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Effect of Drip and Mulch on Growth, Yield and WUE of Tomato under Low Cost Polyhouse in Sikkim Condition

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ABSTRACT

The present investigation was carried out to evaluate the performance of tomato in polyhouse with drip and mulch at AICRP on Plasticulture Engineering and Technologies experimental field of College of Agricultural Engineering and Post-Harvest Technology (CAEPHT), Central Agricultural University (CAU), Ranipool, Sikkim, India. The experiment comprised of three treatments [viz. T1: Drip with no mulch, T2: Drip with mulch, and T3: No drip no mulch (control)] with four replications following Randomized Block Design (RBD). Black low density poly ethylene (LDPE) sheets of 50 micron thickness were used as mulch. The plant growth, yield and WUE were significantly affected by T_2 as compared to T_1 and T_3 inside polyhouse. The maximum number of leaves (9.84, 24.14 and 33.29) and tallest plant (38.40, 102.19 and 170.16 cm), respectively at 30, 60 and 90 DAT was observed in T_2. Similar trend in yield attributes, the highest yield/ plant (1548 g) and yield/ m^2 (3490 g) was observed in T_2, although at par with T_1. The use of drip in combination with mulching, not only increased the yield but also saving irrigation water (62%) as compared to conventional method with highest WUE (58.19 kg m^{-3}). The study thus reveals that drip irrigation with mulch give better water use efficiency, increased yield and thereby achieving the prime objective of 'more crop per drop'.

Introduction

Tomato is considered as one of the most productive as well as protective food because of its nutritive value, widespread production and consumed vegetables worldwide. In India, it is grown in the wide range of climatic condition and ranks 2^{nd} largest nation in production worldwide (Reddy M. S. *et al.*, 2018). It is consumed in many ways and most common ingredient in dishes, sauces, salads and drinks. It is a warm season crop, temperature below 10˚C and above 38˚C may adversely affect the plant tissues thereby effecting the plants physiological activities.

Sikkim state experience adverse weather phenomenon experiencing excess rainfall in monsoon months, extreme cold in winter couple with long dry spell affects the growth and yield of vegetables. Beside, Sikkim is gifted with suitable climates for round the year cultivation of tomato but in the open field it main season is during rabi whereas during the other part of the season its growth and yield is adversely affected due to unfavorable environmental factors. There is however a great scope for profitable cultivation of better quality tomato in protected condition year round in Sikkim. Protected cultivation practices provide the plant with micro climate which is so modified or controlled partially or fully as per the requirement or suitability of the plant. Also, application of irrigation water with drip and conserving moisture through various mulches is considered to give better water use efficiency and thereby achieving the prime objective of 'more crop per drop'.

Drip irrigation is practiced widely especially for the fruit and vegetable crops owing to its precise and direct application of water in the root zone with a considerable saving in irrigation water. Drip irrigation has created interest because of its ability of small, frequent irrigation applications which result in decreased water requirements and possible increased production (P.K. Shrivastava *et al.*,1994). This method of irrigation is suitable and economical for the water scare areas. Drip irrigation is more profitable than the conventional method (surface irrigation) (Pramanik and Biswas, 2012). According to the central institute of agriculture engineering about 39% of water can be saved by adopting drip irrigation for Tomato crop (Reddy M. S. *et al.*, 2018) besides contributing higher yield of tomato than sprinkler or furrow irrigation (Lui, 2000).

Mulches also contribute to the crop production by way of influencing soil productivity, control of weed etc., depending upon the type of mulch (Asiegha, 1991). Mulching practices in crop production also enhance moisture conservation, increased WUE and yield. Sweeney *et al.*, (1987) reported higher tomato yield with black plastic mulch under field conditions. The combined effect of drip (50% crop water requirement) and mulch (polyethylene and straw) on tomato resulted higher yield with increased WUE (Biswas *et al.*, 2015) and also irrigation schedule at three days interval with grass mulch save irrigation water, enhanced yield and quality of greenhouse tomato in warm tropics (Kere *et al.*, 2003). In view of the potentially of the tomato crop in the region, it is imperative to evaluate its performance in polyhouse with drip and mulch. Hence, this experiment was undertaken to study the effect of drip and mulch on growth, yield and WUE of tomato under low cost polyhouse in Sikkim condition.

