INFLUENCE OF SUPER ABSORBENT POLYMER AND IRRIGATION INTERVALS ON THE PERFORMANCE OF TWO TOMATO (*Solanum lycoperiscum)* VARIETIES.

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Abstract
Water deficit is one of the most important limiting factors in crop production, it is becoming an increasingly severe problem in many parts of the world. The growth and yield of tomato an important vegetable crop in agricultural economy and one of the most widely consumed vegetable crop in the world is often constrained by water deficit. Irrigation wtervis becoming scarce and costly, hence there is need to find a reliable water management strategy to cope with water scarcity. The addition of water-saving superabsorbent polymer (SAP) in soil can improve soil physical properties, crop growth and yield and also reduce the irrigation requirement of crops. Pot experiment trials were conducted in the Horticultural nursery site of Department of Crop Production, Federal University of Technology, Minna and the nursery site of Ministry of Forestry Buruku, Kaduna to evaluate Influence of Super Absorbent Polymer (SAP) and irrigation intervals on the performance of two tomato (Solanum lycopersicum L.) varieties during the 2013 dry season. It was a 5 x 4 x 2 factorial experiment laid out in a completely randomized design (CRD) and replicated three times. The treatments were five rates of polymer (0, 1, 2, 3 and 4 g kg^{-1}), four irrigation intervals (daily, 2days, 4days, and 6days intervals) and two tomato varieties (Roma VF and UC82B). Result showed that Roma VF produced taller plants, higher number of fruits and fruit yield than UC82B while the measured parameters were increased with polymer rate of 3g kg^{-1}. Irrigating at 2days interval also had significant effect on the plant height, stem girth, fruit weight and yield. Based on the findings of this study, it is recommended that for higher growth and yield of tomato farmers should plant Roma VF with the application of 2g kg^{-1} or 3g kg^{-1} polymer into the soil irrigated at 2days intervals.
Keywords: Polymer, Irrigation, Tomato.

Introduction

Tomato (*Solanum lycoperiscum* L.) is a herbaceous, sprawling plant which belongs to the family *Solanaceae*. It is an annual plant, typically reaching up to 1-3m in height with weak, woody stem that often vines over other plants (Aquaah, 2005). Tomato is a rich source of minerals like potassium, magnesium, calcium, iron, zinc, vitamins (A, B1, B2, C and E), dietary fiber (Pectin), citric Acid and antioxidants (Islam et al., 2006). The fruits are used as salad for preparation of sauce and tomato juice in canning industries (Anyanwu *et al*., 2005). It contains lycopene which has been found to prevent prostate cancer (Durrant, 2008). Over 160 million tons of tomatoes was produced in the world in 2013, with china as the largest producer (50,644,255) tones and Nigeria ranked as second largest producer of tomato in Africa and fifteen in the world, producing 1,565,000 million tons annually at an average of 20-30 tonnes per hectare (FAO, 2013).

Statement of Research Problem Inconsistencies in water application have been reported to increase physiological disorder such as blossom end root (BER) and fruit cracking (saure,2010). Water deficit is a major environmental constraint that strongly affect cultivated plants, reducing growth and yield especially in tomato production (Umezana *et al*., 2006).

Moisture stress decreases growth and development which lead to reduced photosynthesis a process in which plants combine water, carbon dioxide and light to synthesize carbohydrates for energy (Nyabundi, 2009). Photosynthetic response to drought is highly complex in tomato plants. Vegetable crops are sensitive to water shortage, any deficit in providing water to the plants lead to considerable reduction in yield (Sadregahaen *et al.,* 2010). Tomatoes are very sensitive to water deficit during and immediately after transplanting, at flowering and during development (Nuruddin, 2007).

Tomato plants need a controlled supply of water throughout their growing periods for optimum yield and quality (Kirnak *et al*., 2005). Addina (2008) stated that is it important to improve the water use efficiency (WUE) of tomato plants, since virtually all physiological and biochemical functions of plant cells and tissues take place in the medium of water. There is need to improve water additive that will supply water needed by the plant which will reduce the frequency of water supply and energy waste. The excellent water absorbency and water retention capacity of super absorbent polymers (SAP) may prove especially practicable in Agricultural and Horticultural application for efficient water and nutrient utilization by plants. Information on the effect of SAP on tomato production in Nigeria are few, hence the need for the study. The objective of this study was to evaluate the effect of Super Absorbent Polymer and irrigation intervals on growth and fruit yield of tomato in the Southern and Northern guinea savanna of Nigeria.

