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Investigating MAD and Fertigation Effects on Tomato Under Drip Irrigation System in Greenhouse

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Abstract

Fertigation through drip irrigation has a potential to improve irrigation and fertilizers use efficiency. The main objective was determined the effects of different Management Allowed Depletion (MAD) levels alongside altered doses of fertigation (NIAB prepared and imported water-soluble fertilizers) on the growth and yield of tomato under drip irrigation system in greenhouse. Tomato (*Lycopersicon esculentum*, Sahil variety) was grown under drip irrigation system in greenhouse. There were two MAD levels i.e. 10% and 15% with four fertilizer treatments i.e. F_1 (100% conventional dose), F_2 (NIAB developed, 75% conventional dose), F_3 (NIAB developed, 50% conventional dose), F_4 (imported (NPK 20:20:20), 75% conventional dose). There were eight treatments under drip irrigation system and one conventional/control treatment. Crop water requirement was determined by Penman-Monteith (PM) method. CROPWAT model version (7.0) was used to compute reference ET and Irrigation Water Requirements (IWR). Crop yield and Growth parameters such as plant height, stem diameter, inter node distance, number of leaves and leaf size was also measured. The results showed that treatment T_5 produced maximum crop yield of 45.09 ton/ha than other treatments and control/famer practice. Only 5% difference in MAD level have no significant effect but quality and quantity of DoF have significant variations among treatments.

INTRODUCTION

Greenhouse farming is protected cultivation of crop because it provides controlled conditions for crop production gain maximum crop yield. The main feature of farming in greenhouse is that crop production can be throughout the year and it cannot be possible in open area conditions due to different climatic effects like rain and winds etc. Less area of land is required for production system of agricultural crop enhancing the land productivity. Greenhouse farming is also one of the methods used for creating high values of agricultural crops by applying high fertilizers efficiencies and low water inputs through Fertigation and drip irrigation applications respectively. Fertigation is the injecting of fertilizer into an irrigation system. Fertigation through drip irrigation in greenhouse has potential to improve the irrigation and fertilizer use efficiency. Drip irrigation with fertigation is very productive way to apply nutrients and water to the crop as it saves amount of nutrients and water and upgrade the quantity and quality of fruit crops and vegetables (Patel *et al.*, 2015).

In greenhouse farming system, artificial energy and water irrigation systems are most important components that affects the quality and yield of the grown crop. A proper amount of water was applied to the crop with an accurate time in greenhouse. Therefore, water management was an important feature to avoid moisture stress in plants during the stages of plant growth. Applying fertilizer and water through drip irrigation saves the utilization of fertilizers up to 50% and water that also enhances its quality and plant yield. The application of fertilizers should be in such form that becomes synchrony available with the demand of crop for most consumption of nitrogen in fertilizers (Boyhan *et al.*, 2001).

Tomato (*Lycopersicon esculentum*) is a vegetable crop which is mostly grown worldwide and it is a member of family *Solanaceae*. Present Tomato production in world is about 100 million tons fresh fruit from 3.7 million ha. (FAOSTAT, 2001). Tomato is most convenient source of the vitamins of A and C.

The present study was conducted to check the influences of different Management Allowed Depletion (MAD) levels (10% and 15%) and Fertigation levels on the growth and yield of Tomato under crop under tropical environment in greenhouse. Tomato (*Lycopersicon esculentum*, Sahil variety) was grown under drip irrigation system in greenhouse. Nuclear Institute for Agriculture and Biology (NIAB) prepared and imported water-soluble fertilizers were used as Fertigation dosage for Tomato crop. Optimum moisture contents for crop increased its' yield. Penman Monteith method was used to calculate the crop water requirement of Tomato under. Penman Monteith method was most efficient method for the determination of crop water requirement (Harmanto *et al.,* 2004). CROPWAT model version (7.0) was used to compute reference ET and Irrigation Water Requirement (IWR).

Different instruments were used to collect data inside the greenhouse such as hygrometer, moisture meter, thermometer, anemometer and sunshine to collect solar radiation. The experiment was conducted on 8 different treatments having different MAD and Fertigation levels. The results were compared with another single treatment as control/farmer practice to analyze the effects of MAD and fertigation levels on tomato in and outside the greenhouse. The objective of this stuy was to determine the crop water requirement of drip irrigated tomatoes and also to invetstigate the effect of the soluble fertilizers on plant growth and yield of tomato at 10% and 15% MAD levels.

