Vol. 49, No. 1, pp 23-31, 2021
Indian Journal of Soil Conservation

# Estimation of irrigation interval and soil water content distribution for drip irrigated eggplant using tensiometer under mulching condition

**R. Rahul* and M. Manikandan**

*Agricultural Engineering College and Research Institute, Tamil Nadu Agricultural University, Kumulur – 621712, Trichy, Tamil Nadu.*

**Corresponding author:*
*E-mail: rahulagriengg96@gmail.com (R. Rahul)*

**ARTICLE INFO**

DOI : 10.59797/ijsc.v49.i1.205

***Article history:***
Received : January, 2021
Revised : March, 2021
Accepted : April, 2021

***Key words:***
Drip irrigation
Mulching
Soil water content
Soil matric potential
Surfer 15

**ABSTRACT**

An attempt was made to determine the soil water content distribution pattern and irrigation interval based on soil water potential fluctuation for eggplant (*Solanum melongena* L.) under plastic mulching. The layout of the experiment was conducted in three different conditions *viz*., black mulched drip irrigation (BM + DI), white mulched drip irrigation (WM + DI), and drip irrigation (DI) without mulching. The eggplant variety Dhruva F1 was selected for the experiment period. The observed soil water content at different horizontal and vertical depths was used to draw a contour map by the computer software **"**Surfer 15**"** of the windows version. Soil water content was found to be higher in 0–10 cm of soil layer under all mulching conditions. Drip irrigation with black coloured mulch showed higher soil water content of 26.2% just after irrigation and a lower soil water content of 18.5% after 48 hours of irrigation. The soil water content at the horizontal and vertical direction was decreasing from just after irrigation to 48 hrs after irrigation. Whereas, under drip irrigation with white coloured mulch higher soil water content was observed after two days of irrigation. Irrigation interval was decided based on soil matric potential threshold values reached 15 to 20 kPa, which was found as 1 to 3 days in drip irrigation under white and black coloured mulching condition and 1 to 2 days in drip irrigation without mulching condition. Overall, the study suggests that the irrigation interval for eggplant crops under drip irrigated mulching conditions could be 2 days interval of irrigation period.

## 1. INTRODUCTION

India is the second–largest producer of eggplant after China with the production of 11.42 Mt production from an area of 0.67 Mha. Eggplant is an important vegetable grown in tropical and sub–tropical regions of the world, but it is grown in temperate regions of the world during the warm season. Under the drip method, irrigation water is directly applied to the plant root zone, which minimizes evaporation, percolation, and other water losses (Suryavanshi *et al.,* 2015). Compared to other countries, India has (5.5%) higher penetration level of micro–irrigation. Eggplant belongs to the family is Solanaceae, considered native to India, and is a widely grown vegetable in Asian countries. It is a world-wide important vegetable and grown in more than 1.7 Mha area. The world scenario of production and average productivity of eggplant was 29.46 Mt and 17.43 t $ha^{-1}$ (Pattanayak, 2017). India is the second–largest producer of eggplant after China. Mulching is used to cover the surface of the soil for creating a congenial environment for plant growth (Zhu *et al*., 2018). Polythene sheets are commonly used to cultivate vegetable crops. Commonly used plastic sheet mulching is based on linear low–density polyethylene (LLDPE) because it is economic and durable in use. Some of the desirable benefits of plastic mulching include control of weeds, conservation of soil moisture, regulation of temperature, reduction of salinity problems evapotranspiration (ET) losses and soil erosion, improvement of seed germination, and provides a conducive environment for crop growth (Maughan and Drost, 2016; Poonia *et al*., 2019). It also produces an early harvest, higher yield and quality produces. Plastic mulching sheets are available in different colours such as black colour, transparent, two–sided colour (yellow / black), and also as degradable mulches. By proper selection of plastic mulch composition – thickness and colour help in precise control of soil environment (Iyengar *et al*., 2011). Thickness of mulches ranges from 7 micron to 100 micron, thickness is decided based on age of crop. Black color mulch is very popular, they are available in 25 microns and 50–micron thickness (Awodoyin *et al*., 2007).

Irrigation scheduling of a crop is the decision to take when to irrigate and how much quantity of water to be applied. Soil monitoring methods use tensiometers and sensors at several locations in a field to measure soil water content or soil matric potential. Optimal irrigation scheduling using soil moisture tensiometers and sensors requires accurate threshold values (Michael and Barry, 2002) for individual crops in the given agricultural systems. Soil matric potential thresholds values have shown promising potential for saving water and improving yields (Müller *et al*., 2016). Threshold values are lower limit values which shows the degree to which soil can dry before irrigation is required. Generally, threshold values are selected such that crops do not suffer water stress or there is no yield penalty. Threshold soil matric potential values determined by researchers can be used to prepare irrigation scheduling.

Studies have revealed that combination of drip fertigation with plastic mulching results higher performance in plant growth and production. The combination of drip irrigation and plastic mulching was a more water−saving method compare to flood irrigations. Very limited research work has been carried out in the field of irrigation scheduling *i.e.* timing and amounts of water application over the growing season using soil matric potential threshold values. Thus the objectives of this study were to determine the irrigation amount and irrigation interval at different growth stages and to determine the soil water distribution pattern in different mulching conditions.

## 2. MATERIALS AND METHODS

The study was conducted at Central Farm of Agricultural Engineering College and Research Institute, Kumulur, Tamil Nadu (latitude: $10^0$92'N; longitude: $78^0$82'E; 62 m above the mean sea level). The average annual precipitation is about 881.412 mm (Vaidheki and Arulanandu, 2017).

Soil samples were collected from the experimental field at different depths. By using the international Robinson pipette method, the soil texture was found to be an average value of 74% sand, 14% silt, and 12% clay, which belongs to sandy loam soil. By using the double−ring infiltrometer test, the infiltration rate was determined as 1.71 cm $h^{-1}$ (Mashayekhi *et al*., 2016). The field capacity and wilting point for the soil were estimated by using pressure plate apparatus and the value was 22.26% and 9.52%, respectively. Soil bulk density determined by the core cutter method was 1.413 g $cc^{-1}$.

