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Vegetative Growth and Yield of Tomato as Affected by Water Regime and Mulching

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Abstract
An experiment was carried out with potted tomato plants to investigate the interactive effect of water regime and mulching on the growth and yield of tomato; conducted during the 2012/2013 dry season at the Federal College of Forestry Jos, Nigeria to evaluate water management options on the performance of tomato. The experiment consisted of three levels of irrigation water application depths (0.3, 0.4 and 0.5 liter/day/plant) and three types of mulch materials (Black polyethylene, white polyethylene and straw were used to cover the soil surface of the pots). The pots were arranged in Randomize Complete Block Design (RCBD) system. Watering with different volume of water was done throughout the growth period, the result showed that water regime has no significant effect on vine length, leaf number, leaf area, stem girth but at plant yield except at 4WAT, while the effect of mulch on Vine length and stem girth were significant but leaf number, leaf area, stem girt were not significant. The result showed that the water regime (0.3,0.4 and 0.5litre/day/plant gave the following yield 112.3, 140.01 and 154.34g/pot while for the mulch the corresponding impact on the yield were: 141.49,176.59,158.12 and 66g/pot for straw, black & clear polyethylene and control.

Keywords: Water Regime, mulch, yield, tomato, pots.

Introduction

According to US census Bureau, the world population is projected to grow from 6 billion in 1999 to 9 billion in 2044 , an increase of 50% in 45years. This increasing world population will create a demand for more food and agricultural products; if such estimates holds true agricultural producers will simply need to learn how to make more food with less water (Postels *et al*., 1999). Though water has been typically considered the most limiting factor but with the trend in population increase land and water are the binding constraints on production (Pearce,2006) . Irrigation practices and techniques which minimum water utilization are fast evolving and there is need for evaluation of these practices before adoption. Which will include the employment of techniques and practices that deliver a more accurate of water to crops (FAO. 2002. English and Raja, 1996). The production of most annual crops can be sustained only through irrigation which play a vital role in ensuring continuity of production and good quality crops. The cool-dry season, where irrigation facilities exist, is the prepared environment for tomato production. However, irrigation is not without its drawback. Mismanagement irrigation has adverse effects on both the soil and crop. Hagan *et al.,* (2008) asserted that excessive irrigation delays maturity, harvesting, encourages vine growth, and reduces the soluble solid contents of tomato; while its insufficiency decreases yield and crop quality. In soils, excessive irrigation result in lack of aeration, surface runoff, deep percolation, build up of water table with consequent decrease in root zone depth, water logging, and possibly salinity (Tindall *et al.,* 1991). Studies are needed to increase the efficiency in the use of available water regulated deficit irrigation with mulch is one among many practices that is fast gaining ground, and appears a very promising option to achieving the goal more crops per drop of water if proper adopted (Oiganji *et al.*, 2010). The development of new irrigation scheduling techniques such as deficit irrigation identifying the sensitive crop growth stage to water stress is one of the ways to enhance crop productivity with less water (Bekele and Tilahun, 2007; Jolata *et al*., 2006). Regulated deficit irrigation scheduling practice is the technique of withholding or skipping irrigation, or reducing the amount of water applied per irrigation at some stages of the crop growth with the aim of saving water, labor, and in some cases energy. This practice does lead to some degree of moisture stress on the crop and reduction in crop yield (smith *et al.,* 2002; Prichard *et al.*, 2004: Zhang *et al.*, 2004). Mulches can be composed of plant materials or they may be synthetic consisting of plastic sheets (Allen *et al*., 1998). Plastic mulches can be transparent, white or black. Plastic mulches substantially reduce evaporation of water from the soil surface, especially under deficit irrigation (Allen *et al.*, 1998). In using organic mulches, the depth of organic mulch and the fraction of the soil surface covered will affect the amount of reduction in evaporation from the soil surface. The advantages of plastic mulch are: increased soil temperature, reduced soil compaction, reduced fertilizer leaching, reduced evaporation, cleaner product, reduced weed problems (Rahaman *et al.,*2004; Rafat and Rafiq, 2009)

