



Spacing and Tomatotone Influence on Yield of Rain Fed Tomato (*Solanum lycopersicum* L.) in Sudan Savanna of Nigeria

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ABSTRACT

Some scientific reports indicated that Tomatotone (4-Chlorophenoxy acetic acid (4-CPA) is one of the plant hormones that can be used to increase fruit setting and yield of tomato. The aim of the research is to evaluate the efficacy of 4-chlorophenoxy acetic acid at different plant population density. Field trials were therefore conducted during the rainy season of 2020 at two locations. The treatments consisted of three population density (22,222, 26,666 and 33,333) and four concentrations of 4-CPA (0, 50, 75 and 100 mgL⁻¹ of distilled water). The experiment was laid out in a Complete Randomized Block Design and replicated three times. The data collected on yield and yield components were subjected to analysis of variance. The result showed that 4-CPA had a significant effect on fruit length, fruit weight, marketable fruit yield and total fruit yield. Plant population density was obtained also to have significantly influenced total fruit yield and marketable fruit yield. Based on the results of the study, it could be suggested that farmers in the areas of study can be advised to grow UC82B tomato and apply 4-CPA at a density of 22,222 plants ha⁻¹ for higher yield of the crop during rainy season.

Keywords: Tomato, Population density, 4-Chlorophenoxy acetic acid, Fruit yield.

Introduction

Tomato is perennial plant which is usually grown up as an annual crop. The crop was stated to have originated from Peru and Ecuador from where it spreads to as far north as Mexico in pre-Colombian times. It was introduced into Europe from Mexico by the Spanish in 1523. And from there carried across the Pacific into South East Asia before 1650. Later it was brought into West Africa in the 16th century by the Portuguese and it has

since been regarded in temperate and tropical ranking next to potato in importance (Srinivasan *et al.*, 2010). At first it was only produced as an ornamental for its decorative fruits and was referred to as object of affection and therefore, called the 'love apple'. In earlier times, the plants were consumed only in Italy and it was only from the second half of the 19th century tomatoes have been widely appreciated for the fine food that it provides Srinivasan *et al.* (2010).

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In Nigeria, the leading production area of tomatoes is the Northern part of the country, (latitude 8° – 13° N) under irrigation during dry season between the months of September- March, when the temperatures are mild and humidity moderate. The rain season production (June – September) is also important owing to the fact that fresh tomato demand is all year round, but generally limited by high pests and disease that are rampant under such humid and warm conditions (Grubben and Denton, 2004).

Although tomato plants can be grown under a wide range of climatic conditions, they are exceedingly sensitive to hot and wet conditions, the type of weather that triumphs in the summer and rainy seasons of hot countries (Baliyan *et al.*, 2013).

Tomato requires a relatively cool and dry climate for high yield and premium quality. Tomato production is mainly under field conditions, where changes in climatic situations especially high temperature, high humidity, rainfall, pests and diseases do not allow the realization of the full economic yield of the crop (Grubben and Denton, 2004). However, it is adjusted to a wide range of climatic settings from temperate to hot and humid tropical environments, with optimum temperature for growth in the range of 20 – 27° C (Grubben and Denton, 2004). Moreover, marked prohibition of photosynthesis happens at temperatures above average, causing a remarkable decrease in yield.

Therefore, improved management practices with the potential for reducing the effect of high temperature and humidity for high yield of tomatoes especially during the wet and dry seasons should be investigated in order to meet up with the all-year-round demand of the crop. Several studies indicated increased fruit size and fruit setting in tomato due to manipulation of plant population density and application of plant growth regulators such as 4-chlorophenoxy acetic acid (Tomatotone) and 2, 4-dichlorophenoxy acetic acid (2, 4-D) Ozgtiven (2000). It is with all that in mind that the

research was conceived with the aim of determining the effect of 4-Chlorophenoxy acetic acid (4-CPA) and population density on yield of tomato under rain-fed condition.

Materials and Methods

Location of the Study

The research was conducted during the 2019 rainy seasons at two locations, Research and Teaching Farm of Faculty of Agriculture, Bayero University Kano (BUK) which lies on latitude 11° 97' 98.6'' N and longitude 8° 42' 03.7'' E and 475 m above the sea level and demonstration Farm of Audu Bako, College of Agriculture, Dambatta (DBT) which lies on latitude 11° 83' 40.3'' N and longitude 08° 10' 33.9'' E and 418 m above the sea level all within the Sudan Savanna Zone of Northern Nigeria.