The eggplant variety Dhruva F1 was selected for the experiment. The study was conducted from November 2018 to March 2019, by keeping row−to−row and plant−to−plant distance was 90 cm and 45 cm, respectively. The layout of the experiment was three treatments tested, black mulched drip irrigation (BM + DI), white mulched drip irrigation (WM + DI), and drip irrigation without mulching as shows in (Fig. 1). The irrigation was carried out by the line source drip irrigation system with 4 lph emitters. The 16 mm internal diameter and 45 cm line source emitter were used for each plant. The emitters operated at a pressure of 1 kg

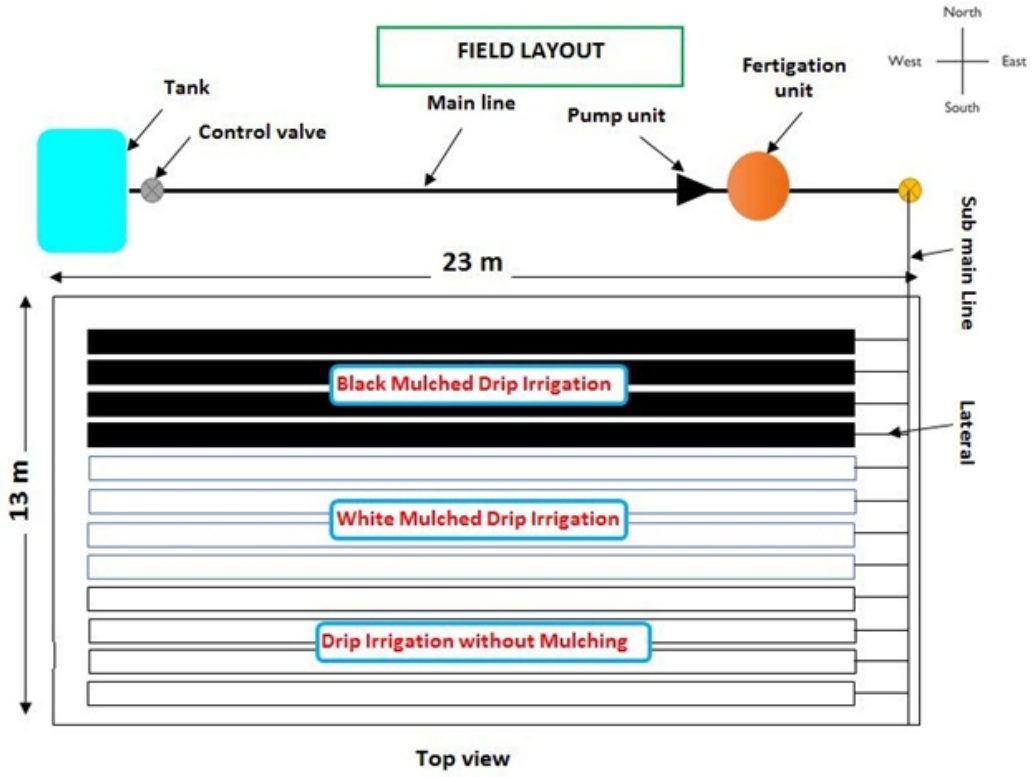



**Fig. 1. Layout of the experiment and irrigation system at AEC&RI kumulur, Trichy, TN**

$cm^{-2}$, which was controlled with bypass arrangement. The soil water movement was determined using tensiometers for maximum rooting depth of eggplant. Tensiometer was calibrated in the field by correlating with tension and volumetric water content measured by gravimetric method. Similarly (Pelletier and Tan, 1993; Shekhar *et al*., 2017; Lalitha *et al*., 2014) using tensiometers to determine the moisture content in the soil. Soil water retention curves are given in (Fig. 2).

The plant height was measured once a week under each mulching condition. Height was measured in centimeters from ground level to the tip of the main shoot with the help of a meter scale. After transplanting, a number of matured leaves were counted manually, once in two weeks. The diameter of the stem was measured at 2 cm above the ground level, using thread and meter scale. Plant spread was measured in north−south and east−west direction by using a meter scale once in two weeks for each mulching condition separately.

Soil samples were taken at 0 cm, 10 cm, 20 cm, and 30 cm distance from the emitter and at depths of 0 cm, 10 cm, 20 cm, and 30 cm, and moisture content was determined using the gravimetric method every 40 days. Soil moisture was estimated some after irrigation and 24 hrs and 48 hrs after irrigation for all three mulching conditions. The soil sample was taken using a soil auger and put in aluminum boxes. The soil samples were immediately weighed and kept in the hot air oven and dried at 105°C for 24 hrs so that constant weight is obtained. Then, the soil moisture on a dry basis was determined. The soil moisture contour maps were plotted using the computer software package "Surfer 15".

Irrigation scheduling was done based on a continuous recording of tensiometer readings. After transplanting of eggplant seedling, common irrigation was given for twenty days at regular intervals. After twenty days tensiometers were installed at maximum rooting depth and maximum rooting intensity of two healthy well grew eggplant crops under mulched and no mulch crop condition. Tensiometers were placed throughout the crop period for different depths. Eggplant crop was irrigated based on daily reference crop evapotranspiration ($ET_0$). After the irrigation tensiometer readings were noted three times in a day (Liu *et al*., 2012), it was 8 am, 2 pm, and 5 pm. The next irrigation was given when the soil matric potential reached 15 kPa to 20 kPa. Various studies indicated that irrigation to crops under sandy loam soil for *Solanaceae* family crops was based on soil matric potential value of 15 kPa to 20 kPa (Marouelli *et al*., 2007; Bilibio *et al*., 2010; Smajstrla and Locascio, 1996; Liu *et al*., 2012). The soil matric potential observed by tensiometers was used to determine the irrigation interval of the eggplant crop. Water productivity (WP) was calculated as the ratio of yield of the eggplant in kg $ha^{-1}$ and ET in mm and can be expressed fresh eggplant yield (kg $ha^{-1}$) divided by ET (mm) and Irrigation water productivity (IWP) was calculated as the ratio of yield of the eggplant in kg $ha^{-1}$ and irrigation water applied in mm and can be expressed as fresh eggplant yield (kg $ha^{-1}$) divided by irrigation water applied (mm).

