YIELD PERFORMANCE OF ROSELLE (*Hibiscus sabdariffa*) AS AFFECTED BY PLANT DENSITY AND INORGANIC FERTILIZER IN OWERRI, NIGERIA.

[1]Nnebue, O.M., [1]Ogoke, I.J., [1]Ihejirika, G.O., [1]Adikuru, N.C. and [2]Okoli, N.H.
[1] Department of Crop Science and Technology, Federal University of Technology, Owerri
[2] Department of Soil Science and Technology, Federal University of Technology, Owerri
Corresponding email: gen2_o@yahoo.com

Abstract
Yield performance in plants is critical in food security and to determine the appropriate population density for the optimum production of roselle, plant population density (4plants/m^2, 2.7plants/m^2 and 1.8plants/m^2) and NPK 20:10:10 fertilizer (0 kg/ha, 250 kg/ha and 500 kg/ha) were evaluated and the treatment arrangement was a 3 x 3 factorial fitted in Randomized Complete Block Design (RCBD). Data were taken on different agronomic and yield parameters. Results show no significant ($p \leq 0.05$) differences in plant height, number of leaves and leaf area/plant. However, number of flower buds and pod weight per plant displayed differences with respect to the treatments. Population density of 4plants/m^2 produced the highest number of flower buds of 9.22 and pod weight of 6.67g/plant while 1.8plants/m^2 produced the lowest number of flower buds of 5.19 and pod weight of 3.22g/plant. The 250 kg/ha NPK 20:10:10 gave the highest number of flower buds of 9.94 and fruit weight of 7.44 g/plant while the least was recorded for the control. Considering the relationship between the agronomic and yield parameters measured in this study, a population density of 4 plants/m^2 and 250 kg/ha NPK 20:10:10 are recommended for further studies. Also further studies on population densities is recommended to ascertain the relationship between number of pods/plant and actual weight of seeds.
Keywords: Yield, Roselle, Plant Density, Nitrogen fertilizer

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is an important vegetable of the Malvaceae family together with Okra. Roselle is native to the region that stretched from India to Malaysia and almost all parts of the crop including the fleshy fruits, leaves, stems, flowers (Calyces), seeds and fibre are important sources of food, raw materials and foreign exchange (Schipers, 2000; Galaudu, 2006). Its antihypertensive properties and use in folk medicine as a diuretic, laxative and in food colourings have continued to attract the attention of food and beverage manufacturers, and pharmaceutical industries.

Understanding crop growth factors such as plant density and nutrient availability will help boost productivity over time. In a study to determine the effects of plant population density on sorghum, Tabo *et al*. (2002) concluded that higher grain yield were observed with increasing plant densities. Studies on the effect of three densities of 10, 6.7 and 5 plants/m^2 on chamomile, Hejseyyedhadi (1999) reported that the highest dry flower yield are produced under the highest density.

Nitrogen is undoubtedly the most limiting nutrient in southeastern soils especially in Imo, Abia and Akwa-Ibom states where the organic matter content, cation exchange capacity (CEC) and base saturation are all low (Ohiri, 1992; Enwezor *et al*., 1989). Its deficiency is evident in pale green or yellowish-green colourations on leaves followed by premature necrosis of old leaves. This limits crop production in the tropics (Thiraporn and Stamp, 1992). In the humid tropical environment of southeastern Nigeria, where roselle is priced for its calyx from which the popular beverage called "Zobo" is prepared, there has practically been no work done on the agronomy of roselle in southeastern Nigeria (Nnebue *et al*., 2015) and owing to the need to determine the desirable plant density and nitrogen requirement for the cultivation of this newly-introduced plant in the agro-ecological zone, this study was, therefore carried out to ascertain the effect of different levels of nitrogen and plant population density on the yield performance of roselle.

MATERIALS AND METHODS

This study was carried out at the Teaching and Research Farm of the Federal University of Technology, Owerri, Imo state. Owerri lies on Latitude 5° 30' 01" N and Longitude 7° 01' 44" E in the tropical rainforest region of Nigeria. The temperature ranges between a minimum of 20°C and a maximum of 32°C with relative humidity of about 83%. The area has a mean annual rainfall of about 2500 mm.