Treatment and Experimental Design

The treatments comprise of three population densities (22,222, 26,666, 33,333) and four concentrations of 4-Chlorophenoxy acetic acid, (0, 50, 75 and 100 mgL⁻¹ of distilled water) The experiment was replicated three times and laid out in a Complete Randomized Block Design with population density assigned to the main plots, while 4-CPA was assigned to the subplots. Seedlings of UC82B variety were raised using seed beds until they were ready for transplanting at 6 weeks old.

The area for the experiment was prepared by clearing, harrowing and ridging using a tractor mould board ridger. The area was then demarcated in to 9 main plots of 24 ridges that were 5 m long (24 x 0.75 x 5 m = 90m²) and later to 36 sub plots. The gross sub plot size was 4.5 x 5m (22.5m²) made up of six ridges and the net plot was 1.5 x 5m (7.5m²) made up of two inner ridges. One meter (1m) alley was left between replications and between main plots, while 0.75m was left between subplots. The seedlings raised in the nursery were transplanted at the age of 6 weeks after sowing on

the spacing of 40 x 75 cm (33,333 plants/ha), 50 x 75 cm (26, 666 plants/ha) and 60 x 75 cm (22, 222 plants/ha), after establishment all agronomic management practices were carried out according to recommendation. The 4-CPA was applied after it was prepared by mixing 0, 50, 75 and 100 mg of 4-CPA powder L⁻¹ of distilled water and two drops of baby shampoo were added to enhance stickiness of the 4-CPA on the flowers as recommended by (Baliyan *et al.*, 2013). The mixtures were later applied to the flowers after few flowers had opened, about 1 ml per flower cluster was applied using hand held sprayer in the morning as from 8 am as recommended by Asian Vegetable Research and Development Center (AVRDC), (2001). Harvesting was done by hand picking at the time the fruits attained physiological maturity specifically when they were observed to changed colour from green to pink or reddish spanning four pickings.

Data Analysis

Data were collected from five tagged plants in the inner row after the boarder rows in the experiment. The data were on: number of flowers clusters plant⁻¹, average fruit length (mm) plant⁻¹, average fruit weight (g) plant⁻¹, marketable fruit yield (t ha⁻¹), non-marketable fruit yield (t ha⁻¹) and total fruit yield (t ha⁻¹). The data collected were subjected to analysis of variance using Genstat (17th Edition) and the means were separated using Fisher's Protected Least Significant Difference Test.

Results

Table 1 shows the population density and 4 – CPA effects on number of flower clusters plant⁻¹, fruit length, (mm) and fruit weight of tomato during 2019 rainy season at BUK and Dambatta. At both locations population density effect on the number of flower clusters plant⁻¹ was significant where the result recorded indicated that population densities of 22,222 and 26,666 plants ha⁻¹ were at par and produced statistically higher number of flower clusters plant⁻¹ than population density of 33,333.

However, the result showed no significant difference among the 4-CPA concentrations on number of flower clusters plant⁻¹ at the two sites of the trial.

On Fruit length the result obtained depicts that difference in plant population densities was recorded to be significant on fruit length at both locations, result obtained showed that 22,222 plant⁻¹ had statistically longer fruits than 26,666 and 33,333 plants ha⁻¹ which were obtained to be statistically similar. The result also revealed that application of 4-CPA significantly affected fruit length of tomato at BUK, 75 and 100mgL⁻¹ were at par with one another in fruit length but 100mgL⁻¹ was statistically higher than 0, and 50 mgL⁻¹ 4-CPA concentrations statistically at par, while at Dambatta the result showed there was no statistical difference among the 4-CPA concentrations on fruit length of the tomato.

Fruit weight of tomato as affected by population density and 4-CPA concentrations during 2019 rainy season at BUK and Dambatta is also presented in Table 1. The result showed that Population density significantly affected the fruit weight in both locations where the result obtained indicated that 22,222 plants ha⁻¹ was statistically higher in fruit weight than 26,666 and 33, 333 plants ha⁻¹ which were at par with one another at BUK, while at Dambatta 26,666 and 22,222 plants ha⁻¹ were at par but 22,222 plants ha⁻¹ was statistically higher in fruit weight than 33,333. However, at BUK the result revealed significant effect of 4-CPA concentrations on the fruit weight, where the result recorded showed that 4-CPA concentrations of 50, 75 and 100 mgL⁻¹ were statistically at par with another but recorded statistically heavier fruits than the control, but at Dambatta the result shows there was no significant effect of 4-CPA concentrations on fruit weight of the tomato.