Variations exist on the effects of water regime and mulch on crops which imply that the effects of water regime on a crop vary with location which may be due to climate of the location which in turn dictates the evaporative demand of the crop, mulch type and the soil type which determines the available water for plant uptake (Postel, 2000, Oiganji *et al.,* 2010). There is a growing interest in irrigating with different water regime a practice to improve water productivity. Mulching is another agronomic practice for conserving soil moisture and reducing the rate of evaporation. Therefore, a combination of regulated deficit irrigation and mulching is expected to improve crop yield. What is not common knowledge is the combination of mulch type (material) and water regime, that can maximize crop yield of potted Tomato crop in Jos. Moreover, information on how a combination of mulch type and deficit irrigation practices, before adoption of any water regime there is need to ascertain the yield response of tomato to water yield by knowing the specific quantity of water and mulch type to a better yield of Tomato (Hune *et al.*, 2009; Oiganji *et al*, 2010).

Tomato fruits are consumed fresh in salads or cooked in sauce. It can also be fried in stews and used as a flouring in soups and meat or fish dishes. They are made into sweetened can dies, dried fruits and even into wine. Economically equally important are the processed forms such as juice, ketchup, canned whole and diced fruits (Caoxl. *et al.*, 2010). Tomato water requirement is influenced by crop variety, soil type, soil moisture regime, physiological and environmental factors. Several researchers have investigated the influence of mulching, irrigation schedule, soil moisture regime, furrow type and size on control and management of irrigation water (Tindall *et al.*, 1991). The objectives of this research is to study the vegetative growth and yield of tomato as affected by water regime and mulching in Jos-plateau state.

Materials and Method

The study was carried out at Federal College of Forestry, Jos; which is located at Latitude 7^0, 11^0N and Longitude 7^0, 25^0E with an annual rainfall of about 1460mm – 1480mm, temperature ranged between 10^0c – 32^0c and an altitude of 1200m above sea level. The Tomato seeds (*Roma variety*) were sourced from the market and planted for 30days before the seedlings were transplanted in 25cm height and 30cm diameter pot. The pots were filled with silt clay loam soil. The field capacity of the soil was 33%; the soil was air dried and sieved through a 2mm sieve for chemical analysis and the general characteristics were: sand 5.8%; silt 60.2%, clay 34% , porosity 49% , maximum holding capacity 46% and bulk density 1.27g/cc. The mulch material were Straw (*impereta cylindrica*), black and white polyethylene. The treatment combination is as shown in Table 1 laid in Randomize Complete Block Design (RCBD) consisting of nine (9) treatments replicated three times. The treatments were maintained by adding required amount of water lost through evapotranspiration for two weeks after transplants of tomato seedlings for proper establishment before treatment were applied. Black polyethylene, clear polyethylene and straw were used to cover the soil surface (as mulch) while one of the plot used as control (without mulch). Nutrient supply and other intercultural operations were done as and when necessary and the treatments were irrigated at different volume of water throughout the growth period as shown in the Table1. Growth parameters were taken at 4WAT, 6WAT and 8WAT and at maturity yield were recorded.

Data Analysis

The data set for leaf area, leaf number, girth measurement, vine length, and fruit yield were subjected to analyses of variance (ANOVA) using SAS software package 9.1 (SAS Institute, 2003).Comparison among the treatments combination were carried out at 0.05% probability level.

Result and Discussion

Vine length

The effect of water regime as it affect the vine length of the tomato at the various week interval is as shown in Table 2.1; indicating that irrespective of the water regime At 4WAT and 6WAT there was no significant difference at 0.05%, which means that they were statically the same but during the 8WAT the W1 (0.3l/day) seems to be higher than W2 (0.4l/day) and W3 (0.5l/day) which might be so because tomato do better with limited amount of water with respect to its growth stage. Comparing the conservative ability of the mulches the black polyethylene 44.78, 74.33 and 78.44cm for 4WAT, 6WAT and 8WAT respectively. However, the interaction of water regime and mulch was significant at 4WAT and not significant (0.05%) for 6WAT and 8WAT.

Leaf Number

During 4WAT, 6WAT and 8WAT the leaf number were 16, 31 and 43 respectively as shown in Table 2.2 was higher than others with higher water regime, indicating that potted tomato in the study area can survive with limited application of water with respect to crop water use required for the various period**,** while for the mulch the clear polyethylene perform better than the black and straw mulch. Nevertheless an interaction between water regime and mulch was not significant at 5%. From the mean separation in Table 2.2 mulching has no significant effects on the leaf number at the various week intervals. At 4 WAT, treatments M1 and M2 are significantly not different from treatments M3 and M4. At 8 WAT, treatments M2 and M3 are significantly not different, while treatment M1 is significantly not different from treatment M4.