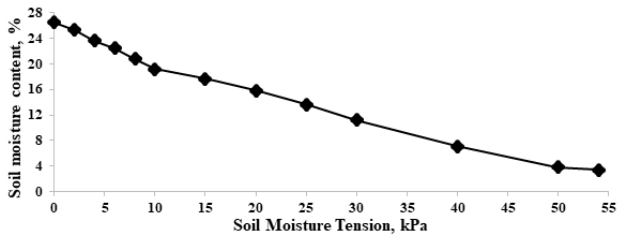



**Fig. 2. Soil water retention curve**

## 3. RESULTS AND DISCUSSION

### Soil Water Content Distribution Pattern

The soil water content varied at different times of operation and when the time of operation increased, soil moisture content also increased. Soil moisture content (26.31%) observed just after irrigation at 0−10 cm of soil layer was found to be higher and soil moisture content (17.5%) was observed at 48 hrs after irrigation at 20−30 cm of the soil layer was found to be lower. Similarly, (Ahmed *et al*., 2016; Clark *et al*., 1993; Liu *et al*., 2018) studied soil water movement in the soil. Soil water content was found to be higher in 0−10 cm of soil layer under all mulching conditions. The observed soil water content at different horizontal and vertical depths was used to draw a contour map by the computer software "Surfer 15" of windows version (Yaghi *et al*., 2013; Zhang *et al*., 2012; Shekhar *et al*., 2017). The soil water contour maps presented in Fig's 3 to 5 showed the moisture available at different vertical as well as horizontal movement of water in the experimental field, just after, 24 hrs, and 48 hrs after irrigation.

Soil water content with respect to the different times of operation decreases gradually under all three mulching conditions. At the initial crop growth stage, soil water content was lower in the root zone. The amount of water present in the soil was higher in drip irrigation with white−

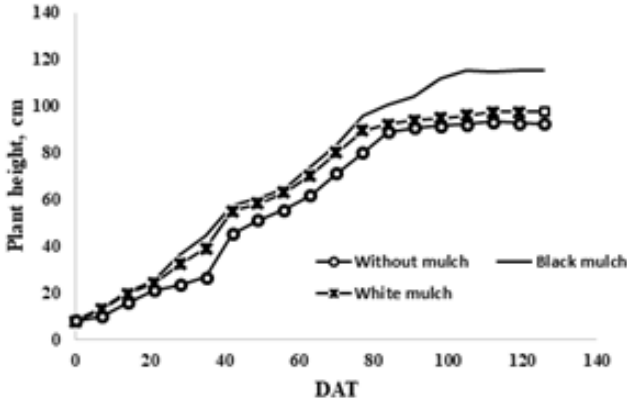



**Fig. 3. Plant height (cm) of eggplant under three mulching condition**

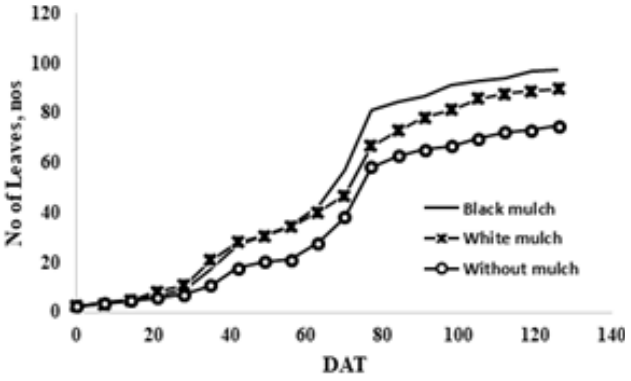



**Fig. 4. Number of leaves of eggplant under three mulching condition**

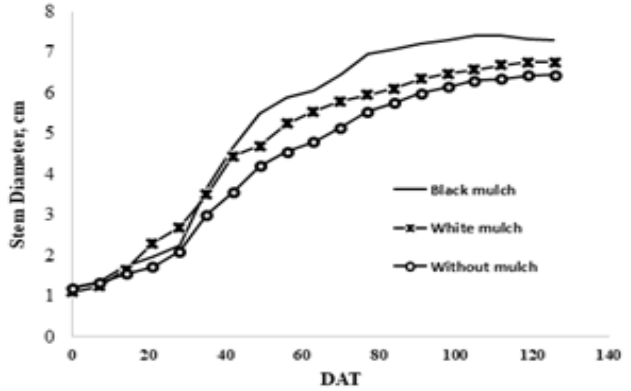



**Fig. 5. Stem diameter of eggplant under three mulching condition**

colored mulching than that in black−colored mulching due to the radiation reflection property of white−colored mulching. Increasing root growth from initial to end−stage is reflected in the water uptake by plants. The soil water content at horizontal and vertical depth was decreasing from just after irrigation to 48 hrs after irrigation. Under drip irrigation white coloured mulching conditions higher soil water content was observed after two days of irrigation.

Under drip irrigation with black−coloured mulching conditions, the higher soil water content of 26.2% was observed just after irrigation, and lower soil water content of 18.5% was observed 48 hrs after irrigation. The higher soil water content of 26.4% was observed just after irrigation and lower soil water content of 21.2% was observed at 48 hrs after irrigation under drip irrigation white colored mulching condition. Datta *et al*. (2017) conducted a study to determine the soil water content white colour and black colour mulching; the observed soil water content was similar to the Piotr *et al*. (2007). Under drip irrigation, without mulching conditions higher soil water content of 26.3% was observed just after irrigation, and lower soil water content of 17.1% was observed 48 hrs after irrigation.