MATERIALS AND METHODS

Location of Experimental Field Plot

The research was carried out at the experimental area of Water Management Research Center (WMRC) located at Post-Graduate Agricultural Research Station (PARS), University of Agriculture, Faisalabad (30^{o} N latitude, 73^{o} E longitude and 184 m altitude). A greenhouse with the size of 180 ft. × 30 ft. was used for the experiment.

Raising of Nursery and Transplanting

The nursery of the Tomato (*Lycopersicon esculentum*, Sahil variety) was prepared on raised beds containing normal field and farm yard manure mixed with soil. Tomato seeds were sown at the start of October. The nursery beds were kept moist, not heavily watered, throughout the duration. Transplanting was completed on raised beds after six weeks of seedlings age with uniform plant to plant spacing of 45 cm and 80 cm from bed to bed distance for all treatments replicated three times. While, planting small holes were made in the soil for each transplant. The holes were than filled with soil after keeping transplant in each hole.

Nutrient Management

To meet the need of nutrients of tomato plants Urea, DAP and SOP were fertigated through irrigation. After 15 days from of transplanting fertigation was started and closed 30 days before the crop harvesting. During the remaining crop duration fertigation through irrigation system was applied accordingly alternate day, weekly, fortnightly and monthly.

Microclimate

Microclimate (i.e. temperature and relative humidity (R.H)) was measured inside the greenhouse by thermometer and hygrometer placed 0.5 m above the ground. Anemometer was used for the measurement of wind speed and Evaporation Pan was used for the measurement of daily evaporation and rain. Sunshine Recorder was used for the measurement of the daily sunshine hours.

A drip irrigation system consisting of emitters, pumps, sub-mains, 24 plastic canes were used for applying water for all 8 treatments inside the greenhouse.

Experimental Design and Procedure

In this study, tomato seedlings were transplanted in rows inside the greenhouse and rows in open field condition for farmer practices treatment. Completely Randomized Design (CRD) with 3 replications and 9 treatments were used. The experiment was conducted on 8 treatments inside the greenhouse and 1 treatment in open field. The treatments are:

$T_1 = F_1M_1$ 100% of conventional *DoF @ 10% MAD.
$T_2 = F_1M_2$ 100% of conventional *DoF @ 15% MAD.
$T_3 = F_2M_1$ Water soluble (NIAB) as 75% of conventional *DoF @ 10% MAD.
$T_4 = F_2M_2$ Water soluble (NIAB) as 75% of conventional *DoF @ 15% MAD.
$T_5 = F_3M_1$ Water soluble (NIAB) as 50% of conventional *DoF @ 10% MAD.
$T_6 = F_3M_2$ Water soluble (NIAB) as 50% of conventional *DoF @ 15% MAD.
$T_7 = F_4M_1$ Water soluble (Imported) as 75% of conventional *DoF @ 10% MAD.
$T_8 = F_4M_2$ Water soluble (Imported) as 75% of conventional *DoF @ 15% MAD.
T_9 Farmer/control Practice.

T = treatment, *DoF = Dosage of Fertilizer, MAD = Management Allowed Depletion, NIAB = Nuclear Institute of Agriculture and Biology.

Crop water requirement (CWR) was measured for every treatment at the end of every two days and the required volume of water was given.

The FAO Penman Monteith method was used for to determine crop water requirement of tomato crop.

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} u_2(e_s - e_a)}{\Delta + \gamma(1 + 0.34u_2)}$$

Where,

ET_o: Reference evapotranspiration [mm/day]

Rn: Net radiation at the crop surface [MJ m^{-2}/day]

G: Soil heat flux density [MJ m^{-2}/day]
T: Mean daily air temperature at 2 m height [°C]
u_2: Wind speed at 2 m height [m/s]
e_s: Saturation vapor pressure [kPa]
e_a: Actual vapor pressure [kPa]
$e_s - e_a$: Saturation vapor pressure deficit [kPa]
Δ: Slope vapor pressure curve [kPa/°C]
ϒ: Psychometric constant [kPa/°C]

Crop Evapotranspiration (Et_c)

Tomato's crop evapotranspiration (ET_C) was calculated by multiplying the reference evapotranspiration by the crop co-efficient.

$$ET_C = K_C \times ET_o$$

Where, K_C = Crop Coefficient, ET_O = Evapotranspiration

CROPWAT Model

CROPWAT model version 7.0 was used to determine ET_C for Tomato crop. This model was used for reading calculated from Penman Monteith method for water requirement of Tomato crop.

