.9	4.65
September	25.2	32.6	80	6	8.3	21.5	4.44
October	24.2	31.8	80	4	8.3	20	4
November	20.9	30.4	80	5	7.8	17.5	3.25
December	18.8	29.5	77	4	8	16.9	2.86
Average	23.5	33.5	77	6	8.3	20.6	4.16

Soil data:

It is required to know the soil parameters for that we have to select the soil in the CROPWAT 8.0 software, values for the different soils are already saved in the software for the present experiment the soil is red loamy soil. The information regarding the soil data is as shown in the **Plate. 1.**

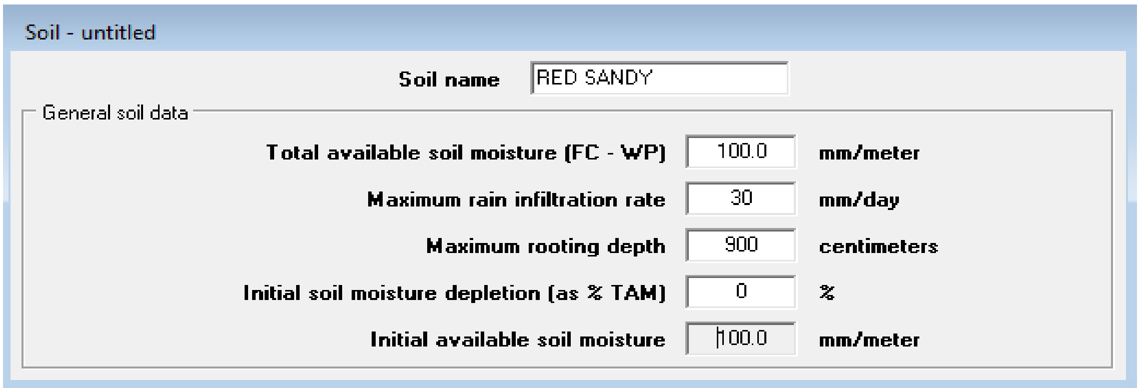

Plate.1. Soil data entered in CROPWAT 8.0.

Crop Data:

Table 2 lists typical values for Kc ini, Kc mid, Kc end for various agricultural crops. The experiment was studied on tomato so select the crop as tomato and enter the planting date then it automatically displays the harvest date and Kc values for different stages and rooting depth for different stages are adopted from the database of the FAO as shown in **Plate. 2.**

Table 2. Crop coefficients of some of the crops

Crop	Kc ini.	Kc mid.	Kc end.
Wheat	0.7	1.15	0.25
Rice	0.50	1.05	0.70
Tomato	0.40	1.05	0.70
Sorghum	0.30	1..0	0.55

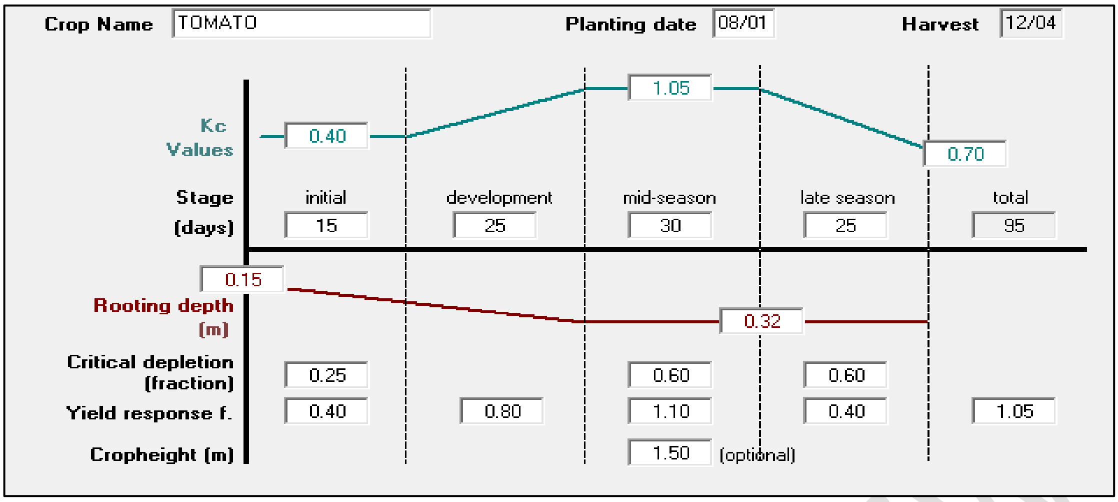

Plate. 2. Crop data entered in CROPWAT 8.0.