Table 1 : Number of Flower Clusters Plant⁻¹, Fruit Length (mm) and Fruit weight (g) of Tomato as affected by 4-CPA and Population density

	Flower Clusters		Fruit Length		Fruit Weight	
	BUK	DBT	BUK	DBT	BUK	DBT
Population						
22,222	10.62 ^a	10.56 ^a	69.74 ^a	68.29 ^a	60.00 ^a	57.76 ^a
26,666	10.51 ^a	9.92 ^a	68.01 ^a	67.41 ^a	50.32 ^a	46.77 ^a
33,333	9.03 ^b	8.33 ^b	67.12 ^a	67.45 ^a	49.51 ^a	48.79 ^{ab}
P-Level	0.036	0.040	0.006	0.009	0.050	0.015
SE+	0.878	0.639	0.138	0.149	0.562	0.380
4-CPA Conc'(C)						
0	10.45	10.10	68.28 ^a	68.87	47.53 ^b	47.78
50	10.11	9.97	66.63 ^b	69.02	50.948 ^a	48.71
75	11.00	10.66	70.70 ^{ab}	68.99	51.34 ^a	48.06
100	11.00	10.85	72.33 ^a	69.00	51.05 ^a	49.25
P - Level	0.056	0.057	0.003	0.084	<0.001	0.070
SE±	0.987	0.897	0.310	0.104	0.669	0.702
Interaction						
V x C	0.022	0.050	<0.001	0.111	0.021	<0.001

Means followed by the same letter(s) are not significantly different at 5% level of using Fisher's protected least significant difference test.

Table 2: Fruit Yield (t ha⁻¹) of Tomato as affected by 4-CPA and Population density.

	Marketable yield		Non Marketable Yield		Total yield	
	BUK	DBT	BUK	DBT	BUK	DBT
Population						
22,222	13.50 ^a	11.90 ^a	0.21	0.12	17.49 ^a	13.66 ^a
26,666	10.07 ^b	9.77 ^b	0.31	0.07	14.96 ^b	11.08 ^b
33,333	09.97 ^b	9.03 ^b	0.24	0.09	12.85 ^b	09.77 ^b
P-Level	<0.001	<0.001	0.076	0.082	0.003	0.005
SE+	0.362	0.357	0.845	0.762	1.092	0.367
4-CPA Conc'(C)						
0	10.81 ^a	9.31 ^a	0.21 ^a	0.11	11.02 ^a	09.42 ^a
50	13.46 ^b	11.78 ^b	0.22 ^a	0.09	13.68 ^b	11.96 ^b
75	14.36 ^b	13.18 ^{ab}	0.18 ^a	0.08	14.54 ^b	13.26 ^b
100	17.45 ^c	15.45 ^c	0.33 ^a	0.13	17.78 ^c	15.58 ^b
P - Level	0.00	0.005	0.048	0.059	0.008	0.005
SE±	1.204	0.067	0.004	0.007	0.910	0.672
Interaction						
V x C	0.829	0.402	0.726	0.367	0.816	0.400

Means followed by the same letter(s) are not significantly different at 5% level of using Fisher's protected least significant difference test.

Table 2 revealed the Marketable fruit yield, non-marketable fruit yield and total fruits yield of tomato as affected by population density and 4-CPA concentrations during the 2019 rainy season at the two locations of the trial. Marketable fruit yield was significantly affected by population density at both locations of the trials, the result indicated that at BUK, 22,222 plants ha⁻¹ was statistically higher in marketable fruit yield than 26,666 and 33,333 plants ha⁻¹ which were at par with one another, while at Dambatta, 22,222 plants ha⁻¹ was statistically higher than 26,666 plants ha⁻¹ which in turn was statistically higher than 33,333 plants ha⁻¹. Furthermore, Marketable fruit yield t ha⁻¹ was significantly affected by application of 4-CPA, the result as shown in Table 2, indicated that at both locations, 100 and 75 mgL⁻¹ 4-CPA concentrations were at par with one another but statistically higher in marketable fruit yield than 50 mgL⁻¹ 4-CPA which was in turn higher than 0 mgL⁻¹ which was the control.

Non-Marketable fruit yield t ha⁻¹ was not significantly affected by population density at both BUK and Dambatta as revealed in Table 2 also, but was significantly affected by 4-CPA concentrations; at BUK, 4-CPA concentration of 75 mgL⁻¹ was significantly higher in non-marketable fruit yield than 4-CPA concentrations of 100, 50 and 0 mgL⁻¹ which were at par with one another, while at Dambatta there was no significant difference among the 4-CPA concentrations.