The input data for CROPWAT Model was:

1. Temperature
2. Relative humidity
3. Sunshine hours
4. Rain
5. Soil data
6. Wind speed

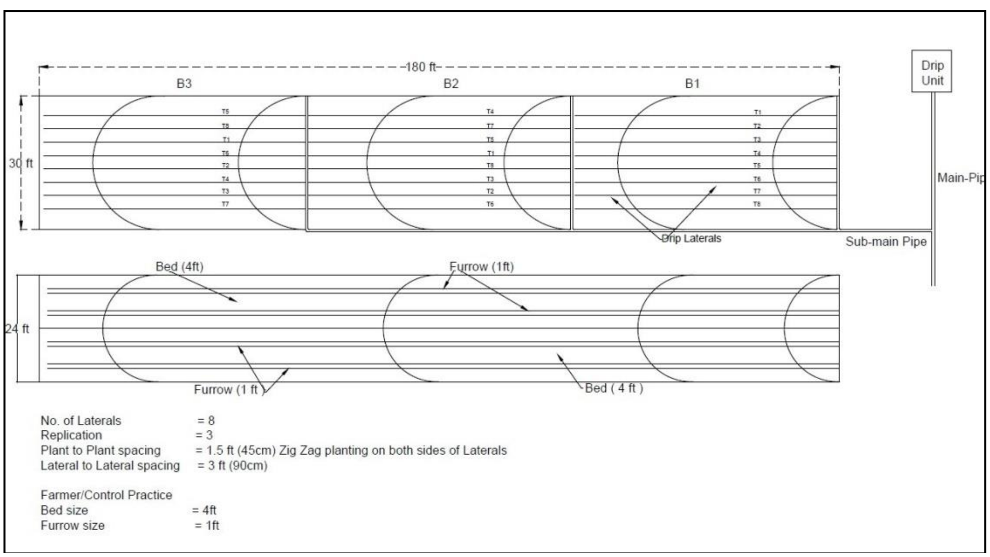

Figure 1: Layout for tomatoes under Greenhouse at Water Management Research Center (WMRC), University of Agriculture, Faisalabad, Pakistan.

RESULTS AND DISCUSSION

Microclimate

The microclimate inside the greenhouse as shown in figure 2 and in open field from weather data as shown in figure 3 was calculated during the experimental time. The average difference of temperature between inside and outside the greenhouse was also calculated. The temperature of air inside the greenhouse was more than the outside temperature. As the climate changes, the temperature differences also increase during the experimental period. Wind speed was also calculated in the greenhouse and in open field. As expected, inside the greenhouse wind speed was much lower than in open field. The main advantage of low wind speed alongside low evapotranspiration process improves crop growth and saves water. Sunshine was also measured inside and outside the greenhouse by using the sunshine recorder. The amount of solar radiation inside the greenhouse was less as compared to the solar radiation in open field. It means that the plants in greenhouse received less energy from solar radiation than in the open field conditions. It was also a reason for less evapotranspiration inside the greenhouse.

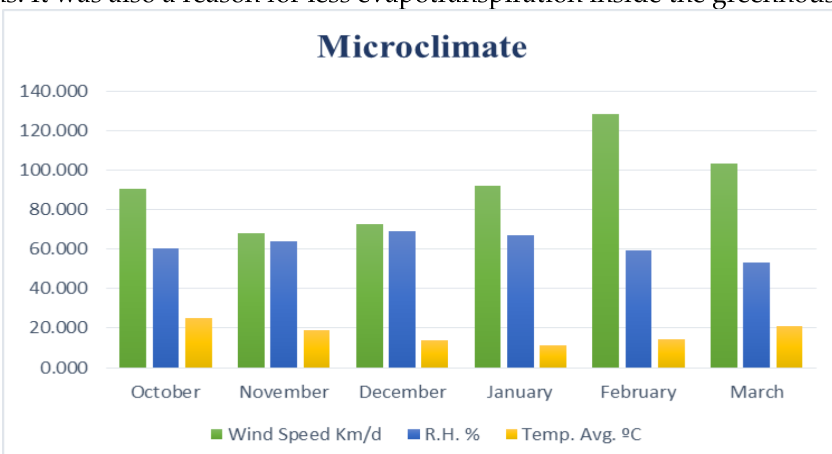

Figure 2: Microclimate inside the greenhouse from October to March 2015-16.