Materials and Methods

An experiment was conducted for two-consecutive years during February to June, 2013 and 2014 at All India Coordinated Research Project on Plasticulture Engineering and Technologies (AICRP-PET) experimental field of College of Agricultural Engineering and Post-Harvest Technology (CAEPHT), Central Agricultural University (CAU), Ranipool, Sikkim, India to study the effect of drip and mulch on growth, yield and WUE of tomato under low cost naturally ventilated polyhouse (NVP) in Sikkim condition. The experiment comprised of three treatments [viz. T1: Drip with no mulch, T2: Drip with mulch, and T3: No drip no mulch (control)] with four replications following Randomized Block Design (RBD). Black low density poly ethylene (LDPE) sheets of 50 micron thickness were used as mulch.

The site is located in East Sikkim District, Sikkim, India, at 27.33^0 North latitude and 88.6^0 East longitude at an altitude of l650 m above mean sea level. The mean maximum and a minimum temperature range from 26 to 36°C and 9.4 to 25.4°C respectively, with humidity ranging from 60 to 97% and 24 to 82%, respectively. The soil has a textural composition of sand, silt, and clay as 62%, 23%, and 15% respectively. The available moisture content of the soil (AWC) is 15% by weight.

Soil tension was measured on daily basis and irrigation was applied, based on the soil moisture depletion. Soil moisture depletion of 50% & 60 % were considered as the lower and upper limit for irrigation application. Irrigation of 6 mm is being applied when the suction nears to 60 cb in all the treatment plots. Localized irrigation (root zone only) was planned for in the treatments (T1: Drip with no mulch and T2: Drip with mulch). Flood irrigation was followed with the same application depth (6mm) in the control plots (T3: No drip no mulch).

Climatic data of Tadong (ICAR) were used for estimation of reference crop evapotranspiration (ET_0) using FAO Penman-Monteith equation. Value of crop coefficient for tomato was taken as 0.6, 1.15 and 0.8 for initial, mid season and late season stages respectively for estimation of crop evapotranspiration (ET_c). Expected monthly rainfall at 80% level of probability was worked out from the rainfall data of 27 years (1983 to 2009). Irrigation requirement was calculated by deducting the effective and expected (80%) rainfall from the estimated value of ET_c.

A gravity based drip irrigation system was designed and installed in the polyhouse. The available head (at the upper terrace) was 3 m. Gravity based drip irrigation system was installed with an overhead tank of 1000 litres, PVC main and submain pipe of 50 and 40 mm dia, respectively, 16mm LLDPE laterals and online drippers of 2 lph discharge capacity to provide irrigation to 144 plants for the crop spacing of 60 X 50cm. The system was evaluated for 24 laterals and upto 18 drippers in a lateral. Average discharge per dripper was found to be 1.24 lph at the average pressure of 0.3 kg/cm^2. UC for drippers in a single lateral were observed to be 95.73%. The corresponding value for drippers among different laterals was found to be 94.87%.

General recommended cultural practices were followed to raise a good crop. Tomato seedlings were transplanted at the spacing of 60 cm × 50 cm in a raised bed (having an area of 1.8 m^2) accommodating 12 plants per plot. Manuring was done as per the organic equivalent doses of recommended NPK of tomato @ 5kg/m2 FYM as per RDF (Chadha, 2003) as basal dose and additional dose of vermicompost @ 1kg/m2 was applied one month after transplanting. Observations on various plant growth, yield and WUE were recorded on randomly selected plants in each treatment and replication. The WUE was calculated as marketable yield divided by seasonal irrigation water applied. The data collected for various parameters were subjected to statistical analysis using RBD one factor SPSS-16 software.