Materials and Methods

A multi-locational trial was conducted at the Horticultural nursery of the Department of Crop Production, Federal University of Technology (Gidan kwano campus) Minna, (lat. 9º37'N; long.6º 28'E) located in the Southern Guinea Savannah and Ministry of Forestry nursery at Buruku, Kaduna (lat.10º 15'N; long. 7º 45'E) located in the Northern Guinea Savanna of Nigeria during the 2013 dry season. Top soils were collected at random along a transect across the study site bulked to obtain a composite sample which was subjected to routine physical and chemical analysis using standard laboratory procedures as described by Agbenin, (2005) to determine the characteristics of the soil.

The experiment was a 5 x 4 x 2 factorial experiment laid out in a completely randomized design (CRD) and replicated three times. The treatments were: five rates of polymer (0, 1, 2, 3 and 4 kg^{-1}), four irrigation intervals (daily, 2days, 4days and 6days) and two tomato varieties (Roma VF and UC 82B). the tomato seed were obtained from an Agro-allied company along Maitumbi road, Minna while super absorbent polymer (Potassium polyacrylamide acrylate copolymer) was obtained from Makfaz petro-chemical limited, Kado Estate, Abuja.

The tomato seeds were sown in seedling trays in the nursery and watered on daily basis for four weeks. Poly pots measuring 24cm x 22.5cm were washed and dried. 6kg top soil was used to fill each poly pots (Wong *et al.,* 2003). The different SAP level were then thoroughly mixed with 5kg of top soil out of the 6kg top soil to be used while the remnant 1kg was spread on top of the 5kg top soil mixed with the various SAP levels to prevent breakdown of the polymer. Seedlings were then transplanted into the poly pots at four weeks at two seedlings per pot and later thinned to one stand per pot. In the first week of transplanting, poly pots were irrigated daily with 500ml of water to reduce water stress and to ensure proper establishment of the seedlings after which the experimental irrigation intervals commenced with 1750ml of water (water required to saturate the pores of 6kg of soil). Weeds that emerged were hand pulled weekly. Fresh neem leaves were collected, crushed and soaked in

tap water for 30 minutes and the solution was filtered through a filter paper, 100ml of the solution was mixed with 1 liter of water and sprayed on the leaves of the tomato to serve as insecticide against insect infestation as described by (Biswas, 2008). Harvesting of tomato fruits was done when the fruits were firm and greenish yellow at intervals of 3 days.

Parameters measured includes, plant height, stem girth, number of branches at 6 and 9 WAT, days to first flowering, number of fruit and fruit yield in grams. The data collected were subjected to analysis of variance (ANOVA) and means separated using least significant difference (LSD) at 5% probability.

Table 1: effect of super absorbent polymer and irrigation intervals on plant height of two tomato varieties at Minna and Kaduna during the 2013 cropping season.
Plant Height (cm)

	6WAT		9WAT	
	Minna	Kaduna	Minna	Kaduna
Varieties (V)				
Roma VF	25.9	26.8	35.6	37.6
UC 82B	25.1	25.0	33.0	34.5
LSD (0.05)	1.52	1.45	4.57	3.03
Polymer rates(P)				
0g/kg	20.1	23.4	32.9	34.6
1g/kg	20.3	25.6	37.9	37.7
2g/kg	26.3	27.7	33.9	38.8
3g/kg	30.1	27.3	35.7	36.9
4g/kg	2.30	2.42	7.24	4.18
LSD (0.05)	2.30	2.42	7.24	4.18
Irrigation intervals (I)				
Daily	26.9	25.3	37.3	38.1
2 days	27.9	27.8	38.4	38.2
4 days	26.9	27.2	41.0	40.2
6 days	21.1	23.3	20.3	25.5
LSD (0.05)	2.06	0.61	6.47	4.29
Interaction				
VxP	NS	NS	NS	NS

VxI	NS	NS	NS	NS
PxI	NS	NS	NS	NS
VxPxI	NS	NS	NS	NS

Table 2: effect of super absorbent polymer and irrigation intervals on stem girth of two tomato varieties at Minna and Kaduna during the 2013 cropping season.
Stem Girth (cm)