The experiment was laid as a 3 x 3 factorial in RCBD and replicated 3 times. Three (3) levels of plant population density; 50cm x 50cm, (4 plts/m^2), 75cm x 50cm (2.7 plts/m^2) and 75cm x 75cm (1.8plts/m^2) and three levels of NPK 20:10:10 fertilizer; 0, 250 and 500 kg/ha) were evaluated. The roselle seeds were planted out on flat.

Data were collected on agronomic and reproductive parameters such as plant height, number of leaves, leaf area, number of branches, number of days to flower bud appearance, number of flower buds/plant, leaf spot and mosaic disease incidence, pod weight, number of seeds/pod and 100 seed weight. All data were subjected to Analysis of Variance (ANOVA) and significant means were separated using LSD at 5% using the Genstat (Ed. 4).

RESULTS AND DISCUSSION

Results of Analysis of Variance indicate that neither fertilizer rates, population density nor their interaction had significant ($p \leq 0.05$) effect on the plant height, number of leaves and leaf area at 4 and 8 weeks after planting. Rhoden *et al*. (1993) had earlier reported that increased nitrogen application did not cause an increase in plant height of roselle. Noticeably, except in plant height, there was a progressive decrease in the number of leaves as the population density increases and a progressive increase across these agronomic parameters as the fertilizer rates increase (Table 1).

At later stages of growth, there were marked differences in the incidence of leaf spot and mosaic symptoms on roselle. Increasing population densities cause a proportionate decrease in leaf spot incidence with 1.8 plants/m^2 mostly affected (64.9% and 61.1% at 8 and 10 WAP) and 4 plants/m^2 least affected (52.4% and 50.3% at 8 and 10 WAP) (Table 2). Similar trend played out for mosaic incidence but with relatively lower incidence. Lower population densities create better conditions for plant vegetative growth which increases the relative humidity within the micro climate hence posing a threat of spread of disease pathogens (Table 3).

Table 1. Effect of fertilizer rates and population density on some agronomic parameters of roselle

Population Density (plants/m^2)	Plant height (cm) Fertilizer rate (kg/ha)								No of leaves Fertilizer rate (kg/ha)								Leaf area (cm^2) Fertilizer rate (kg/ha)							
	4 WAP				8 WAP				4 WAP				8 WAP				4 WAP				8 WAP			
	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean
4.0	7.74	7.53	7.34	7.54	23.04	22.83	21.75	22.54	6.17	6.08	6.25	6.17	12.08	16.75	12.83	13.89	39.4	41.2	41.8	40.8	94.9	122.6	104.2	107.2
2.7	7.83	8.05	7.11	7.66	22.04	21.92	20.79	21.59	6.42	6.42	6.33	6.39	13.83	16.25	12.25	14.11	43.1	43.0	36.5	40.8	100.5	101.5	114.6	105.6
1.8	6.79	6.74	7.31	6.95	18.75	19.25	23.79	20.60	6.08	5.67	6.33	6.03	12.17	13.42	19.33	14.97	38.1	35.8	43.7	39.2	97.1	109.8	127.7	111.5
Mean	7.45	7.44	7.26		21.28	21.34	22.11		6.22	6.06	6.31		12.69	15.47	14.81		40.2	40.0	40.6		97.5	111.3	115.5	
$LSD_{0.05}$ (Fertilizer rate)	NS				NS				NS				NS				NS				NS			
$LSD_{0.05}$ (Population density)	NS				NS				NS				NS				NS				NS			
$LSD_{0.05}$ (Fertilizer rate x Population density)	NS				NS				NS				NS				NS				NS			

WAP = Weeks After Planting

Table 2. Effect of fertilizer rates and population density on leaf spot disease incidence on roselle

