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# Growth and Yield Attributres of Tomato (*Solanum Lycoperscicum* L.) Influenced by Different Mulches and Levels of Irrigation in Northern Dry Zone of Karnataka

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**Abstract:** An experiment was carried at College of Horticulture, Bagalkote to study the effect of different mulches and levels of irrigation on growth and yield attributes of tomato. The study was carried out with 12 treatment combinations and replicated thrice in split plot design. The main plots were assigned four irrigation levels based on cumulative pan evaporation: $I_1$: 100%, $I_2$: 80%, $I_3$: 60%, and $I_4$: 40%. The subplots consisted of three mulching treatments: $M_1$: no mulch, $M_2$: sugarcane mulch, and $M_3$: polythene mulch. Irrigation was given based on cumulative pan evaporation (CPE) following alternate day irrigation schedule using drip. The treatment combination ($I_2M_3$) comprising drip irrigation at 80% CPE in combination of polythene mulch recorded highest plant height (112.1 cm), maximum number of branches plant$^{-1}$ (16.0) and maximum plant canopy in East-West (112.5 cm) and North-South (111.8 cm) directions. Total yield (51.8 t ha$^{-1}$) and other yield attributing characters like flowers number cluster$^{-1}$ (7.23), fruits cluster$^{-1}$ (6.1), average weight of the fruit (63.4 g), fruit yield plant$^{-1}$ (2.7 kg) were also high under this treatment.

**Key words**: Mulch, drip irrigation, evaporation, water use efficiency, cumulative pan evaporation.

Tomato (*Solanum lycopersicum* L.) is a very popular vegetable crop which belongs to the family solanaceous, having a Peru- Ecuador-Bolivia as centre of origin. Tomato is treated as "Protective food" since being rich in health protecting phytochemicals such as vitamins and minerals (Khapte *et al.*, 2018). It is rich source of beta-carotene and the strongest antioxidant lycopene. It dominates the domestic market, besides having high export demand. The tomato is processed into a number of products such as tomato puree, paste, sauce, ketchup, and powder; it is generally referred to as the 'number one processing vegetable.

The global tomato market has reached a remarkable scale, with a production volume of 170.75 mt, spanning an area of 5.02 mha and achieving an average yield of 33.99 t ha$^{-1}$. India ranks second worldwide in both area and production of tomatoes. In India, tomatoes are grown on 0.81 mha, yielding a total production of 19.67 mt, with an average productivity of 24.36 t ha$^{-1}$. In Karnataka, tomato cultivation spans 0.063 mha, resulting in a production of 2.14 mt and an average productivity of 33.55 t ha$^{-1}$ (Anonymous, 2018).

Tomato is a day neutral crop, and less tolerant to shade conditions. It is moderately tolerant to soil salinity and acidity. Crop being deep tap rooted, is moderate in its water requirement. Water is scarce resource in northern dry zone of Karnataka as rainfall is low. Therefore, it is essential to utilize water efficiently, and mulching offers an effective strategy to enhance water conservation and optimize moisture retention in the soil. Mulching also reduces the weed menace, decreases dispersion of soil particles by rain drops and contain soil erosion and balances soil temperature. The method of irrigation significantly impacts crop yield and quality. Among various irrigation methods, drip irrigation stands out as the most promising option for ensuring high-quality yields. The use of crop evapotranspiration (CPE) data is particularly beneficial in determining irrigation schedules and calculating the appropriate water quantities needed to maintain optimal soil moisture levels. This precision in water management not only supports healthy crop growth but also enhances resource efficiency.

Given the water scarcity situation, estimating the quantity of water required for crop growth is crucial, especially in conjunction with various mulching practices. The implementation of trickle (drip) irrigation combined with different types of mulches can significantly enhance water use efficiency and soil moisture retention. The present study was carried out to assess the impact of drip irrigation and mulching on tomato growth and yield.