After the completion of the data entry as mentioned above, the crop water requirement could be estimated in CROPWAT 8.0. The irrigation scheduling and duration for the tomato crop is estimated based on crop water requirement calculated by CROPWAT 8.0. The amount of water required for the tomato crop calculated by CROPWAT 8.0 is taken as 100 percent of irrigation and the same amount of water applied to the control plot (conventional method) by applying with hose pipe.

Bulk density:

Bulk density is an important parameter and is defined as the dry weight of soil per unit volume of soil. In this study for the determination of bulk density the soil samples are collected before and after the experiment from the four plots.

Formulae used for calculation of bulk density:

Bulk density = Mass of dry soil/Volume of core cutter (gm/cm^3)

Mass of wet soil = (Mass of core cutter + wet soil) - Mass of core cutter (gm)

Volume of core cutter = $\pi/4\ (D^2) \times$ Height (cm^3)

Soil temperature:

Soil temperature plays an important role during the life cycle of the plant right from the germination, root extension, emergence to the reproductive stage. Soil thermometers are required to measure the temperature of the soil at a depth of 15 cm during crop period at initial stage, flowering stage and harvesting stage.

Moisture content:

The soil samples were collected from each plot for crop period during initial stage, flowering stage and harvesting stage at a depth of 15 cm by using soil auger. The collected samples are used to estimate moisture content present in the soil samples by following oven-drying method. The formula used for calculation of moisture content is given by eqn (1).

$$w = \frac{M_2 - M_3}{M_2 - M_1} x100 \quad \text{--------------eqn (1)}$$

Where,

w = Moisture content in percentage (%)

M_1 = Mass of container (gm)

M_2= Mass of container + wet soil (gm)

M_3=Mass of container + dry soil (gm)

Water use efficiency of tomato crop

The water use efficiency is the ratio of total yield obtained to the amount of water used. The following formula is used for calculating the water use efficiency of the cabbage under different treatments. The water use efficiency is calculated by using eqn (2).

$$\textbf{Water use efficiency} = \frac{yield\ (\frac{kg}{ha})}{Amount\ of\ water\ applied\ (mm)} \quad \text{-------eqn (2)}$$

Weed control efficiency (%)

Weed control efficiency (WCE) denotes the magnitude of weed reduction due to weed control treatment. It indicates the comparative magnitude of reduction in weed dry matter in different treatments. It was worked out by using the following formula which was suggested by **(Mani *et al.*,1973)** and expressed in percentage given by eqn (3).

$$\textbf{Weed control efficiency} = \frac{DWC - DWT}{DWC} \times 100 \quad \text{------------eqn (3)}$$

Where,

DWC = Dry weight of weeds from control plot and

DWT = Dry weight of weeds from treated plot.

Statistical analysis: All data were analyzed using the SPSS software package (version 20.0) (IBM Corporation, Armonk, New York). The data were subjected to one-way of variance (ANOVA) and means were separated by the least significant difference test at $p < 0.05$.

Results and Discussion:

Crop Water Requirement for Tomato

The crop water requirement for the tomato crop are presented in **Plate. 3** and it was found that crop water requirement for tomato crop during experimental period (January 1st week to April 1st week) as during the crop growing period, rainfall is not considered as experiment was conducted in summer season.

Crop Water Requirements

ETo station: NUNNA　　Crop: TOMATO

Rain station: NUNNA　　Planting date: 08/01

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Jan	1	Init	0.40	1.19	3.6	3.0	3.6
Jan	2	Init	0.40	1.21	12.1	15.1	0.0
Jan	3	Deve	0.49	1.57	17.3	10.2	7.1
Feb	1	Deve	0.74	2.45	24.5	0.7	23.8
Feb	2	Mid	0.94	3.30	33.0	0.0	33.0
Feb	3	Mid	0.98	3.68	29.5	0.4	29.0
Mar	1	Mid	0.98	3.94	39.4	5.2	34.2
Mar	2	Late	0.97	4.18	41.8	7.7	34.1
Mar	3	Late	0.86	3.87	42.5	7.1	35.5
Apr	1	Late	0.72	3.33	33.3	5.7	27.5
Apr	2	Late	0.63	3.04	6.1	1.0	6.1
					283.0	**56.2**	**233.9**

Plate. 3. Crop water requirement for tomato crop in CROPWAT 8.0.