Discharge rate of drippers

Uniformity coefficient (UC) of application of water was determined by collecting the discharge of the drippers in the can for a specified period at selected laterals and the hydraulic performance of the drip irrigation system was evaluated by finding out the Christiansen's coefficient of uniformity (UC) as per the following formula

$$UC = \left(1 - \frac{D}{M}\right) X\, 100$$

where M, mean emitter discharge rate (l/h); D, mean deviation of the emitter discharge from mean value. The actual average discharge of the dripper was measured to be 1.24 l/h. The discharge of drippers at each crop root zone were to be adjusted with time of operation of the drippers according to the volume of water exactly required on the basis of varying irrigation requirement throughout the crop season.

Results and Discussion

The pooled data (Table - 1 & Table – 2) reflected that the plant growth, yield and WUE were significantly affected by the treatment of drip irrigation with mulch (T_2) as compared to T_1 (Drip with no mulch) and T_3 (control: No drip no mulch) treatment inside polyhouse. The maximum number of leaves (9.84, 24.14 and 33.29) and tallest plant (38.40, 102.19 and 170.16 cm), respectively at 30, 60 and 90 days after transplanting (DAT) was observed in T_2. Accept the number of leaves at 60 DAT was at par with T_1 (23.28). The lowest number of leaves (8.63, 21.81 and 29.28) and plant height (33.20, 93.35 and 156.41 cm), respectively at 30, 60 and 90 days after transplanting (DAT) was noticed in T_3. Similarly, the highest yield/ plant (1548 g) and yield/ m^2 (3490 g) was observed in T_2, which was at par with T_1. Whereas, the lowest yield/ plant (1257 g) and yield/ m^2 (3490 g) was recorded in T_3. The increased in plant growth and yield in T_2 could be ascribed due to adequate supply of moisture directly to the root zone, minimum evaporation loss pertaining optimum moisture regime, proper temperature control owing to presence of mulch, better uptake of nutrients and excellent soil-water-plant relationship as reported by Hundal *et al.*, 2000, Zhang *et al.*, 2005 and Biswas *et al.*, 2015. Beneficial responses of vegetable crops to mulch in terms of growth and yield have been reported by many investigators (Narendra Agarwal *et al.*, 2010, Baye Berihun, 2010).

Table.1 Effect of drip and mulch on vegetative growth of tomato in low cost polyhouse

Treatments	No. of leaves/ plant			Plant height (cm)		
	30 DAT	60 DAT	90 DAT	30 DAT	60 DAT	90 DAT
T1	8.84	23.28	31.37	35.53	95.87	164.18
T2	9.84	24.14	33.29	38.40	102.19	170.16
T3	8.63	21.81	29.28	33.20	93.35	156.41
CD (0.05)	0.86	1.12	1.18	NS	3.66	4.68

Table.2 Effect of drip and mulch on yield and WUE of tomato in low cost polyhouse

Treatments	Yield/ plant (g)	Yield/ m^2 (g)	Rate of irrigation applied (litre per plant)	Saving of irrigation water (%)	WUI (kg of produce per cum of irrigation water applied)	Irrigation applied to produce 1 kg of tomato (litres)
T1	1479	4107	35.1	50	42.13	23.73
T2	1548	4299	26.6	62	58.19	17.18
T3	1257	3490	70	-	17.9	56.68
CD (0.05)	109.27	303.59	9.9	-	-	-

There was a saving of 62% irrigation water by the treatment which applied drip irrigation coupled with mulch over the control. It is also observed that highest irrigation water use efficiency 58.19 kg m^{-3} was with the treatment T_2. 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. This finding is in agreement with the finding of tomato cultivation under drip irrigation as reported by Singnadhupe *et al.*, 2003 and Mukherjee 2010.

The necessity for adoption of novel irrigation technologies has been the most important issue in the present agricultural production systems. The main challenge is to improve WUE and sustainable water use for rain fed agriculture and irrigated agriculture. 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 62% saving in irrigation water. Although the fruit yield (42.99 t/ha) under drip with mulch (T_2) was at par with drip without mulch (T_1) however highest WUE was noticed in T_2 as compare to T_1 and T_3 (Control). In conclusion, the present study can state that combination of drip irrigation and mulch not only increased the yield but also improved the WUE remarkably. Therefore, it is the subject of future investigations, on combination of different mulching material under drip irrigation to address the economical as well as environmental feasibility, especially in protected cultivation practiced areas where water and nutrient utilization is the primary objective.

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