

EFFECT OF DIFFERENT FERTILIZER SCHEMES AND IRRIGATION INTERVALS ON TOMATOES' RESPONSE TO WATER SHORTAGE

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ABSTRACT

The growing concerns on increasing global water scarcity require efficient use of water resources. Aimed to investigate the growth and yield responses of tomato to water stress in varied fertilization scheme, a two-factor experiment involving three (3) fertilizer management practices (use of recommended inorganic fertilizer, organic fertilization at 10 T/ha and 20 T/ha) and three (3) watering schedules (daily, two days interval, and three days interval) was done. Analysis of the plant height showed that at increased level of organic fertilizer, plants were taller even up to three (3) days watering interval. Height was significantly reduced for plants applied with 10 T/ha compost and watered at three (3) days interval and those applied with pure inorganic fertilizer. Moreover, prolonging the interval of watering up to three (3) days on compost-fertilized tomatoes allowed them to initiate flowering earlier. This was not significantly different with tomatoes applied with pure inorganic fertilizer but watered daily. Finally, examination of the analysis on the cumulative yield showed that the highest yields, 10.54 and 8.96 MT/ha, were obtained on tomatoes applied with 20 T/ha compost and watered daily and at two (2) days interval, respectively. Significant reduction in yield was exhibited by tomatoes applied with inorganic fertilizer only and watered daily, more so, when watering was at two (2) and three (3) days interval. A conclusion is drawn that application of compost reduces the negative effects of water shortage to flower initiation and plant height even up to three (3) days watering interval and up to two (2) days interval to yield.

Keywords: water stress, fertilizer management, watering schedules, plant height, flower initiation, cumulative yield

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) is one of the important horticultural crops and is a member of the solanaceae family which includes eggplant and peppers. In the tropics, tomato production is said to be limited by a number of factors. Such factors range from moisture stress and lack of good cultural management practices to ensure that crop growth does not suffer. Excessive water can pose a threat of water logging, leaching of applied fertilizers, high salt build up, as well as, lodging in tomato which results in low yield. On the other hand, severe drought will cause wilting and an eventual death of plants.

The same issues of concern today on increasing agricultural productivity despite the challenges brought about by changes in climate were addressed by researchers and policy-makers

during the International Symposium on Climate and Food Security in 1987. They recognized three (3) critical world problems: (1) several billion people often lack the most basic human need that is food security; (2) population growth and the demand for improved living standards are putting severe pressure on the soil and water resources that sustain all food production; and (3) unfavorable weather and climate remain the most frequent cause of crop failure (Glantz, 2009).

In a study conducted by Sibomana et al. (2013), water stress resulted in the significant decrease in plant growth and yield of tomato. Further 69 percent yield reduction was observed for the most stressed plants. The study of Yousef *et al.* (2013) on the response of Echinacea (*Echinacea purpurea* L.) to irrigation regime and different biofertilization treatments indicated that the highest growth parameters and yield components were obtained when plants were grown under the highest irrigation water quantity and treated with the highest biofertilizer level.

Improved water-use and irrigation efficiency and proper fertilization management, especially with the application of organic matter in the soil to improve its water holding capacity are among the adaptation and mitigation strategies to combat the impacts of climate change to agriculture. Accordingly, the objective of this study was to evaluate the growth and yield responses of tomatoes grown under different fertilizer managements to varying watering schedules.

MATERIALS AND METHODS

Study Site

The study was conducted in one of the production areas of the Cebu Technological University – Barili Campus which is located about 25 m west of an automatic agrometeorological station (10° 7' 57.96" N latitude, 123° 32' 41.2" E longitude, 207 m amsl). The soil in the area was generally clayey and alkaline. The area is classified under Type III of the Modified Coronas characterized by no very pronounced maximum rain period, with a short dry season.

Experimental Design and Procedure

The field experiment was carried out on August to October of 2013. There were few rainfall events during the period, thus, water was supplied mainly by irrigation, making possible the application of the irrigation schedule treatments. A widely used commercial tomato variety, "Diamante", was used for the test crops.

At least 200 seeds were treated for germination and sown in a seed bed composed of garden soil and vermi-compost. One month after sowing, the seedlings were transplanted to the prepared raised beds 1m x 0.75 m each in area on the field. The study was a two-factorial experiment in a Randomized Complete Block Design (RCBD) replicated three (3) times. The treatments were summarized as follows:

Fertilizer Management:

- F1 – recommended inorganic fertilization
- F2 – 10 t/ha vermicompost
- F3 – 20 t/ha vermicompost

Irrigation Schedule:

- W1 – daily
- W2 – 2 days interval
- W3 – 3 days interval

The treatments were applied per raised bed. In each plot, six (6) sample plants were grown. The treatments on fertilizer management were applied prior to transplanting. On the other hand, treatments on watering schedule were applied a month after transplanting to allow the seedlings to recover from transplanting stress before water stress was induced to the plants. Scheduled irrigation was done using a watering dipper at around 5 pm following the irrigation schedule treatments. One dipper, approximately one (1) liter of water, per plant was applied in every scheduled irrigation. Weeding and provision of trellis were done when found necessary.

Data on weekly plant height and date to onset of flowering were recorded. The fruits were harvested when they reached market maturity. Data gathering terminated 64 days after transplanting and cumulative yield was computed.

The effect of the different treatments was statistically analysed through Analysis of Variance (ANOVA) for Randomized Complete Block Design (RCBD). Comparisons among means were done using Duncan's Multiple Range Test (DMRT) to determine the specific significant differences among treatment means.