Irrigation Scheduling

Irrigation schedules were prepared for Tomato crop based on the climate data, crop data, cropping pattern data and soil data using CROPWAT 8.0 model consider there is no rainfall during the crop period and furnished in **Table 3**. It was found that 83.3 mm of water was required for development stage, 87.2 mm of water was required for middle stage and 99.3 mm of water was required for late stage. Time of operation of the drip irrigation system for all the drip treatments with and without plastic mulch (A, S and M) was calculated and operated the drip system daily as per the irrigation schedule and for conventional method of irrigation without mulch K (control), 8mm depth of water is applied at daily throughout the crop period with the help of pipe.

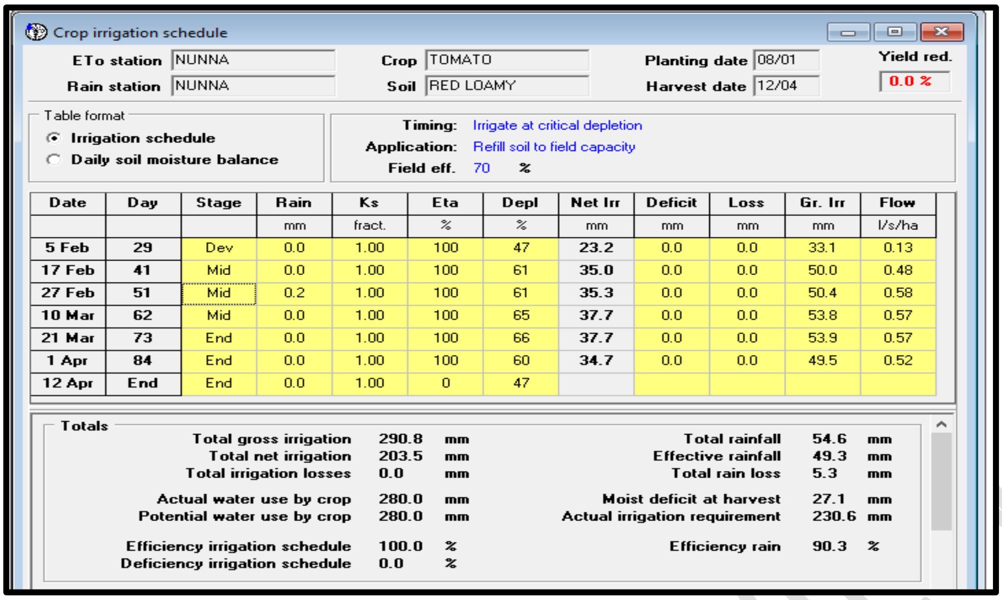

Plate 4. Irrigation scheduling in CROPWAT 8.0.

Table. 3 Irrigation schedule for the tomato crop for all drip treatments

Month	Decade	Stage	Irrigation requirement (mm/day)	CWR (mm/day)	Time of operation per day for drip system (min)
Jan	1	Init	3.6	1.19	10.71
Jan	2	Init	12.1	1.21	10.89
Jan	3	Deve	17.3	1.57	14.13
Feb	1	Deve	24.5	2.45	22.05
Feb	2	Mid	33.0	3.30	29.7
Feb	3	Mid	29.5	3.68	33.12
Mar	1	Mid	39.4	3.94	35.46
Mar	2	Late	41.8	4.18	37.62
Mar	3	Late	42.5	3.87	34.83
April	1	Late	33.3	3.33	29.97
April	2	Late	6.1	3.04	27.36

Soil physical properties:

Bulk density

The average values of bulk density for initial stage of the crop and at harvesting stage of the crop are shown in **Table 4** and observed that the slight increase in the bulk density in the drip plots comparatively from control i.e. traditional method of cultivation. Maximum Value of bulk density 1.56 g/cc was observed in the control treatment which is significant @ p=0.05

with a change of 0.26 g/cc in bulk density due to the soil compaction with the over application of water. In drip irrigation experimental plots having the lesser change in bulk density before and after experiment due to the effect of mulching. These results are also in line with results of treatments in (Qu. B., et al., 2019).

Table 4. Bulk density values before and after the experiment in different treatments.