	Weeks after planting															
	……4……				……6……				……8……				……..10……			
Population density (m^2)	Fertilizer rate (kg/ha)			Mean	Fertilizer rate (kg/ha)			Mean	Fertilizer rate (kg/ha)			Mean	Fertilizer rate (kg/ha)			Mean
	0	250	500		0	250	500		0	250	500		0	250	500	
4.0	59.6	26.8	34.6	40.3	36.6	32.3	63.4	44.1	57.8	41.3	58.1	52.4	55.5	42.5	53.1	50.3
2.7	45.4	57.1	40.5	47.7	38.8	55.6	54.3	49.6	53.3	67.8	60.4	60.5	62.5	70.2	58.7	63.8
1.8	47.6	32.9	37.7	39.4	51.9	43.5	56.7	50.7	65.2	63.5	66.1	64.9	63.4	63.2	56.7	61.1
Mean	50.8	38.9	37.6		42.4	43.8	58.2		58.8	57.5	61.5		60.5	58.6	56.1	
$LSD_{0.05}$ (Fertilizer rate)			NS				NS				NS				NS	
$LSD_{0.05}$ (Population density)			NS				NS				6.60				9.03	
$LSD_{0.05}$ (Fertilizer rate x Population density)			NS				NS				11.43				NS	

Table 3. Effect of fertilizer rates and population density on Mosaic disease incidence on roselle

	Weeks after planting															
	……5……				……7……				……9……..				……..11……			
Population density (m^2)	Fertilizer rate (kg/ha)			Mean	Fertilizer rate (kg/ha)			Mean	Fertilizer rate (kg/ha)			Mean	Fertilizer rate (kg/ha)			Mean
	0	250	500		0	250	500		0	250	500		0	250	500	
4.0	24.5	19.5	14.9	19.6	48.1	31.8	48.9	43.0	28.4	39.6	34.2	34.0	31.6	34.9	41.9	36.1
2.7	14.8	33.3	22.8	23.6	33.8	45.9	48.7	42.8	38.4	43.4	47.9	43.3	61.6	49.4	41.5	50.8
1.8	15.1	20.7	17.8	17.8	36.4	38.8	44.3	39.8	51.6	61.9	44.5	52.7	53.2	43.0	57.0	51.0
Mean	18.1	24.5	18.5		39.5	38.8	47.3		39.5	48.3	42.2		48.8	42.4	46.8	
$LSD_{0.05}$ (Fertilizer rate)			NS				NS				NS				NS	
$LSD_{0.05}$ (Population density)			NS				NS				14.02				10.17	
$LSD_{0.05}$ (Fertilizer rate x Population density)			NS				NS				NS				NS	

The effect of fertilizer rates and population density and their interaction was significant on some of the reproductive parameters measured. Highest number of flower buds/plant of 9.22 was observed for plots with 4 plants/m^2 and this differed significantly (43%) from plots with 1.8 plants/m^2 which produced 5.19 flower buds (Table 4). This may be linked to high disease incidence recorded with decreasing plant population in this study. Again, higher number of plants per unit area allows the utilization of environmental parameters with greater efficiency; therefore, a higher number of pod/plant is expected and fruit number/plant is expected to follow the same pattern. This is in agreement with the works of Mirzayi (2005) and Martin and Deo (2000) who found similar results for marigold.

However, for fertilizer rate, a drop in the number of flower buds and number of pods/plant was with increased rate of NPK fertilizer application beyond 250 kg/ha. Plots that received 250 kg/ha of NPK produced flower buds (9.94) and pods/plant (7.11) which are significantly higher (38.22% and 42.19% respectively) than those in the control plots (6.14 and 4.11 respectively). Cooke *et al*. (2006) reported that yield losses in crops were higher for plots to which low rates of fertilizer were applied compared to those with larger applications. The same trend was observed for pod weight/plant. Variations in percentage flower bud abortion/plant was however not significant but plots with 1.8 plants/m^2 had more of its flower buds aborted (Table 4).

The interaction between NPK fertilizer and population density was significantly effective on the variations in pod weight/plant with 250kg/ha NPK and 4 plants/m^2 giving the highest pod weight of 10.00 g/plant while 250 kg/ha and 1.8 plants/m^2 gave the lowest pod weight of 3.00 g/plant.