		6WAT		9WAT	
	Minna	Kaduna	Minna	Kaduna	
Varieties (V)					
Roma VF	0.60	0.64	0.91	0.89	
UC 82B	0.59	0.65	0.88	0.89	
LSD (0.05)	0.05	0.04	0.13	0.08	
Polymer rates(P)					
0g/kg	0.55	0.61	0.80	0.89	
1g/kg	0.58	0.63	0.95	0.94	
2g/kg	0.63	0.67	0.94	0.97	
3g/kg	0.61	0.64	0.92	0.88	
4g/kg	0.60	0.62	0.84	0.87	
LSD (0.05)	0.07	0.06	0.02	0.12	
Irrigation intervals (I)					
Daily	0.60	0.62	0.61	0.89	
2 days	0.61	0.68	0.97	0.95	
4 days	0.58	0.65	0.98	0.92	
6 days	0.59	0.62	0.63	0.79	
LSD (0.05)	0.07	0.05	0.18	0.11	
Interaction					
VxP	NS	NS	NS	NS	
VxI	NS	NS	NS	NS	
PxI	NS	NS	NS	NS	

VxPxI	NS	NS	NS	NS

Table 3: effect of super absorbent polymer and irrigation intervals on number of branches of two tomato varieties at Minna and Kaduna during the 2013 cropping season.

Number of Branches

		6WAT		9WAT	
	Minna	Kaduna	Minna	Kaduna
Varieties (V)				
Roma VF	8.0	8.0	10.0	10.0
UC 82B	7.0	8.0	9.0	10.0
LSD (0.05)	0.45	0.43	1.31	0.79
Polymer rates(P)				
0g/kg	7.0	8.0	9.0	10.0
1g/kg	8.0	8.0	10.0	10.0
2g/kg	8.0	9.0	9.0	10.0
3g/kg	8.0	9.0	10.0	10.0
4g/kg	7.0	8.0	9.0	8.0
LSD (0.05)	0.71	0.68	1.90	1.12
Irrigation intervals (I)				
Daily	8.0	8.0	10.0	10.0
2 days	8.0	9.0	11.0	11.0
4 days	7.0	8.0	10.0	10.0
6 days	7.0	8.0	6.0	8.0
LSD (0.05)	0.64	0.61	1.90	1.12
Interaction				
VxP	NS	NS	NS	NS
VxI	NS	NS	NS	NS
PxI	NS	NS	NS	NS
VxPxI	NS	NS	NS	NS

Table 4: effect of super absorbent polymer and irrigation intervals on days to first flowering, number of seeds per fruit, seed weight and fruit yield of two tomato varieties at Minna and Kaduna during the 2013 cropping season.

	Days to first flowering		*number of fruits*		*Fruit yield (s)*	
	Minna	Kaduna	Minna	Kaduna	Minna	Kaduna
Varieties (V)						
UC 82B	96.0	102.0	1.00	2.00	11.85	18.67
LSD (0.05)	12.93	11.99	0.36	0.56	1.92	2.24
Polymer rates (P)						
0g/kg	100.0	100.0	1.58	1.33	12.24	17.64
1g/kg	108.0	106.0	1.67	2.54	13.47	19.45
2g/kg	82.0	88.0	2.13	2.33	11.73	22.03
3g/kg	94.0	107.0	1.67	2.04	13.88	17.35
4g/kg	102.0	103.0	1.46	1.16	11.36	11.85
LSD (0.05)	20.44	18.96	0.57	0.81	3.02	3.54
Irrigation intervals (I)						
Daily	105.0	102.0	1.87	2.07	13.61	17.84
2 days interval	102.0	102.0	1.90	2.17	14.76	21.54
4 days interval	103.0	102.0	2.07	2.60	12.91	19.50
6 days interval	79.0	93.0	0.97	1.50	8.87	2.76
LSD (0.05)	18.29	16.96	0.51	0.73	2.70	3.17
Interaction						
V x P	NS	NS	NS	NS	NS	NS
V x I	NS	NS	NS	NS	NS	NS
P x I	NS	NS	NS	NS	NS	NS
V x P x I	NS	NS	NS	NS	NS	NS

Results and Discussion

Plant height

The height of tomato plant differed significantly (P≤0.05) in Kaduna at 6 WAT only (table 4), such that, Roma VF produced taller plants than UC 82B. polymer rate has a significant (P≤0.05) effect on height of tomato in both locations at 6 WAT only, while polymer rate of 3 g kg^{-1} produced taller plants than other rates. Irrigation intervals also had a significant (P≤0.05) effect on height of tomato in both locations at 6 and 9 WAT, such that irrigation intervals of 2 and 4days produced similar taller plants compared to 6days irrigation intervals which recorded shorter plants. The differential growth with respect to plant height observed between the varieties with Roma VF being the tallest may be attributed to difference in genetic characteristics of the individual varieties including rapid growth rates, tallness or shortness of species. This finding is in line with Olaniyi *et al*. (2009) who reported variation in plant height among tomato varieties. The taller plants produced by polymer rate of 3 g kg^{-1} might be attributed to the presence of polymer in the soil which store and releases water gradually for the crop requirement over a period of time. This result is in agreement with that of Tulaee *et al.* (2009) who reported increase in height of olive tree as the concentration of polymer increases.