## Material and Methods

The investigation was carried out at Vegetable Block of College of Horticulture, Bagalkote, University of Horticultural Sciences, Bagalkote during the rabi 2019-2020. The research plot was brought to fine tilth by thoroughly ploughing the field with the disc plough. The raised bed (15-20 cm height) of one meter width were prepared. Every bed had two rows of planting and two drip laterals were laid with discharge holes distanced at 40 cm. The main plot was assigned four different irrigation levels of size is 9.6 m x 3.6 m and three mulch treatments as subplots comprising of size 3.2 m x 3.6 m. Popular tomato hybrid Arka Rakshak was used in the experiment, and seedlings were made ready by using soilless media in portrays. Healthy seedlings of 30 days old were transplanted into main field.

The present study was laid out in the split-plot design. Four irrigation levels were categorized as main plots and three types of mulches were designated as subplots, with each treatment being replicated three times. The irrigation levels included drip irrigation application at 100% ($I_{100}$), 80% ($I_{80}$), 60% ($I_{60}$), and 40% ($I_{40}$) of cumulative pan evaporation. The mulching treatment included sugarcane mulch (SM) and polyethylene mulch (PM), and a no mulch control (WM). In total, this resulted in 12 distinct treatment combinations: $I_{100}$WM, $I_{100}$SM, $I_{100}$PM, $I_{80}$WM, $I_{80}$SM, $I_{80}$PM, $I_{60}$WM, $I_{60}$SM, $I_{60}$PM, $I_{40}$WM, $I_{40}$SM, and $I_{40}$PM.

The irrigation water quantity to be applied was based on the cumulative pan evaporation (CPE) data recorded in the meteorological unit situated at University of Horticultural Sciences, Bagalkote. The obtained CPE value was converted into required pumping hours to discharge water into the plots according to four different irrigation levels viz., 100, 80, 60 and 40% of CPE.

## Results and Discussion

The results showed that plant height, number of branches plant$^{-1}$ and plant canopy at 90 days after transplantation was affected by different irrigation levels and mulches significantly (Table 1). The mean plant height (108.3 cm), mean number of branches (13.8) and mean plant canopy in East-West (109.6 cm) and North-South (107.6 cm) directions were maximum in the treatment $I_{100}$ which was at par with the treatment $I_{80}$. Minimum plant height, number of branches and plant canopy both in East-West and North-South directions were recorded with drip irrigation at 40% CPE ($I_{40}$). Presence of higher moisture under the drip throughout growing period enabled the

*Table1.Vegetative parameters of tomato (plant height, number of branches and plant canopy) as influenced by different irrigation levels and mulches*

| | Plant height (cm) | | | | | Number of branches | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean |
| WM | 106.7 | 103.1 | 100.1 | 88.7 | 99.6 | 12.5 | 12.0 | 10.4 | 9.4 | 11.1 |
| SM | 107.8 | 106.8 | 100.8 | 92.8 | 102.0 | 13.7 | 13.0 | 11.0 | 9.9 | 11.9 |
| PM | 110.3 | 112.1 | 103.8 | 95.4 | 105.4 | 15.3 | 16.0 | 11.8 | 10.8 | 13.5 |
| Mean | 108.3 | 107.3 | 101.5 | 92.3 | | 13.8 | 13.7 | 11.1 | 10.0 | |
| | S.Em± | | CD @ 5% | | | S.Em± | | CD @ 5% | | |
| Main plot (M) | 0.78 | | 2.69 | | | 0.47 | | 1.62 | | |
| Sub plot (S) | 1.39 | | 4.17 | | | 0.8 | | 2.4 | | |
| M×S | 0.7 | | 2.08 | | | 0.42 | | 1.25 | | |

| | Plant canopy (East-West) (cm) | | | | | Plant canopy (North-South) (cm) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean |
| WM | 108.4 | 106.9 | 97.4 | 84.4 | 99.3 | 104.7 | 103.5 | 98.27 | 89.87 | 99.1 |
| SM | 109.1 | 108.3 | 102.9 | 90.8 | 102.8 | 107.2 | 104.2 | 102.23 | 94.4 | 102.0 |
| PM | 111.1 | 112.5 | 104.7 | 102.2 | 107.6 | 110.7 | 111.8 | 104.4 | 97.17 | 106.0 |
| Mean | 109.6 | 109.2 | 101.7 | 92.5 | | 107.6 | 106.5 | 101.63 | 93.81 | |
| | S.Em± | | CD @ 5% | | | S.Em± | | CD @ 5% | | |
| Main plot (M) | 1.93 | | 6.67 | | | 0.84 | | 2.9 | | |
| Sub plot (S) | 2.4 | | 7.21 | | | 1.23 | | 3.69 | | |
| M×S | 2.09 | | 6.26 | | | 0.62 | | 1.85 | | |