RESULTS AND DISCUSSION

Growth

The differences in the plant height and the number of days to onset of flowering were used to study the effect of water deficit stress on the growth of the tomato plants grown under different fertilizer managements. Considering that approximately the same amount of water per plant was applied every scheduled watering, those plants watered daily received the most amount of water for the entire duration of the study. Consequently, tomato plants watered in three (3) days interval experienced the most water deficit stress compared to plants on other treatments. Table 1 shows that significant reduction on plant height occurred when irrigation was done in three (3) days interval. This supports the results of Sibomana et al. (2013) on tomato,

Yousef et al. (2013) on Echinacea (*Echinacea purpurea* L.), and Abdelmoneim et al. (2014) on corn (*Zea mays* L.).

Table 1. Effect of Varying Watering Schedules, Different Fertilizer Managements and their Interactions to the Growth and Yield of *Lycopersicon esculentum*.

Treatment	Plant Growth Parameters and Yield		
	Plant Height (cm)	Number of Days to Flowering (days)	Yield (mT/ha)
Irrigation Interval			
Daily	64.89 ^a	39.00 ^b	6.36
Two Days Interval	61.89 ^a	42.89 ^a	4.67
Three Days Interval	54.22 ^b	40.11 ^{ab}	0.95
Fertilizer Management			
Pure Inorganic	47.33 ^c	46.00 ^a	0.99
10 T/ha Organic	63.89 ^b	43.00 ^b	3.85
20 T/ha Organic	69.78 ^a	33.00 ^c	7.14
Irrigation Interval x Fertilizer Management			
Pure Inorganic Fertilizer			
Daily	55.00 ^b	31.00 ^d	2.46 ^c
Two Days Interval	51.33 ^b	53.00 ^a	0.50 ^d
Three Days Interval	35.67 ^c	54.00 ^a	0.00 ^b
10 T/ha Organic Fertilizer Applied			
Daily	70.67 ^a	46.00 ^b	6.07 ^b
Two Days Interval	66.00 ^a	44.66 ^b	4.56 ^b
Three Days Interval	55.00 ^b	38.33 ^c	0.92 ^{cd}
20 T/ha Organic Fertilizer Applied			
Daily	69.00 ^a	40.00 ^c	10.54 ^a
Two Days Interval	68.33 ^a	31.00 ^d	8.96 ^a
Three Days Interval	72.00 ^a	28.00 ^d	1.92 ^{cd}

Means in each column showing letter in common are not significantly different ($P < 0.05$) by Duncan's Multiple Range Test Values are the means of three replications

The increment in plant height due to quantity of irrigation water may be attributed to increase in node number or internode length or both (Yousef et al., 2013).

The number of days to flowering was not significantly influenced by the frequency of irrigation. Similar results were obtained by Koesriharti et al. (2012) on tomato plants and claimed that time to flowering, fruiting and harvesting of tomato plants seem to be determined by the genetic rather environmental factor. In this study, tomato plants started to flower at 29 – 43 days after transplanting.

The data presented in Table 1 show also the significant effect of different fertilizer managements to the plant height and number of days to start of flowering of the tomato plants. The tallest plants were those applied with the highest amount of organic fertilizer while plants fertilized with pure inorganic fertilizer showed notable reduction in plant height. These results corroborate with the findings of Ibrahim and Fadni (2013) on the effects of organic fertilizers in the soil properties, growth and yield quality of tomatoes. They concluded that organic manure fertilizer is an efficient amendment for improving the physical, chemical and nutritional properties of the soil and increasing crop yield. Moreover, addition of organic fertilizers can reduce soil pH values and increase the nutrient uptake of plants.

The data of bi-interactions between the studied factors (Table 1) revealed that the height of the tomato plants measured at flowering stage of majority of the test plants were not significantly different to those applied with 20 t/ha and 10 t/ha organic fertilizer. However, significant reduction in height was observed when organic fertilization was reduced to 10 t/ha and watered at three (3) days interval. Moreover, reduced plant height was significant to those treated with pure inorganic fertilizer and watered in two (2) days interval which recorded the least average plant height of 35.67 cm.

Yield

Looking at the individual effect of irrigation frequency to yield of tomato, a general reduction in yield was observed as the stress level experienced by the plants increased. The highest fruit yield of 6.36 t/ha was observed in plants watered daily while the most stressed plants only produced 0.95 t/ha. On the other hand, increasing the amount of organic fertilizer significantly increased the yield of the tomato plants. These results conform to the findings of Badiane et al. (2012) which states that water stress application resulted in significantly lower grain yields of corn. Furthermore, organic matter amendment enhanced the effect of water stress on its grain yield. The results showed that the effective treatment was observed under the interaction between the most frequent irrigation (daily) and highest amount of organic fertilizer applied (20 t/ha) which gave a yield of 10.54 t/ha. However, this was not significantly different

with the yield obtained from tomato plants applied with same amount of organic fertilizer but watered at two (2) days interval (8.96 t/ha). Significant yield reduction was observed on plants watered at three (3) days interval regardless of the fertilizer management treatment. The same reduction in yield for tomato plants applied with pure inorganic fertilizer regardless of the irrigation interval was recorded.

CONCLUSION

The results of this experiment demonstrated the effects of adding organic fertilizer to the growth and yield of tomatoes subjected to different irrigation intervals. A conclusion is drawn that application of compost reduces the negative effects of water shortage to flower initiation and plant height even up to three (3) days watering interval and up to two (2) days interval to yield. In the context of water-saving technology, the study suggests that postponing irrigation to up to two (2) days interval will not significantly reduce yield if organic fertilizer is added to the soil. Further study may be conducted on water stress adaptation of crops at different growth stages for optimization of water use.

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