Total fruit yield (t ha⁻¹) of tomato as affected by population density and 4-CPA concentration during the 2019 rainy season at the two sites of the trial is presented on Table 2 also. The result showed that total fruit yield in tons ha⁻¹ was significantly affected by population density. The result recorded indicated that at the two sites of the trial; 22,222 plants ha⁻¹ was obtained to be statistically higher in total fruit yield than 26,666 and 33,333 plants ha⁻¹ which were statistically at par with one another. Total fruit yield in tons ha⁻¹ was also significantly affected by 4-CPA

application; the result indicated that 4-CPA at 100 mgL⁻¹ concentration was statistically higher than 4-CPA concentrations of 75 and 50 mgL⁻¹ which were statistically at par with one another but statistically higher than 0 mgL⁻¹ concentration.

Discussion

Effect of Population Density on Growth and Yield of Rain Fed Tomato

Plant population density is known to be an important factor in crop production as reported by Muhammed *et al.* (2007) who described it as the number of plants per unit area and which plays an important role in increasing or decreasing the yield of crop per unit land area. The Fresh yield per plant was found to be higher on the low population density of plant ha⁻¹ during the trials and this could be attributed to the availability of more space for nutrients and sunshine exploitation by the tomato which was in line with the findings of Papadopoulos and Pararajasingham (1997) who in their studies reported that high plant densities have been shown to have detrimental effect on assimilate partitioning, because of an inadequate supply of photosynthesized substances as a result of increase in shading.

Also Baloch *et al.* (2002) observed that lowering plant densities increased the nutrient area per plant and this led to an increase in agronomic characters such as fresh weights and yield. Muhammed *et al.* (2007), observed that plant population density plays an important role in increasing or decreasing the yield of crop per unit land area, the result of the study indicates that plant population density of 22,222 plants ha⁻¹ had significantly higher marketable and total fruit yield in the two successive years of the trials at both locations. The result obtained is in harmony with what was reported by Anonymous and Baloch *et al.* (2002) that low plant density recorded more fruit number and highest fruit diameter and weight than high plant population density.

Effect of 4-CPA on Yield of Rain Fed Tomato

The result of the study showed that application of 4-CPA significantly increases the total fruit yield of tomato at both locations, higher fruit yield was obtained with application of 100 mgL⁻¹ 4-CPA. This could be attributed to the ability of the 4-CPA to enhance flower retention by the plant resulting to more fertilized flowers without much abscission and high fruit retention. This result was supported by the findings of Asian, Vegetable Research and Development Center (AVRDC, 2012), Nandwani *et al.* (2014), Ozguven (2000), Baliyan *et al.* (2013) and Lathiya & Sanjeev (2017) who reported that application of plant growth regulators has been shown to improve fruit setting in tomato, they further reported that sprays of hormone especially 4-chlorophenoxy acetic acid on flower cluster effectively increase the fruit set as well as fruit production. Also Karim *et al.* (2015) had shown that application of 4-CPA induced higher number of fruit set to some extent. It was further reported that application of plant growth regulators increased fruit set of summer tomato (Rahman *et al.*, 2015). 4-CPA is also used in reducing pre-harvest fruit drop and resulting in increased number of fruits and yield in tomato crop. Alam and Khan (2002) reported that other plant growth regulators were also reported to increase fruit production and retention in tomato for example it was reported that application of Naphthalene Acetic Acid (NAA) at the time of flowering prevents pre-harvest flower abscission by increasing auxin concentration at this critical phase of reproductive development hence increasing yield. Meliha, Bengu and Kit (2006) reported that a number of studies have already established that external application of synthetic growth regulators and mineral nutrients are effective in increasing both yield and quality of crops including horticultural crops. They further revealed that the growth regulating substances used increased the number and size of fruits of tomato and their fresh and dry weights with 4-CPA being most effective.

Conclusion

From the result of this study, it can be concluded that; Tomato responded positively to 4-CPA application and population density where the highest yield was recorded with plant population density of 22,222 plants ha⁻¹ due to application of 100 mgL⁻¹ 4-CPA concentration. Therefore, based on the findings of this study, it can be suggested that further studies is needed to evaluate composition difference of the yield if any and also to ascertain the health safety of the hormone. If found to be safe without significant difference in composition, farmers in the areas of study should be recommended to grow tomato and apply 4-CPA at 100 mgL⁻¹ of distilled water in order to increase fruit yield of the crop during rainy season.

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