**Determination of Irrigation Interval**

Proper irrigation water management requires knowledge of irrigation scheduling. Irrigation scheduling of crops gives the details about when to irrigate and how much to irrigate. Irrigation scheduling based on soil matric potential measured using tensiometers provides accurate results on time of irrigation. So the time of irrigation was decided based on soil matric potential observed using tensiometer installed at a depth of maximum rooting intensity of crop. Irrigation was given to the eggplant crops when soil moisture approached wilting point. Irrigation was given when the soil matric potential exceeds 15 to 20 kPa (Dabach *et al*., 2015). The soil matric potential was noted three times a day at 8 am, 2 pm, and 5 pm. The soil matric potential has an inverse relation with the soil water content. Higher soil matric potential indicates lesser soil water content. The soil matric potential observed at a depth of 10 cm is shown in Fig's 6 to 17. In all the mulching conditions the maximum rooting intensity was found within 5 to 10 cm only, so installation of tensiometer was decided at a depth of 10 cm for the entire duration of the eggplant crop. Each crop growth stage of eggplant irrigation interval was determined based on the continuous measurement of tensiometer readings (Dabach *et al*., 2011) as shown in Table 1.

Eggplant crops is grown under drip irrigation with black and white coloured mulching condition resulted in more irrigation interval when compared to drip irrigation without mulching condition. Due to plastic mulching, zero evaporation from soil, and only water loss occurred was by transpiration. Water lost from soil due to evaporation and transpiration was very high under without mulching conditions. Drip irrigation black and white coloured mulching condition needed 39 number of irrigation and without mulching, condition needed 44 number of irrigation for the entire crop growth period.

**Irrigation Interval for Drip Irrigation Black Coloured Mulching Condition**

Graphical representation between soil matric potential *vs* time for drip irrigation black coloured mulching conditions for different crop growth stages is presented in Fig's 10 to 13. The irrigation interval at the initial stage of the eggplant crop growing period was 9 number of irrigation,

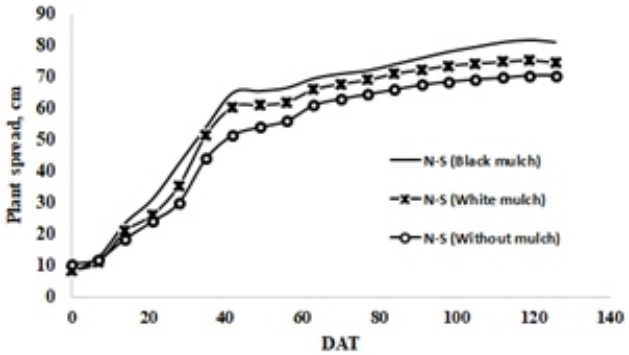



**Fig. 6. Plant spread in north−south direction under three mulching condition**

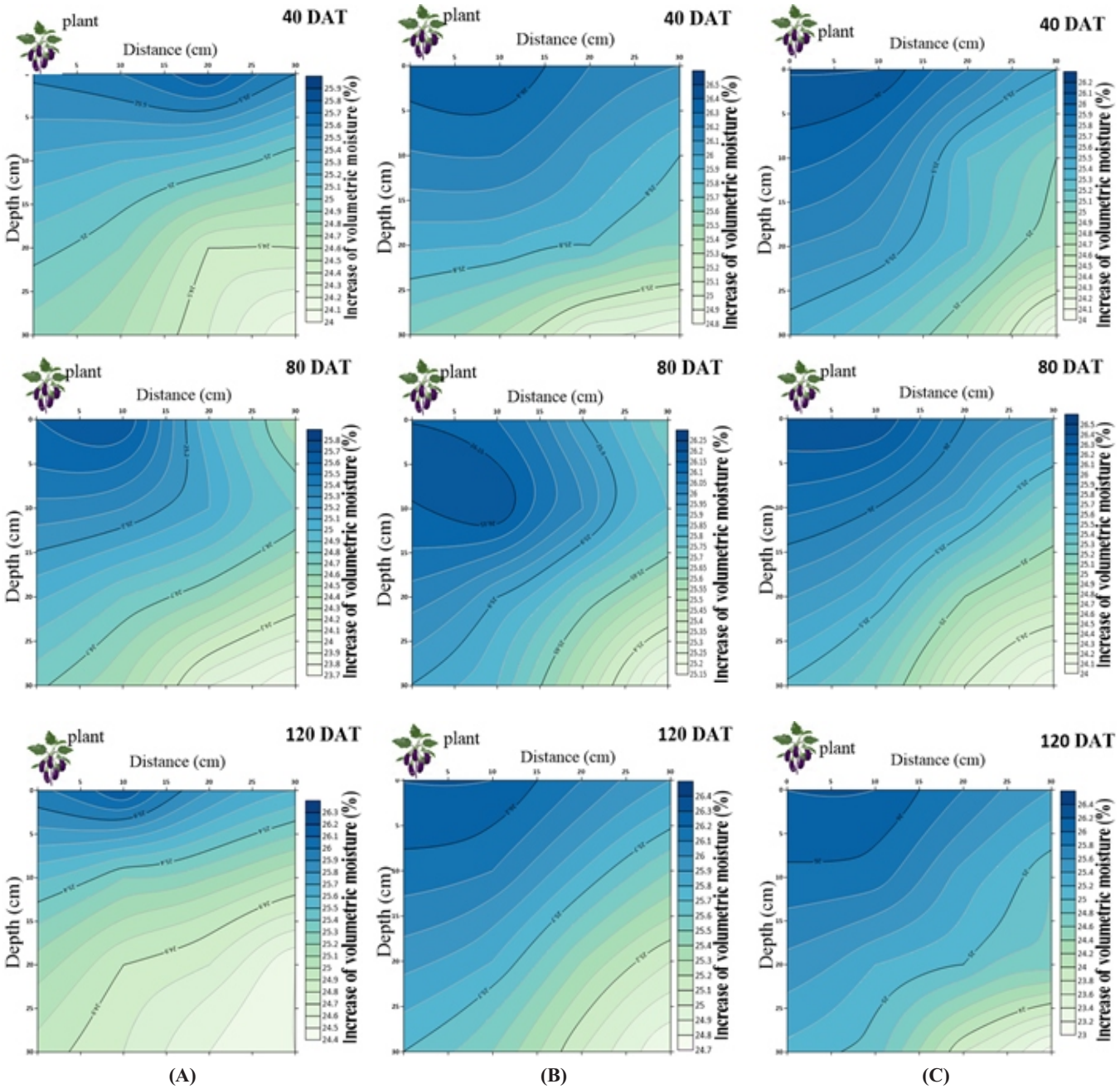
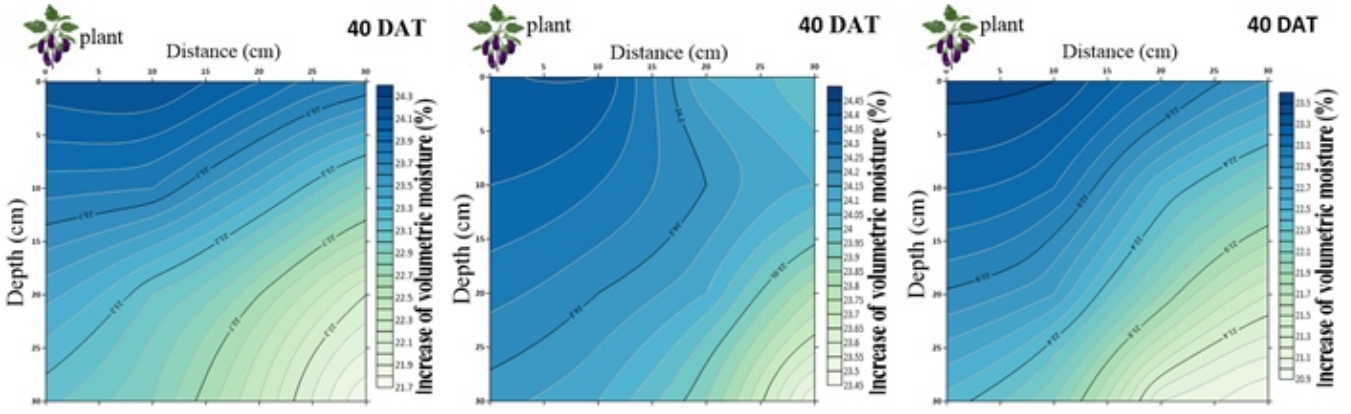