$I_{100}$, $_{I80}$, $I_{60}$ and $I_{40}$ : Drip irrigation at 100%, 80%, 60% and 40% cumulative pan evaporation, respectively; WM: without mulch, SM: sugarcane mulch, PM: polyethylene mulch. CD: Critical difference; SEm: Standard error of mean

availability and uptake of nutrients by plant which in turn resulted in greater vegetative growth of plant. Biswas *et al.* (2015) also noticed highest plant height of 115.8 cm in tomato when irrigated at 100% evapotranspiration (ET). Almost identical research findings were recorded by Cheena *et al*. (2018); Kishore *et al*. (2018) and Al-Marri *et al.* (2020) in tomato. With the application of mulches, most parameters viz. plant height, number of branches and plant canopy increased. The increase following application of the polythene mulch was at par with that of sugarcane mulch. Lowest plant height, minimum number of branches and plant canopy both in East-West and North-South were recorded in plants grown under without mulch. Improved vegetative growth observed under mulch may be attributed to enhanced access to soil moisture, along with the maintenance of favorable temperatures and other conditions in the plant root zone. Ashrafuzzaman *et al.* (2011) in chilli, Rajablariani *et al*. (2012) in tomato and Kishore *et al*. (2018) in tomato also recorded the increased height of the plant and number of branches following mulch application.

Among interactions between levels of drip irrigation and mulch treatments, $I_{80}$ PM resulted in maximum plant height (112.10 cm), greater number of branches per plant and also plant canopy. These values were not significantly different from that of $I_{100}$ PM. Lowest plant height (88.70 cm), minimum number of branches (9.37) and lowest plant canopy in East-West (84.43 cm) and North-South (89.87 cm) directions was recorded under $I_{40}$ WM. This difference in growth parameters can be attributed to increased water and nutrient utilization, better soil-water-air relationship, decreased weed competition and better soil hydrothermal regime. Raina *et al.* (1999); Bahadur *et al.* (2009); Kishore *et al*. (2018) and Samui *et al*. (2020) had also recorded the similar trend.

Irrigation levels had significant influence on flowering parameters in tomato. Treatment receiving minimum irrigation water i.e. $I_{40}$ reached to flowering first (27.8 days) and to 50% flowering in 32.6 days, which was at par with $I_{60}$ (Table 2). However, late flowering was observed under the highest level of irrigation i.e. $I_{100}$ in which and it took 31.1 day for first

*Table 2. Days to first flowering, 50% flowering, flowers cluster-1 and fruits cluster-1 as influenced by different irrigation levels and mulches*

| | Days to first flowering | | | | | Days to 50% flowering | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean |
| WM | 32.3 | 31.6 | 29.3 | 27.3 | 30.1 | 39.1 | 37.9 | 34.8 | 31.5 | 35.8 |
| SM | 31.0 | 30.9 | 27.4 | 26.6 | 29.0 | 37.5 | 35.8 | 32.4 | 32.5 | 34.6 |
| PM | 30.2 | 28.6 | 27.5 | 29.4 | 28.9 | 35.8 | 34.9 | 33.3 | 33.9 | 34.5 |
| Mean | 31.1 | 30.4 | 28.1 | 27.8 | | 37.5 | 36.2 | 33.5 | 32.6 | |
| | S.Em± | | CD @ 5% | | | S.Em± | | CD @ 5% | | |
| Main plot (M) | 0.42 | | 1.44 | | | 0.4 | | 1.37 | | |
| Sub plot (S) | 1.43 | | NS | | | 1.54 | | NS | | |
| M×S | 0.71 | | 2.14 | | | 0.77 | | 2.3 | | |