Stem girth

The stem girth of tomato plants was not significantly (P≤0.05) different between the varieties in both locations throughout the sampling periods (Table 2). Polymer rates differed significantly (P≤0.05) on stem girth, stem girth increases with increase in polymer rate in both locations. Irrigation interval had a significant (P≤0.05) effect on stem girth. In both locations 2days irrigation intervals produced thicker stems than 6days irrigation intervals at 6 and 9 WAT. The thicker stems produced by 2g kg^{-1} polymer rate may be attributed to the conducive environment created by the polymer in the soil which enhanced water availability to the plant. This finding is similar to that obtained by Azevedo *et al.* (2009) in coffee with the application of polymer.

Number of Branches

The number of branches of tomato was not significantly (P≤0.05) different between the varieties in both locations (Table 3). Polymer rate had a significant (P≤0.05) effect on number of branches in Minna at 6 WAT and in Kaduna at 9 WAT. Polymer rate of 3g kg^{-1} produced more branches than the other polymer rates in Minna at 6 WAT and polymer rate of 1g kg^{-1} produced more branches than the other polymer rates in Kaduna at 9WAT. Irrigation interval had a significant (P≤0.05) effect on number of branches of tomato in both locations such that, 2days irrigation intervals produced more branches than 6days irrigation intervals which recorded fewer branches. The higher number of branches produced by polymer rate of 3g kg^{-1} and 1g kg^{-1} than other polymer rates and control may be due to less excessive water in the soil than higher polymer rates and less water in the control which supported efficient plant growth and development and hence higher number of branches of tomato. This finding is at par with the report of Ghasemi and Khoshkhuy (2006) who reported higher number branches with the application of polymer to the soil.

Days to first flowering

The days to first flowering of tomato plants was not significantly (P≤0.05) different between the varieties in both locations (table 4). Polymer rate had a significant (P≤0.05) effect on days to first flowering with polymer rate 2g kg^{-1} flowered earlier than the other polymer rates. Irrigation interval had a significant (P≤0.05) effect on days to first flowering of tomato in Minna only. With 6days irrigation intervals flowering earlier than the other irrigation intervals. The earliest days to first flowering produced by 2g kg^{-1} than other polymer rates

could be attributed to adequate amount of polymer in the soil that retained moisture in the soil thereby enhancing the growth and yield of the crop. Similar result was reported by Ghasemi and Khoshkhuy, (2006).

Number of fruits

The number of fruits of tomato plant was significantly (P≤0.05) different between the varieties in Minna (table 4), where Roma VF had higher number of fruits than UC82B, no significant difference was observed in Kaduna. On the effect of polymer rates on the number of fruits highly significant differences was observed, polymer rates of 1 g kg^{-1} and 2 g kg^{-1} had higher number of fruits in Kaduna which was similar to Minna while polymer rate 4 g kg^{-1} had lower number fruits. Irrigation intervals also showed significant difference on the number of fruits at both locations where 4days interval had higher of fruits than other intervals.

Fruit yield

The fruit yield of tomato plants was not significantly (P≤0.05) different between the varieties in both locations (table 4). Polymer rate had a significant (P≤0.05) effect on fruit yield in Kaduna, polymer rate of 2 g kg^{-1} produced higher fruit yield similar with polymer rate of 1gkg^{-1} compared to other polymer rates. Irrigation intervals influenced fruit yield of tomato with 2days irrigation intervals producing higher yield of tomato similar with 4days irrigation intervals than the other irrigation intervals in both locations respectively. The higher fruit yield produced by polymer rate of 2g kg^{-1} could be attributed to the ability of SAP to increase the reserve pool of nutrients in the soil and increased the uptake efficiency in the plant. Similar results were reported by Zohreshah *et al*. (2013).