Table 4. Effect of fertilizer rates and population density on some reproductive parameters of roselle

Population Density	Fertilizer rate (kg/ha)																							
	No of days to flw bud app				No of flower buds/plant				No of pods/plant				% flower bud abortion				Pod Weight (g/plant)				No of seeds/pod			
(plants/m^2)	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean	0	250	500	Mean
4.0	82.67	79.00	81.67	81.11	8.67	10.33	8.67	9.22	5.67	9.33	6.00	7.00	34.70	21.00	30.40	28.70	6.00	10.00	4.00	6.67	9.72	11.83	7.02	9.52
2.7	82.67	82.00	81.33	82.00	5.83	13.17	4.50	7.83	3.00	9.33	5.67	6.00	42.50	39.70	4.30	28.90	3.33	9.33	6.67	6.44	9.44	13.19	11.47	11.37
1.8	82.33	82.33	81.33	82.00	3.92	6.33	5.33	5.19	3.67	2.67	3.33	3.22	13.30	44.80	54.80	37.60	3.33	3.00	3.33	3.22	11.50	6.67	8.33	8.83
Mean	82.56	81.11	81.44		6.14	9.94	6.17		4.11	7.11	5.00		30.20	35.20	29.90		4.22	7.44	4.67		10.22	10.56	8.94	
$LSD_{0.05}$ (Fertilizer rate)	NS				3.095				2.754				NS				1.855				NS			
$LSD_{0.05}$ (Population density)	NS				3.095				NS				NS				1.855				NS			
$LSD_{0.05}$ (Fertilizer rate x Population density)	NS				NS				NS				NS				3.212				NS			

Considering the relationship between agronomic parameters, disease incidence and reproductive parameters as observed in this study, a population density of 4 plants/m^2 is recommended for further studies. Also, further studies on population densities is recommended to ascertain the relationship between number of pods/plant and actual weight of seeds.

References

Cooke, B.M., Gareth Jones, D. and Kaye, B. (2006). The Epidemiology of Plant Diseases (2nd ed.). Springer Publishers, The Netherlands. www.springer.com.

Enwezor, W.O., E.J. Udo and R.A. Sobulo, 1989. Fertility states and productivity of acid sands. In: acids sands of southeastern Nigeria, Monograph No. 1 Soil Sciences Society of Nigeria, pp: 56-73.

Galaudu, M.S. (2006) "Effect of moisture on the germination rate of roselle (*Hibiscus sabdariffa* L.) plant". Proceedings of the 23rd Annual Conference of the Horticultural Society of Nigeria, Port Harcourt. Pp 30-32.

Hejseyyedhadi, M. (1999). Study of effect of sowing date and plant density on growth, yield and active substance quantity of chamomile. M.Sc. Thesis on Agriculture, University of Tehran, Department of Agriculture, 11: 375-382.

Martin R.J., Deo B (2000). Effect of plant population on (*Calendula officnalis*) flower production. New Zealand *J. Crop Hortic. Sci*., 28(1): 37-44.

Mirzayi A.M. (2005). Effect of different plant densities and sowing dates on marigold. M.Sc. Thesis on Agriculture, Department of Agriculture, University of Tabriz, Tabriz, Iran, p. 108.

Nnebue, O.M., Ogoke, I.J., Obilo, O.P., Agu, C.M., Ihejirika, G.O. and Ojiako, F.O. (2014). Estimation of planting dates for roselle (*Hibiscus sabdariffa* L.) in the humid tropical environment of Owerri, southeastern Nigeria. *Agrosearch journal*. Vol. 4 (2): 168-178.

Ohiri, A.C. (1992). Soil and fertilizer use on maize in South eastern states of Nigeria. pp. 22-24. An update proceedings of 3rd National fertilizer workshop. Ibadan.

Rhoden, E.G., David, P. and Small, T. (1993). Effect of nitrogen nutrition on roselle. p. 583-584. In: J. Janick and J.E. Simon (eds.), New crops. Wiley, New York.

Schippers, A.A. (2000) "African Indigeneous vegetable". Natural Resources Institute, 95pp. UK. Chatham Publisher.

Tabo, R., Olabanji, O.G., Ajayi, O. and Flower (2002). Effect of plant population density on the growth and yield of sorghum varieties grown on a *vertisol. African Crop Science Journal*, 10(1): 31-38

Thiraporn, R.B. Feil and P. Stamp, 1992. Effect of nitrogen fertilization on grain yield and accumulation of nitrogen and potassium in the grains of Tropical Maize. *J. Agron. Crop Sci.*, 169: 9-16.