**Fig. 7. Soil water content distribution pattern under three mulching condition just after irrigation**



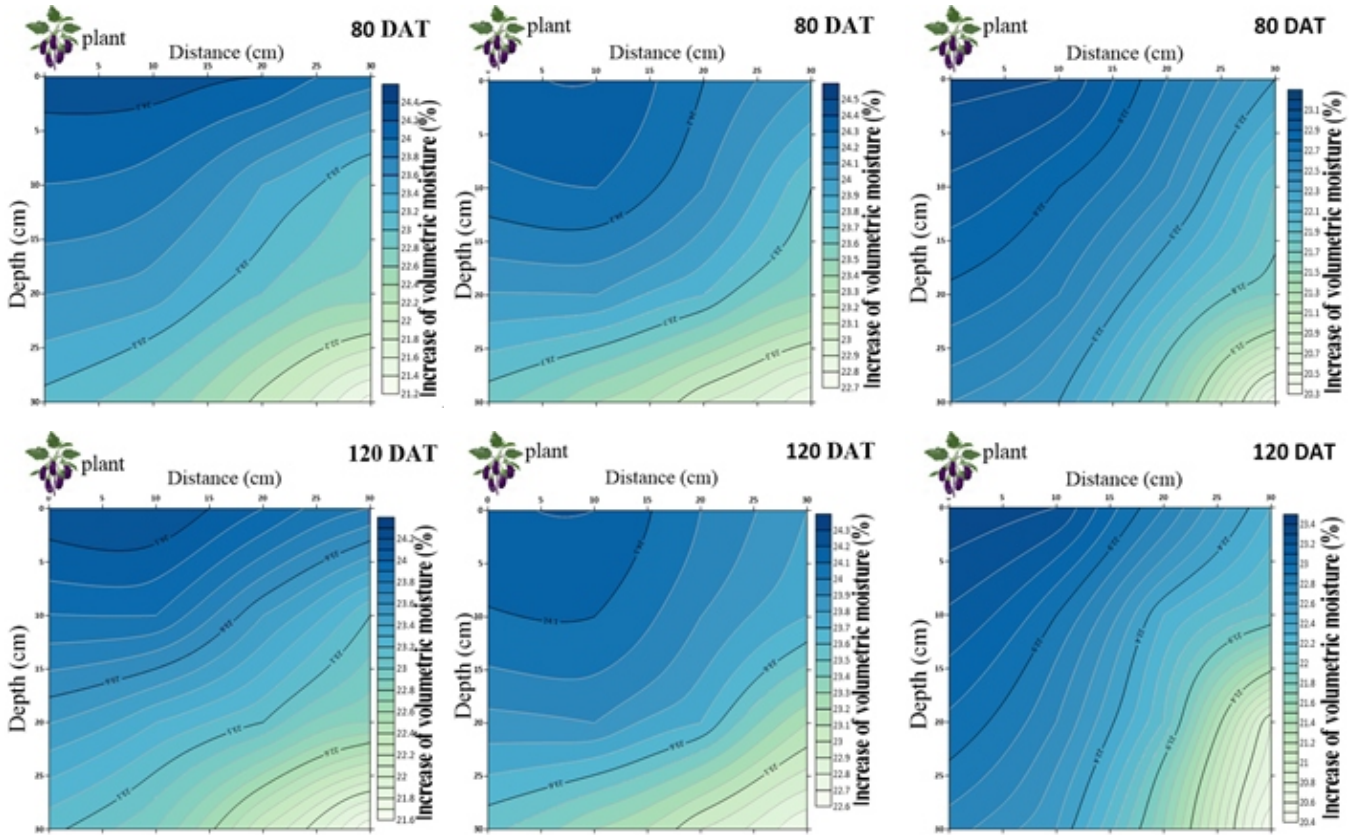
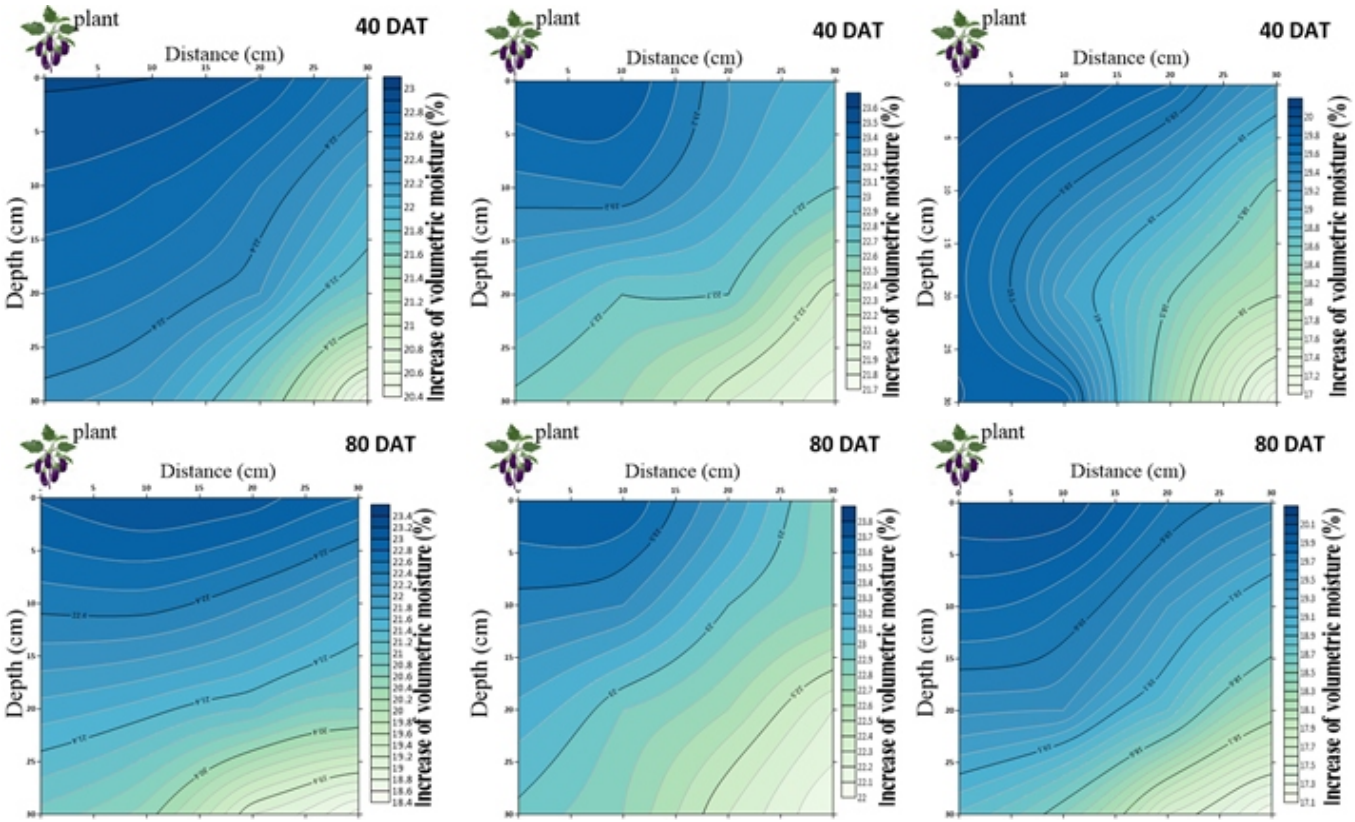
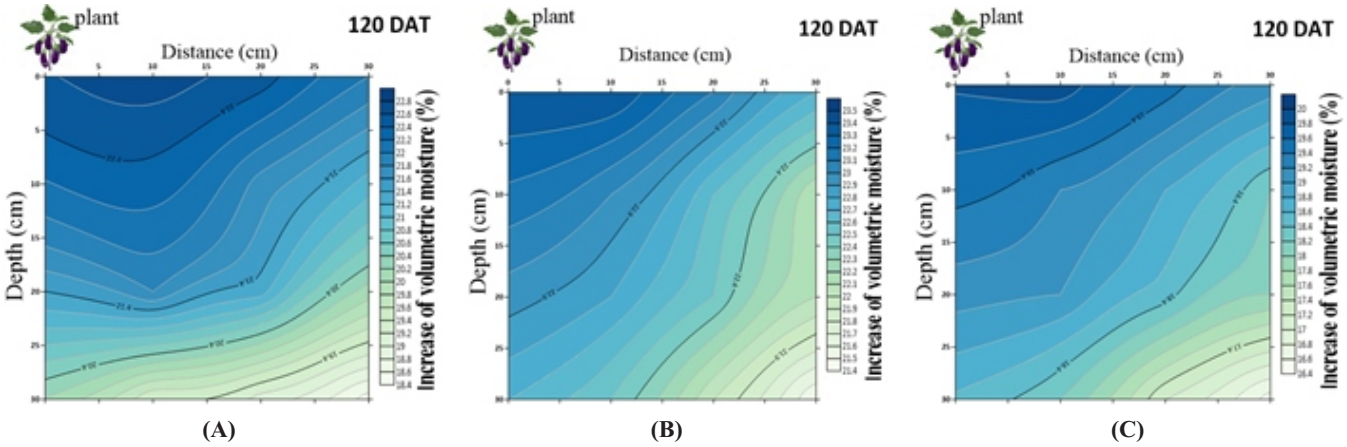