| | Flowers cluster$^{-1}$ | | | | | Fruits cluster$^{-1}$ | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean |
| WM | 5.2 | 4.6 | 4.5 | 3.4 | 4.4 | 4.7 | 4.34 | 3.06 | 3.0 | 3.8 |
| SM | 6.1 | 5.7 | 4.7 | 4.0 | 5.1 | 5.5 | 5.1 | 3.58 | 3.3 | 4.4 |
| PM | 7.0 | 7.2 | 4.7 | 4.8 | 5.9 | 5.9 | 6.1 | 4.53 | 3.8 | 5.1 |
| Mean | 6.1 | 5.8 | 4.6 | 4.1 | | 5.4 | 5.2 | 3.72 | 3.4 | |
| | S.Em± | | CD @ 5% | | | S.Em± | | CD @ 5% | | |
| Main plot (M) | 0.12 | | 0.43 | | | 0.11 | | 0.4 | | |
| Sub plot (S) | 0.5 | | 1.5 | | | 0.29 | | 0.85 | | |
| M×S | 0.25 | | 0.75 | | | 0.14 | | 0.43 | | |

$I_{100}$, $I_{80}$, $I_{60}$ and $I_{40}$ : Drip irrigation at 100%, 80%, 60% and 40% cumulative pan evaporation, respectively; WM: without mulch, SM: sugarcane mulch, PM: polyethylene mulch. CD: Critical difference; SEm: Standard error of mean

flower to open and 37.5 days to reach 50% flowering. These values were at par with $I_{80}$. However, the influence of mulch on earliness of either first or 50% flowering was not significant. Under higher irrigation levels, adequate amount of moisture was possibly available for the plant which enhanced the vegetative growth as a result flowering was delayed. However, Kishore *et al*. (2018) had reported contrasting results. But in contrast to earliness flowers cluster$^{-1}$ and number of fruits cluster$^{-1}$ were maximum under $I_{100}$ and lowest in $I_{40}$.

Crop yield (both plant$^{-1}$ and ha$^{-1}$) were maximum i.e. 2.5 kg plant$^{-1}$ and 46.3 t ha$^{-1}$ respectively under $I_{100}$ which was at par $I_{80}$ (Table 3). Similar findings were observed in study conducted by Bahadur *et al.* (2009) and Al-Marri *et al.* (2020) in tomato. The higher yield in $I_{100}$ was the result of greater bearing of fruits plant$^{-1}$ and average fruit weight and is also corroborated by number of flowers cluster$^{-1}$ and fruits cluster$^{-1}$ fruits plant$^{-1.}$ However, average fruit weight was maximum (59.1 g) under $I_{80}$. It is possible that the increased competition between the flowers for moisture and nutrient might have decreased the weight of fruit in $I_{100}$. Gupta *et al.* (2015) also reported that maximum average fruit weight (49.7 g) was observed under drip irrigation at 80% CPE. Similar results were noticed in tomato crop by Singh and Kumar (2007); Bahadur *et al*. (2009); Dung *et al*. (2016) and Samui *et al*. (2020). These results are also in agreement with those of Saleh *et al*. (2007); Singh *et al*. (2009); Panigrahi *et al*. (2010); Helyes *et al*. (2012) and Alaoui *et al*. (2014). Lower irrigation regimes i.e. $I_{60}$ and $I_{40}$ directly negatively impacted plant growth and, consequently, their yielding ability. This reduction in growth adversely affected yield-related traits, leading to a significant decrease in overall yield. These results are in accordance with the findings of Dung *et al*. (2016); Ragab *et al*. (2019); Oke *et al*. (2020) and Samui *et al*. (2020) and in chilli by Cheena *et al*. (2018).