S. No	Treatment plot	Average bulk density (g/cm^3)	
		Before experiment	After experiment
1.	Drip with Plastic mulch (A)	1.31[a]	1.44[c]
2.	Drip with Live mulch (S)	1.30[b]	1.41[d]
3.	Drip without mulch(M)	1.29[c]	1.49[b]
4.	Control (K)	1.30[b]	1.56[a]
Mean		1.3	1.41
CV		0.62	4.44
Standard error		0.004	0.0032
Mean±Standard deviation		1.3±0.008	1.41±0.065

Values with different letters in the same column indicate significant differences between treatments (p<0.05, n = 4).

Soil moisture content

The results are shown in **Table 5**. The soil moisture in initial stage of growth was high in Control (10.23%) and Drip with without Mulch (10.08%) and least was in Drip with coconut coir (8.23%). In flowering stage, it was high in both Drip with coconut coir (15.23%) and Drip with without mulch (15.8%) and less in control (13.8%). The soil moisture during harvesting stage is maximum in Drip with plastic mulch (17.53%) and least in Drip with without mulch (14.23%). This is due to the mulch that helps in conserving moisture and there is less need for irrigation (Kundu *et al.,* 2019 and Devi, L. K., *et al.,* 2020).

Table 5. Soil moisture contents at intial, flowering and harvesting stages in different treatments

Sl.no	Treatments	Initial	Flowering	Harvesting
1.	Drip with Plastic mulch(A)	9.9[c]	14.2[c]	17.53[a]
2.	Drip with coconut coir(S)	8.23[d]	15.23[b]	16.24[c]
3.	Drip with without mulch(M)	10.08[b]	15.8[a]	14.23[d]
4.	Control(K)	10.23[a]	13.8[d]	16.5[b]
Mean		9.61	14.75	16.12
CV		9.67	6.23	8.56
Standard error		0.46	0.45	0.69
Mean±Standard deviation		9.61±0.92	14.75±0.92	16.12±1.38

Values with different letters in the same column indicate significant differences between treatments (p<0.05, n = 4).

Soil temperature

The soil temperatures were recorded during different growth stages at different a depth of 15cm in all treatments by using soil thermometer and results were presented in the **Table 6**. During initial stage the soil temperature was high in control (30.43°C) and Drip with without mulch (29.8°C) and the least was observed in Drip with coconut coir (28.5°C). During the flowering stage control treatment had a temperature of (33.58°C), drip with without mulch (32.0°C), Drip with plastic mulch (31.43°C) and Drip with coconut coir (27.5°C). In harvesting stage, the maximum soil temperature was observed in control (34.5°C) followed by Drip with without mulch (33.7°C), Drip with plastic mulch (32.13°C) and Drip with coconut coir (31.2°C). From the above results it is clear that mulch helps in conservation of moisture and there by lessening the effect of temperature on soil (Abhivyakti, 2016). Here in the present scenario Drip with coconut coir is showing low temperatures which are significant at 0.05% probability level.

Table 6. Soil temperature (˚C) at different stages of tomato crop in different treatments

S. No.	Treatments	Initial	Flowering	Harvesting
1.	Drip with Plastic mulch(A)	29.08[c]	31.43[c]	32.43[c]
2.	Drip with coconut coir(S)	28.5[d]	30.53[d]	31.2[d]
3.	Drip with without mulch(M)	29.8[b]	32.0 [b]	33.7 [b]
4.	Control(K)	30.43[a]	33.58 [a]	34.5 [a]
Mean		29.45	31.88	32.95
CV		2.85	4.020	4.39
Standard error		0.42	0.64	0.72
Mean±Standard deviation		29.45±0.84	31.88±1.28	32.95±1.44

Values with different letters in the same column indicate significant differences between treatments (p<0.05, n = 4).

Crop yield and yield attributes

Crop growth

Crop growth was observed under different treatments with the help of plant parameters such as plant height and Number of plant leaves are presented in **Table 7**. The results revealed that, these crop growth and yield attributes are significantly higher in the drip with plastic mulch (A) as compared to the rest of the treatments. These results are in agreement with the results in references (Kumar, *et al.*2019 and Devi, L. K., *et al.,* 2020).