**Fig. 8. 24 hrs after irrigation soil water content distribution pattern under three mulching condition**






*A − Drip irrigation black coloured mulching, B − Drip irrigation white coloured mulching, C − Drip irrigation without mulching*

**Fig. 9. 48 hrs after irrigation soil water content distribution pattern under three mulching condition**

**Table: 1**
**Number of irrigation under three mulching condition for eggplant**

| Crop growth stage | Duration, days | Black mulch, days | White mulch, days | Without mulch, days |
|---|---|---|---|---|
| Initial stage | 30 | 9 | 9 | 9 |
| Development stage | 40 | 12 | 12 | 14 |
| Mid–season stage | 40 | 12 | 12 | 15 |
| End stage | 20 | 6 | 6 | 6 |
| Total | 130 | 39 | 39 | 44 |

for the development stage, mid−season stage, and end−stage of the crop, the number of irrigation was 12, 12, and 6 times, respectively and the total number of irrigation was 39. Irrigation interval was observed as 1 to 3 days during the crop growth period. At the initial stage, a higher irrigation interval was observed due to lesser root growth. At the maturity stage lesser irrigation interval was observed. Higher irrigation interval observed during some periods was due to lower sunshine hours and lesser root water uptake.

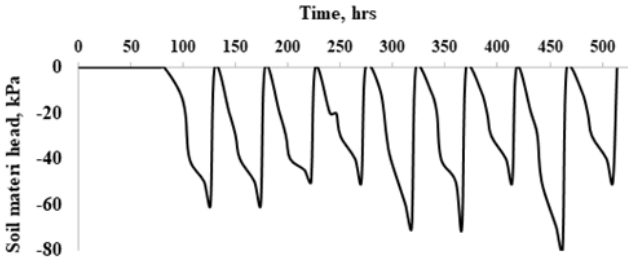



**Fig. 10. Irrigation interval for BM+DI initial stage (0 – 30 days)**

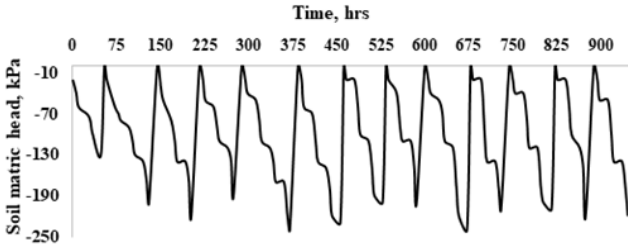



**Fig. 11. Irrigation interval for BM+DI crop development stage (31− 70 days)**

### Irrigation Interval for Drip Irrigation White−Coloured Mulching Condition

The relationship between soil matric potential *vs* time for drip irrigation white coloured mulching conditions for different crop growth stages is presented in Fig's 14 to 17. Irrigation interval at the initial stage of the eggplant crop

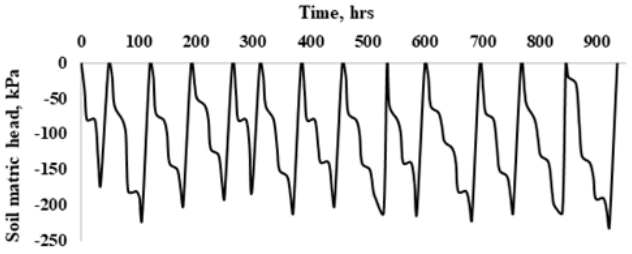



**Fig. 12. Irrigation interval for BM+DI mid−season stage (71 – 110 days)**

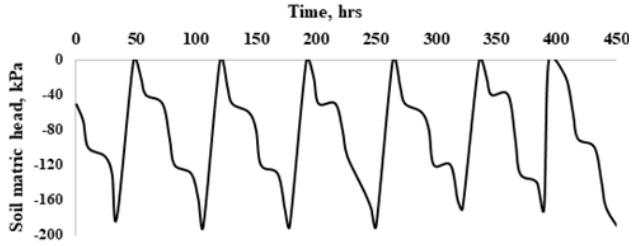



**Fig. 13. Irrigation interval for BM+DI end stage (111−130 days)**

growing period was 9 number of irrigation, for the development stage, mid−season stage and end−stage of the crop, the number of irrigation was 12, 12 and 6, respectively and the total number of irrigation was 39. These results confirmed the findings of (Liu *et al*., 2012).

### Irrigation Interval for Drip Irrigation Without−Mulching

Fig's 18 to 21 presents irrigation interval by comparing soil matric potential *vs* time for drip irrigation without mulching conditions for different crop growth stages. When compared to the other two mulching conditions, in this mulching condition the number of irrigation interval was observed higher. At the initial stage number of irrigation was 9, for the development stage, mid−season stage, and end−stage of the crop, the number of irrigation was 14, 15, and 6 times, respectively and the total number of irrigation was 44.

## 4. CONCLUSIONS

The eggplant cultivation under drip irrigation system with different mulching has increased the water use efficiency (reducing the volume of water utilized) by reducing the ET losses hence, thereby increased the yield per unit area. The soil matric potential was observed using tensiometers were used to observe at different crop growth stages. Irrigation was provided to the eggplant when the soil matric potential reached 15 kPa to 20 kPa. In order to determine soil water