An adequate supply of water that meets the crop's requirements promotes physiological activities in plants, thereby enhancing overall crop yield. Higher irrigation levels foster increased vegetative growth, which manifests as a larger leaf area, improved gaseous exchange,

*Table 3. Number of fruits, average fruit weight and yield as influenced by different irrigation levels and mulches*

| | Numbers of fruits plant$^{-1}$ | | | | | Average fruit weight (g) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean |
| WM | 43.0 | 41.9 | 37.6 | 35.1 | 39.4 | 55.3 | 55.1 | 53.7 | 51.7 | 54.0 |
| SM | 44.3 | 44.0 | 39.0 | 36.6 | 41.0 | 55.0 | 58.8 | 55.8 | 54.1 | 56.0 |
| PM | 46.0 | 46.1 | 40.7 | 38.3 | 42.8 | 59.7 | 63.4 | 57.8 | 56.1 | 59.3 |
| Mean | 44.4 | 44.0 | 39.1 | 36.7 | | 56.7 | 59.1 | 55.7 | 54.0 | |
| | S.Em± | | CD @ 5% | | | S.Em± | | CD @ 5% | | |
| Main plot (M) | 0.82 | | 2.82 | | | 0.86 | | 2.99 | | |
| Sub plot (S) | 1.1 | | 3.3 | | | 1.45 | | 4.35 | | |
| M×S | 0.6 | | NS | | | 0.73 | | 2.17 | | |

| | Yield plant$^{-1}$ (kg) | | | | | Yield (t ha$^{-1}$) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean | $I_{100}$ | $I_{80}$ | $I_{60}$ | $I_{40}$ | Mean |
| WM | 2.3 | 2.1 | 1.9 | 1.7 | 2.0 | 43.9 | 41.5 | 34.1 | 32.2 | 37.9 |
| SM | 2.5 | 2.3 | 2.0 | 1.9 | 2.2 | 46.0 | 44.6 | 36.8 | 33.53 | 40.2 |
| PM | 2.6 | 2.7 | 2.1 | 2.0 | 2.4 | 49.0 | 51.8 | 40.1 | 35.6 | 44.1 |
| Mean | 2.5 | 2.34 | 2.0 | 1.9 | | 46.3 | 46.0 | 37.0 | 33.78 | |
| | S.Em± | | CD @ 5% | | | S.Em± | | CD @ 5% | | |
| Main plot (M) | 0.06 | | 0.19 | | | 1.07 | | 3.72 | | |
| Sub plot (S) | 0.11 | | 0.33 | | | 1.38 | | 4.13 | | |
| M×S | 0.06 | | 0.17 | | | 0.69 | | 2.07 | | |

$I_{100}$, $I_{80}$, $I_{60}$ and $I_{40}$ : Drip irrigation at 100%, 80%, 60% and 40% cumulative pan evaporation, respectively; WM: without mulch, SM: sugarcane mulch, PM: polyethylene mulch. CD: Critical difference; SEm: Standard error of mean

and more active stomata. These factors contribute to a higher rate of photosynthesis, which may lead to the development of more fruit-bearing nodes in plants subjected to elevated irrigation levels. Additionally, providing sufficient water during the flowering stage can facilitate nutrient translocation and reduce flower drop, resulting in a higher number of fruits cluster$^{-1}$. Any water stress condition during or prior to flowering may hamper the fruit setting percentage in tomato which might have happened at lower irrigation levels Our conclusions are in conformity with the findings of Cheena *et al*. (2018); Ragab *et al*. (2019); Al-Marri *et al*. (2020); Oke *et al*. (2020) and Samui *et al*. (2020).

Results of this study also clearly brought out the effect mulching. Highest yield plant$^{-1}$ (2.4 kg) and yield ha$^{-1}$ (44.12) was recorded in the treatment having the polythene mulch which was at par with sugarcane mulch and in both cases considerably higher than control. Results of Kere *et al*. (2003) have also shown positive effect of polythene mulch. Similar findings were reported by Ravinder *et al*. (1997) in chilli, Bhujbal *et al*. (2015) and Kundu *et al*. (2019) in tomato. Use of mulch must have enabled increased availability of moisture and nutrients, leading to their better translocation (Kundu *et al*., 2019).

## Conclusion

From the present research, it can be inferred that the treatment combination comprising of drip irrigation at 80% CPE combined with polythene mulch ($I_{80}$ PM) is the best treatment combination which gives maximum benefits in terms of growth and yield of tomato, besides saving 20% of irrigation water over the treatment combination of drip irrigation at 100% CPE with or without combining with polythene mulch ($I_{100}$ PM) water throughout growing period and this treatment combination performs better than the individual irrigation and mulch treatments.

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