Leaf area

Leaf area as affected by the different water regime at 4WAT, 6WAT and 8WAT seems to be statically at par with respect to the variation in water applied, it was observed that treatments irrigated with 0.4l/day leaf area were higher compared to others as shown in Table 2.3 in the following order 14.52, 11.69 and 13.47cm^2 for 4WAT, 6WAT and 8WAT respectively; black polyethylene perform better than others. However, the interactive effect of water regime and mulch seems not to be significant at 5%.

Stem Girth

The interaction of water regime and Mulch was significant at 4WAT and not significant at 5%; when the tomato plant was irrigated with 0.5l/day the corresponding stem girth were 1.82, 2.30 and 2.65 cm during 4WAT, 6WAT and 8WAT but with respect to other water regime they are statically at par; for the various mulch used clear polyethylene perform better during 4-6WAT, at 8WAT back polyethylene performed better as indicated in Table 2.4. Types of mulch used has no significant effects on the stem girth at the various week intervals except at 4 WAT, in which the control (M4) showed a significantly low effect on stem girth.

Fruit Yield

The fruit yield harvested before the on-set of rains is as shown in Table 2.5, when the pots were irrigated with 0.5, 0.4 and 0.3l/day the corresponding effect on yield were 154.34, 140.01 and 112.3 g/plant which was lower compared to yield (0.77-1.46kg/plant) obtained by Juanjuan *et al*.,(2012), however Molla *et al*., (2003) obtained 0.07kg/plant lower compared to the results obtained in this research. The interaction between water regime and mulch was significant; the black polyethylene mulch yield better result compared to other mulch type considered in this research.

Conclusion

The result showed that water regime has no significant effect on vine length, leaf number, leaf area and stem girth except for the fruit yield when irrigated with 0.5l/day the yield was higher with 154.43 g/plant when mulched with black polyethylene the yield was 176.59g/plant. From the present investigation and other reviewed work, water use efficiency of tomato can be increased significantly by mulching. Un-mulched pots resulted in higher crop water use, by way of increased evapotranspiration.

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Table 1: Treatment Description

Treatments	Combination	Description
T_1	AW1	Irrigated with 0.3L/day/plant covered with straw
T_2	BW1	Irrigated with 0.3L/day/plant covered with black polyethylene
T_3	CW1	Irrigated with 0.3L/day/plant covered with clear polyethylene
T_4	AW2	Irrigated with 0.4L/day/plant, covered with straw
T_5	BW2	Irrigated with 0.4L/day/plant, covered with black polyethylene
T_6	CW2	Irrigated with 0.4L/day/plant, covered with clear polyethylene
T_7	AW3	Irrigated with 0.5L/day/plant covered with straw
T_8	BW3	Irrigated with 0.5L/day/plant covered with black polyethylene
T_9	CW3	Irrigated with 0.5L/day/plant, covered with clear polyethylene

A= straw B= Black polyethylene C= Clear Polyethylene *irrigation interval was one week interval. W1 = 0.3L/day/plant, W2 = 0.4L/day/plant, W3 = 0.5L/day/plant.

Table 2.1 Effect of water Regime and Mulch on Vine Length

	Water Regime on vine length		
Weeks after Transplanting	4WAT	6WAT	8WAT
W1 (0.5L/day)	42.78[a]	69.20[a]	85.00[a]
W2 (0.4L/day)	40.42[a]	62.42[a]	72.33[b]
W3 (0.3L/day)	42.00[a]	67.25[a]	79.17[ab]
SE±	3.0	3.9	3.9
	Mulching on vine length		
M1 (Straw)	43.67a	67.56ab	77.89a
M2 (Black polyethylene)	44.78a	74.33a	78.44a
M3 (Clear polyethylene)	47.44a	67.33ab	83.67a
M4 (Control)	31.03b	55.93b	75.33a
SE±	3.4	4.5	4.4
Water Regime* Mulching	S	ns	ns