Conclusion

In conclusion, plant height, stem girth, number of branches, fruits and fruit yield were significantly higher in Roma VF with addition of SAP as compared to the control. Plants grown in soil amended with polymer rate of 3gkg^{-1} performed better than the other polymer rates except for polymer rate of 2g kg^{-1} that is not significantly different from 3g kg^{-1}. The improved growth and yield of the tomato plants could be attributed to improved physical properties of the soil as it is able to utilize the nutrients in the soil more efficiently due the presence of the polymer. Irrigation interval also had significant influence on the growth and yield parameters measured with the 2days irrigation intervals produced taller plants, thicker stems, earliest days to first flowering, higher number of fruits and higher fruit yield than the 6days irrigation intervals.

Recommendation

Based on the findings of the study, it is recommended to use 2g kg-1 polymer rate in order to obtain significantly higher number of fruits and 3g kg^{-1} for other parameters while irrigation interval should be at 2days to avoid drought stress as SAP is necessary for improving water use and crop productivity as it moderates drought stress. Roma VF variety is also recommended in terms of growth and yield. It is recommended that there should be further trials in the field as this is only a nursery experiment.

Reference

Acquaah, G. (2005). Principles of crop production. Theory, techniques and technology. Upper saddle river, N. J. New Delhi India: Prentice Hall of India private limited.

Addina, E. N (2008). A study of water constraints in the establishment of nursery and plantation. Journal of forestry, 20, 45-50.

Agbenin, J. O. (2005). Laboratory manual for soil and plant analysis. Selected method and data analysis. Institute for Agricultural research, Zaria, Nigeria. 7-71.

Anyanwu, A. C, Anyanwu, B. & Anyanwu, V. A (2005). Agricultural science for school and colleges, Ibadan. 6th edition Africana publishers ltd, 25-32.

Azevedo, T. L., Bertonha, A & Rezende, R. (2009). Levels of super absorbent polymer, irrigation intervals on coffee plant growth. Acta saentianum, 24(5), 1239-1243.

Durrant, L. (2008). Origin of tomato (*lycopersicum esculentum mill*.) plant. Acta horticulture, 32(6), 125-136.

FAO, (2013). Food and agricultural organization of the united nations. FAOSTAT. http//faostat3.fao.org/home/index/index.html

Ghasemi, M. & Khoshkhuy, M. (2006). The impact of super absorbent polymer on irrigation cycleand plant growth of corn. Horticulture science and techniques. 8(2). 65-82.

Kirnak, H., Kaya, C., Tas, L & Higgs, D. (2005). The influence of water deficit on vegetable growth, physiology, fruit yield, quality in egg plants. Bulgarian journal of plant physiology, 27(4), 34-46.

Nuruddin, M. M. (2007). Effect of water stress on tomato at different growth stages. Mc Gili University, Montreal, Canada. Journal of Agricultural Research, 22(3), 245-248.

Nyanbundi, J. O & Hsia, T. C. (2009). Effect of water stress on growth and yield of field grown tomatoes. Biomass partitioning between vegetative and productive growth. East African Agricultural journal, 55(2), 53-61.

Olaniyi, J. O., Akanbi, W. B., Adejumo, Y. A & Akande, O. G. (2009). Growth, fruit yield and nutritional quality of tomato varieties. Journal of food science, 4(6), 398-402.

Sadreghaen, H., Akbari, M., Afshar, H & Nakhjavan, M. (2010). Effect of three method micro-irrigation and irrigation level on yield of tomato. Journal of water and soil, 4(3),574-582.

Saure, M. C. (2010). Blossom end rot of tomato (*lycoperiscum esculentum Mill.*) a calcium- or stress- related disorder. Scienta horticulture. 90, 193-208.

Talaee, A. R., Asadzaheh, A., Aksri, M. A & Behbahana, S. M. R. (2009). Evaluation of super absorbent Hydrogel effect on reduction of drought stress of olive trees. Journal of science and technology. 8, 163-172.

Wong, M. H., Cheung, Y. H & Cheung, C. L. (2003). The effect of ammonia and ethylene oxide in Animal manure and sludge on the seed germination and root elongation of *brassica paranchinensis* (flowering Chinese cabbage). Environmental pollution. 30, 109-123.

Umezama, T., Fujita, M., Fujita, Y., Yamaguchi-Shinozaki, K & Shinozaki, K. (2006). Engineering drought tolerant in plants: discovering and tailoring genes to unlock the future. Current opinion in Biotechnology. 17(2), 113-122.

Zohreshah, R., Farhad, M & Azad, H. (2013). Effects of super absorbent polymer on tomato yield under water stress conditions and its role in the maintenance and release of nitrate. World rural observation. 5(2), 15-19.