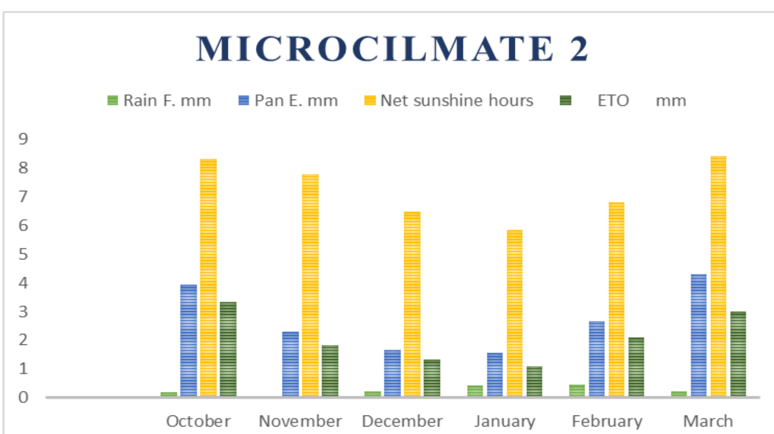

Figure 3:.Microclimate in open field from October to March 2015-16.

Fertigation on Tomato Yield

The amount of Urea, SOP and DAP fertilizers 5.52 kg, 11.45 kg and 7.11 kg respectively was mixed with fluid with the ratio of 2:1, 3:1 and 3:1, respectively, and applied through the drip irrigation. Plant height in treatments T_5, T_4 and T_6 with water-soluble NIAB as 50, 75 and 75, respectively, of conventional dosage of fertilizer at 10%, 15% and 15% MAD levels, respectively, were higher than the plant height of all other treatments.

Plant Height

Plant height was determined in cm of each tagged plant and then average was calculated. Data in relation to this parameter are given in following graph. Maximum plant height was noted in fifth treatment (T_5).

Yield of Tomato

Fruit yield data have significant variations among treatments. Maximum yield of 45.09 ton/ha was obtained from T_5 treatment and 44.25 ton/ha yield was obtained from the T_4 treatment and yield of T_2, T3, T6, T7, T_8, T_9 treatments were 43.74, 43.98, 44.70, 43.52, 43.84, 43.35 ton/ha respectively. T_1 produced the lowest yield of 43.13 ton/ha with 10% of MAD level as shown in figure 4.

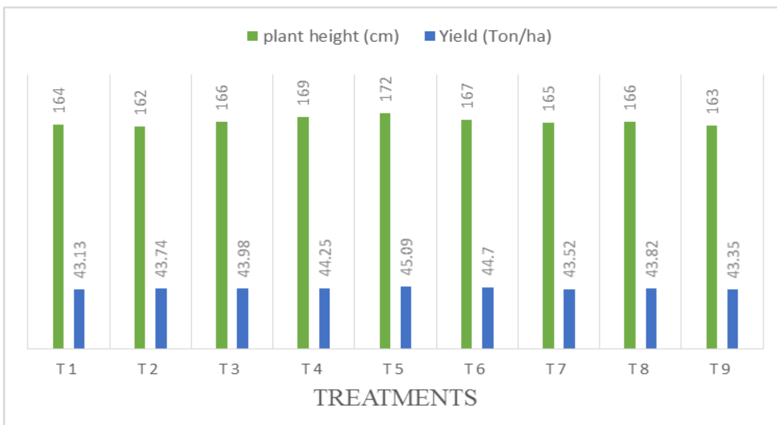

Figure 4: Effect of MAD levels on plant heght and yield of tomato.

CONCLUSION

For tomatoes production, system of greenhouse farming is most efficient system in terms of irrigation water saving, crop quality and yield. Drip irrigation in the greenhouse can save about 25-28% of water as compared to open field irrigated farming system. The quantity of water applied affects crop yield, plants' growth and water productivity. It was concluded that the measurement of crop water requirement from equation of evapotranspiration by directly calculating microclimate from inside the greenhouse might be the more suitable way.

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