Table 2.2 Effect of water Regime and Mulch on Leaf Number

Water Regime on leaf Number			
Weeks after Transplanting	4WAT	6WAT	8WAT
W1 (0.5L/day)	16^{a}	31^{a}	43^{a}
W2 (0.4L/day)	11^{a}	26^{a}	37^{a}
W3 (0.3L/day)	14^{a}	24^{a}	34^{a}
SE±	1.8	3.5	4.0
Mulching on leaf Number			
M1 (Straw)	14^{ab}	26^{a}	37^{ab}
M2 (Black polyethylene)	15^{ab}	31^{a}	43^{a}
M3 (Clear polyethylene)	17^{a}	31^{a}	44^{a}
M4 (Control)	9^{b}	19^{a}	27^{b}
SE±	2.1	4.0	4.6
Water Regime* Mulching	ns	ns	ns

Table 2.3 Effect of water Regime and Mulch on Leaf Area

Water Regime on leaf area			
Weeks after Transplanting	4WAT	6WAT	8WAT
W1 (0.5L/day)	12.08^{a}	12.15^{a}	11.00^{a}
W2 (0.4L/day)	14.52^{a}	11.69^{a}	13.47^{a}
W3 (0.3L/day)	15.83^{a}	11.80^{a}	13.53^{a}
SE±	1.7	1.3	1.3
Mulching on leaf area			
M1 (Straw)	14.23^{ab}	12.23^{a}	13.57^{a}
M2 (Black polyethylene)	16.69^{a}	11.86^{a}	13.18^{a}
M3 (Clear polyethylene)	15.51^{ab}	10.77^{a}	11.32^{a}
M4 (Control)	10.13^{b}	12.67^{a}	12.60^{a}
SE±	2.0	1.5	1.5
Water Regime* Mulching	ns	ns	ns

WAT = weeks after transplanting

Table 2.4 Effect of water Regime and Mulch on Stem Girth

Water Regime on stem Girth			
Weeks after Transplanting	4WAT	6WAT	8WAT
W1 (0.5L/day)	1.82[a]	2.30[a]	2.65[a]
W2 (0.4L/day)	1.61[a]	2.19[a]	2.53[a]
W3 (0.3L/day)	1.81[a]	2.32[a]	2.59[a]
SE±	0.1	0.1	0.1
Mulching on Stem girth			
M1 (Straw)	1.81[a]	2.33[a]	2.56[a]
M2 (Black polyethylene)	1.78[a]	2.27[a]	2.74[a]
M3 (Clear polyethylene)	1.96[a]	2.38[a]	2.59[a]
M4 (Control)	1.43[b]	2.10[a]	2.47[a]
SE±	0.1	0.2	0.1
Water Regime* Mulching	s	ns	ns

WAT = weeks after transplanting

Table 2.4 Effect of water Regime and Mulch on Stem Girth

Water Regime on stem Girth			
Weeks after Transplanting	4WAT	6WAT	8WAT
W1 (0.5L/day)	1.82[a]	2.30[a]	2.65[a]
W2 (0.4L/day)	1.61[a]	2.19[a]	2.53[a]
W3 (0.3L/day)	1.81[a]	2.32[a]	2.59[a]
SE±	0.1	0.1	0.1
Mulching on Stem girth			
M1 (Straw)	1.81[a]	2.33[a]	2.56[a]
M2 (Black polyethylene)	1.78[a]	2.27[a]	2.74[a]
M3 (Clear polyethylene)	1.96[a]	2.38[a]	2.59[a]
M4 (Control)	1.43[b]	2.10[a]	2.47[a]
SE±	0.1	0.2	0.1
Water Regime* Mulching	s	ns	ns

WAT = weeks after transplanting

Table 2.5 Effect of water Regime and Mulch on Fruit Yield

Water Regime on fruit yield	
	Yield g/plant
W1 (0.5L/day)	154.34[a]
W2 (0.4L/day)	140.01[a]
W3 (0.3L/day)	112.30[a]
SE±	18.0
Mulching on fruit yield	
M1 (Straw)	141.49[a]
M2 (Black polyethylene)	176.59[a]
M3 (Clear polyethylene)	158.12[a]
M4 (Control)	66.00[b]
SE±	20.8
Water Regime* Mulching	s

WAT = weeks after transplanting