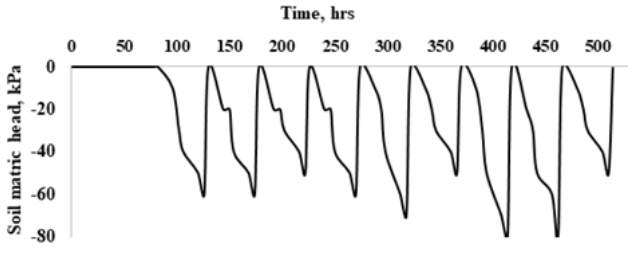



**Fig. 14. Irrigation interval for WM+DI initial stage (0−30 days)**

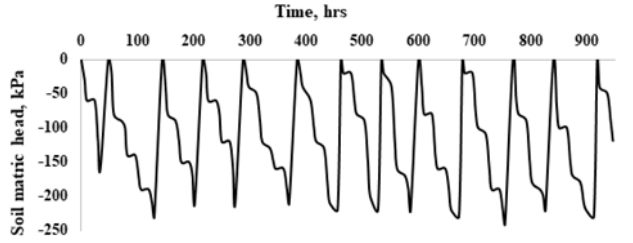



**Fig. 15. Irrigation interval for WM+DI crop development stage (31 − 70 days)**

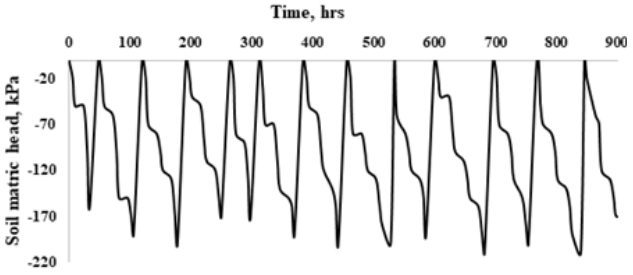



**Fig. 16. Irrigation interval for WM+DI mid−season stage (71 − 110 days)**

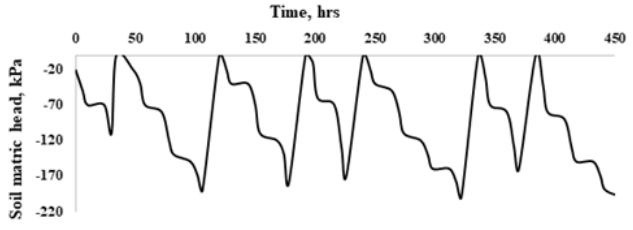



**Fig. 17. Irrigation interval for WM+DI end stage (111 − 130 days)**

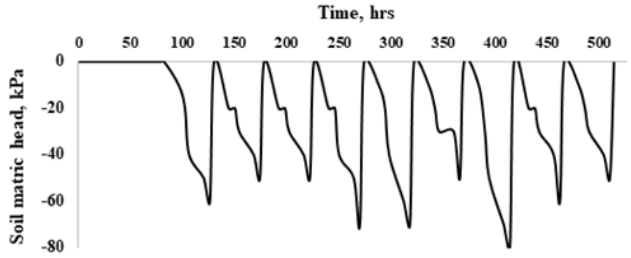



**Fig. 18. Irrigation interval for DI initial stage (0 − 30 days)**

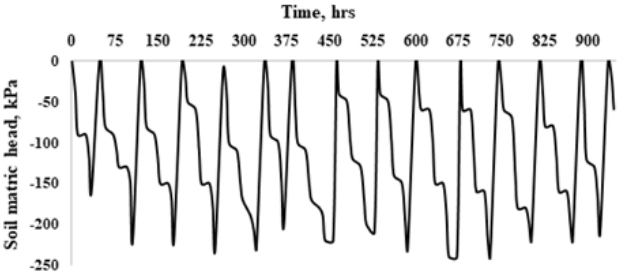



**Fig. 19. Irrigation interval for DI crop development stage (31−70 days)**

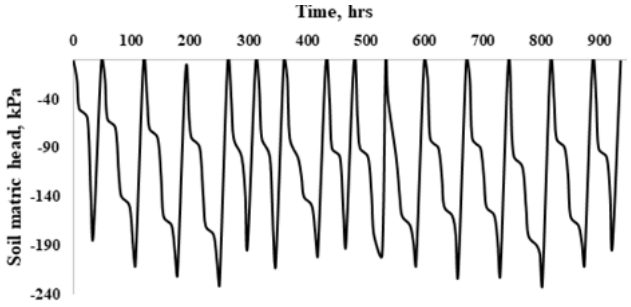



**Fig. 20. Irrigation interval for DI mid−season stage (71 – 110 days)**

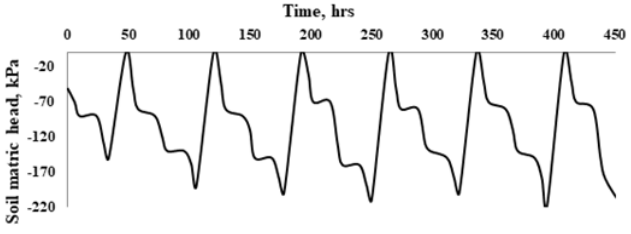



**Fig. 21. Irrigation interval for DI end stage (111 − 130 days)**

movement under three mulching conditions, at different eggplant growing periods. The time period divided just after, 24 hrs, and 48 hrs after irrigation. Soil samples were collected at different vertical (0 cm, 10 cm, 20 cm, and 30 cm) and horizontal distances (0−10 cm, 10−20 cm, 20−30 cm) of the soil horizons. Soil water content was plotted using the computer software "Surfer 15" of the windows version and contour maps were drawn.

At the initial crop growth stage, soil water content was lesser in the root zone. The amount of water present in the soil was higher in drip irrigation with white−coloured mulching than with black−coloured mulching due to the reflection property of white−coloured mulching. Increasing root growth from initial to end−stage is reflected in the water uptake by plants. The soil water content at horizontal and vertical directions was decreasing from just after irrigation to 48 hrs after irrigation. Under drip irrigation with white−coloured mulching conditions, higher soil water content was observed after two days of irrigation. Irrigation interval was decided based on soil matric potential threshold values, it was found as 1 to 3 days in drip irrigation white and black coloured mulching condition (39 irrigation) and 1 to 2 days in drip irrigation without mulching condition (44 irrigation). Finally from the study, it can be concluded that irrigating eggplant crop at 2 days interval.

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