Table 7. Crop growth parameters at different stages in different treatments

Sl. No	Treatment plots	Initial		Flowering		Harvesting	
		Plant height (cm)	Number of leaves	Plant height (cm)	Number of leaves	Plant height (cm)	Number of leaves

1	Drip with Plastic mulch	16.3^{b}	18^{a}	42^{a}	37^{a}	67^{a}	51^{a}
2	Drip with coconut coir	13.9^{c}	13^{c}	35.6^{b}	31^{b}	62.7^{b}	46^{b}
3	Drip with without mulch	18.5^{a}	16^{b}	31.8^{c}	29^{c}	56.1^{c}	41^{c}
4	Control	13^{d}	9^{d}	29.5^{d}	24^{d}	45.4^{d}	39^{d}
Mean		15.42	14.00	34.72	30.25	57.80	44.25
CV		16.06	27.96	15.73	17.77	16.26	12.15
Standard error		1.239	1.957	2.731	2.688	4.701	2.688
Mean±Standard deviation		15.42±2.4	14.0±3.9	34.72±5.4	30.25±5.3	57.80±9.4	44.25±5.3

Plant height

It was shown in **Table 7**, that in the initial stage the plant height was more in Drip with without mulch (M) (18.5cm), followed by Drip with plastic mulch (A) (16.3cm), Drip with coconut coir (S) (13.9cm) and least in control (K) (13cm). In flowering stage, it is maximum in Drip with plastic mulch (A) (42cm) followed by Drip with coconut coir (S) (35.6cm), Drip with without mulch (M) and least in Control (K) (29.5cm). In harvesting stage, the plant height is maximum in Drip with plastic mulch (A) (67cm) and least in control (K) (45.4cm). This pattern of plant height more in Drip with plastic mulch is similar to the results in (Kumar, *et al.*2019 and Devi, L. K., *et al.*, 2020).

Number of leaves

It was shown in **Table 7**, that the number of leaves observed in initial stage is more in Drip with plastic mulch (A) followed by Drip with without mulch (M), drip with coconut coir (S) and control (K). In the flowering stage this is more in plastic mulch (A) and coconut coir (S). The least is observed in Control (K). During harvesting the leaves are maximum observed in black plastic mulch (A) and the least in Control (K). These results are in line with agreement with the results of (Kumar, *et al.*2019 and Devi, L. K., *et al.*, 2020).

Crop yield

The drip irrigation in combination with different mulches significantly increased the yield of tomato as compared to drip irrigation without mulch **Table 8**. Among various treatments, the highest yield (2.018 t/ha) was recorded under drip with plastic mulch (A), followed by Drip irrigation with coconut coir (S) (1.412 t/ha), Drip with without mulch (M) (1.405 t/ha) and the lowest yield (0.873 t/ha) was recorded under conventional method of irrigation control (K). This might be due to water stress during the critical growth period, coupled with aeration problem in first few days immediately after irrigation. Another reason to get low yield by conventional practice of irrigation might be due to less availability of nutrients for crop growth due to leaching and high weed infestation between the crops. These results showed the same trend as the results obtained in references (Kundu *et al., 2019;* Kumar, *et al.*2019 and Devi, L. K., *et al.,* 2020) who showed that drip with the combination of plastic mulch is yielding higher.

Table 8. Yield comparison of tomato crop

S. No	Treatments plots	Area (m^2)	Yield (t/ha)
1	Drip with Plastic mulch (A)	15 x 3.5	2.018
2	Drip with coconut coir (S)	15 x 3.5	1.412
3	Drip with without mulch (M)	15 x 3.5	1.405
4	Control (K)	15 x 3.5	0.873

Water use efficiency

Water use efficiency (yield per unit area per unit depth of water used) increased under all the treatments of drip irrigation system over the conventional practice of irrigation without mulch (control) is as shown in **Table 9**. There was a saving of 84.5 % irrigation water by the treatment which applied drip irrigation along with mulch over the control. It is also observed that highest irrigation water use efficiency 8.6 kg/ ha-mm was with the treatment (A). Greater WUE and saving of irrigation water under drip with mulch could be due to minimum water loss due to percolation, runoff, seepage and soil evaporation as water is applied directly near the root zone of the crop in required quantity. The results showed agreement with the results reported by (Singnadhupe *et al.,* 2003; Mukherjee 2010 and Devi, L. K., *et al.,* 2020).

Table 9. Water use efficiency in different treatments

S. No	Treatments	Water applied (mm)	Water use efficiency (kg/ha-mm)
1	Drip with Plastic mulch (A)	233.9	8.6
2	Drip with coconut coir (S)	233.9	6.03
3	Drip with without mulch (M)	233.9	6.01
4	Control (K)	720	1.21

Weed control efficiency

Weed control efficiency results are shown below in **Table 10**. This is due to the reason that plastic mulches modified the soil temperature in the soil which promotes faster and best crop vegetative growth and thereby suppressing the weed growth. The mulching will cover the surface area thereby making it difficult for the weed growth and also irrigation will be available to the crop instead of weed in case of drip as compared to control treatment.

Table 10. Comparison of weed control efficiency with control treatment

S. No	Treatment plots	Weed control efficiency (%)
1	Drip with Plastic mulch (A)	57
2	Drip with coconut coir (S)	41.3
3	Drip with without mulch (M)	22.8
4	Control (K)	---

CONCLUSION

The present study shows that the combination of drip irrigation and mulch not only increased the yield but also improved the water use efficiency and weed control efficiency remarkably. Drip irrigation has effectively increased fruit yield of tomato and improved WUE due to application of appropriate quantity of water. However, integrated use of drip irrigation and mulch was more efficient and profitable. The use of drip in combination with mulching, can increase the tomato yield substantially over the conventional method of irrigation, with about 84.5% saving in irrigation water. The fruit yield (2.018 t/ha) under drip with plastic mulch (A) was at par with drip without mulch (M) and control (K) treatments. The main challenge which is faced by farmers in rain fed areas is to improve yield, water use efficiency and weed control efficiency can be achieved by use of mulch along with drip.

References

Baye Berihun, (2013). Effect of mulching and amount of water on the yield of tomato under drip irrigation, *Journal of Horticulture and Forestry*, 3(7): 201-206.

Devi,L.K., Panda,J., Santosh Rangrao Yadav, Jhajharia D., Sakharam. N. I., and Sharma, P, S, A. (2020). Effect of Drip and Mulch on Growth, Yield and WUE of Tomato under Low Cost Polyhouse in Sikkim Condition. *Int.J.Curr.Microbiol.App.Sci.* 9(1):193-198. doi: https://doi.org/10.20546/ijcmas.2020.901.022

Firake, N. N., Bangal, G. B. and Gutal, G. B. (1987). Soil moisture conservation efficiency of mulches in tomato. A paper presented in 23rd ASAE conservation on 9-11 March, 1987 at Jabalpur (M. P.).

Kumar, R. R., Singh, R. N., Sohane, R. K. and Singh, A. K. (2019). "Effect of Different Type Mulch on Growth, Yield Attributes and Yield of Brinjal (Solanum melogena)", *Current Journal of Applied Science and Technology*, 37(6), pp. 1-6. doi: 10.9734/cjast/2019/v37i630333.

Kundu, P., Adhikary, N., Saha, M., Ghosal, A. and Sahu, N. (2019). The Effects of Mulches on Tomato (Lycopersicon esculentum L.) in Respect of Yield Attribute in Ecosystem of Coastal Bengal. Current Journal of Applied Science and Technology. 35, 4 (May 2019), 1-8. DOI:https://doi.org/10.9734/cjast/2019/v35i430190.

Mani V, S., Malla, M,L., Gautam K, C and Bhagwandas (1973). Weed killing chemicals in potato cultivation. *Indian Farming,* VXXII: 17-18.

Mukherjee, A., Kundu, M. and Sarkar, S. (2010). Role of irrigation and mulch on yield, evapotranspiration rate and water use pattern of Tomato (*Lycopersicon esculantum* L). Agricultural Water Management. 98:182-189.

Pupalienė R., Sinkeviciene, D. Jodaugienė, and M. Urbonienė. (2009). The influence of organic mulches on soil properties and crop yield. *Agronomy Research*,7:485-491.

Qu B, Liu Y, Sun X, Li S, Wang X, Xiong K. (2019). Effect of various mulches on soil physico—Chemical properties and tree growth (*Sophora japonica*) in urban tree pits. PLoS ONE 14(2): e0210777. https://doi.org/10.1371/journal.pone.0210777

Rajbir Singh (2005). Influence of mulching on growth and yield of tomato (Solanum lycopersicum L.) in north Indian plains. *Vegetable Science*, 32 (1): 55-58.

Reza, H., Khan, F. H and Rafezi, R. (2012). Effect of coloured plastic mulches on yield of tomato and weed Biomass. *Journal of environmental science and Development*, 3(6): 590-593.

Singandhupe, R. B., Rao, G. G. S. N., Patil, N. G., and Brahmanand, S. (2003). Fertigation studies amd irrigation scheduling in drip irrigation system in Tomato crop.

European Journal of Agronomy. 19:327-340.

Abhivyakti., Kumari, P., Ojha, K, R., and Job, M. (2016) Effect of plastic mulches on soil temperature and tomatoyield inside and outside the polyhouse .Agricultural Science Digest.2016.(36):333-336.

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