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Research paper

Effects of n: p: k 20: 10:10 fertilizer on growth and yield of yam (dioscorea rotundata poir) minisett in an ultisol

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Abstract

Two field experiments were carried out to investigate effects of N.P.K (20:10:10) fertilizer on the growth and yield of yam minisetts in 2016 and 2017 cropping seasons at the Teaching and Research farm, Department of Agronomy, Cross River University of Technology. Obubra, Cross River State Nigeria. The experimental design was a randomized complete block design they were eight treatments namely 0, 5 0, 100, 150, 200, 250, 300 and 350 kg/ha NPK 20:10:10: fertilizer replicated four times. The results should that the application of NPK 20-10-10 fertilizer significantly ($p<0.05$) increased growth and yield of yam minisetts. The used of 350 kg/ha NPK 20:10:10: gave the highest number of leaves, branches per plant an10: fertilizer in commercial yam minisetts cultivation for optimum growth and tuber seedlings yield and reduce cost of planting materials in Obubra central, Cross River, Nigeria condition. Therefore, based on this research findings, 250-300kg/ha of NPK 20:10:10 fertilizer should be applied in the cultivation of yam minisetts for optimum growth and yield of seed yam tubers (planting materials) and is recommended to farmers to adopt for large scale production of seed yam tubers to be used as planting material.

Keywords: *NPK; Yam; Minisett; Ultisol; Growth.*

1. Introduction

Yam (Dioscorea spp) is of the family Dioscoreaceae. The most economic important species of yam are white guinea yam (Dioscorea rotundata), yellow yam (Dioscorea cayenensis), water yam (Dioscorea alata), aerial yam (Dioscorea bulfera), Chinese yam (Dioscorea esculenta) and three leaf yam or Trifoliate yam (Dioscorea dometorum) [1].The white guinea yam (Dioscorea rotundata poir) is the most valuable and commonly cultivated and is indigenous to West Africa [1]; [2]. Yam is valuable for its tuber that is a source of calorie and is cheaper than grains. In West Africa, especially Nigeria yams are cultivated on large scale for their tubers that provide staple carbohydrate sources (Food and Agricultural Organization (FAO) [3]. Studies have shown that most of the yam produced in various parts of West Africa are consumed within the area of production, only very little enters international trade [2]; [4]; [5]. Among all the factors militating against commercial profitable yam production such as low soil fertility, lack of adequate inputs, staking labour, scarcity of planting materials among other, high cost of seedlings or seed yams is the most important.

Okoil, et al., [6] reported that the greatest constrain to large scale cultivation of yam is the high cost of seed yam during the planting time and yam mode of propagation. Yam like all other vegetative propagated root and tuber crops is cultivated solely by planting the same tuber that is use for food.

Ogbedeh et al., [7] observed that large scale cultivation of yam by seed is very difficult because some yam cultivars do not flower at all, or produces only male flowers. Further more, when yam seeds are found, they have prolong dormancy periods, poor germination and poor or slow grown and field establishment.

The international Institute of Tropical Agriculture (IITA) [8] introduced the “minisetts” technique of seed yam production as a step to rapid multiplication of yam setts for planting [9]; [10].

Yam “minisetts” technique involves the use of 25g of setts to produce whole tubers which serve as “seed” yam (Okoli and Akoroda [11] was developed to address the problem of high cost of seed yam. Kalu [12] assessed the seed yam production potential of three yam species (Dioscorea rotundata, Dioscorea alata, Dioscorea caynensis) and reported that the yam minisetts technique is a better and cheaper technique of multiplication of seed yam with bigger size, weight and quality for planting.

Ekoteren et al [13] observed that the quantity and quality of wear yam tuber at harvest is the function of the size of the seed yam planted among other factors. Literature showed that proper use of fertilizer has been found to increase soil fertility and also increase crop yield. The use of fertilizer is a major condition for high growth and yield of crops in South Eastern Nigeria due to low fertility status and leaching of the soil [14]. Earlier researchers (Onwueme and Charles [15]; Ikeh [16]; and Ikeh [17] reported that apart from location, environmental conditions, fertilizer application and management, significantly affect yam tuber yield.

There is paucity of literature information on the nutrition need for commercial production of yam minisetts in Cross River State. Hence, this study aimed to investigate the efficiency of NKP 20:10:10 fertilizer on the growth and large scale production of yam minisetts in Obubra, Cross River, South –South Nigeria.

2. Materials and methods

Field studies were conducted at the Teaching and Research farm, Department of Agronomy, Obubra campus, Cross River University of Technology in 2009 and 2010 cropping seasons. Obubra is located at latitude 05^0 59” and longitude 08^0 16” E [18].
The experimental design was a Randomized Complete Block Design (RCBD). Treatments were eight rates of NPK fertilizer 20:10:10 at 0, 50, 100, 150, 200, 250, 300 and 350 kg/ha laid out in Randomized Complete Block Design with four replications. The experimental site was manually, cleared, ploughed, harrowed, ridged and divided into four blocks on April 15^{th}, 2016 and 2017. Each block was sub-divided into eight plots. Each measuring 5×4m ($20m^2$) which was separated from adjourning plot by a space of one meter. Earth bounds (75 cm and 25 cm) was used to demarcate the plots to avoid lateral nutrient drifts.

2.1. Planting

Healthy tubers of white guinea yam (Dioscorea rotundata) were collected from Obubra market washed and cut into 25 grams minisetts Weight. Cutting of yam tuber was done carefully to ensure that each pieces contain outer bark with 2-4 nodes. They cut pieces were treated with fungicide dust (Apron plus) and air dried in shade for 24-36 hours before planting. Planting was done at the rate of one minisett piece per hill on the crest of the ridge at spacing of 0.50m × 0.52m inter and intra row spacing respectively on 10^{th} May, 2016 and 2017 respectively.
NPK 20:10:10 fertilizer was applied at four weeks after planting (WAP) at the rate stated above according to eight treatments of the study.

2.2. Cultural practices

Weeding was done regularly to keep the field as weed free as possible.

2.2.1. Staking

Staking of the seedlings was done at four weeks after planting when the yam seedlings shoots were up to 50cm to 100cm long. A single erect staking material (bamboo sticks) of 5m long was provided for each yam minisett plant.

2.3. Data collection

Data were collected on both agronomic, vegetative growth and yield parameters such as mean number of leaves, branches per plant, plant height, number of tubers per plant, tuber weight and yield per hectare
Ten plants were randomly selected from the inner rows of each plot and tagged for easy identification .

2.3.1. Establishment percentage

This was determine at one month after planting by counting the number of spouted yam stands.

2.3.2. Vine length

Was determined by measuring the length of the main vine from the ground level to apex of growing point using a meter rule

2.3.3. Number of leaves per plant

Was determined by counting the number of leaves of ten plants in inner row and taking the mean to the nearest whole number.

2.3.4. Leaf area

Was determined by measuring the length and weight of leaf and multiplied by the correction factor (0.705) [19].

2.3.5. Leaf Area Index

Leaf area index was determined by using the formula stated below by Brown and Retherforth [20].
The formula outline by Radford and Brown [21] was used to measure Leaf Area Index (LAI) Crop growth rate (CGR) as stated below

2.3.6. Leaf area index

LAI=La x (p)-1
Where; LAI = Leaf Area index
La = Total leaf area per plant
P = Feeding area available (for ground support).

2.3.7. Number of tubers per plant

Was determined by physical counting of seed tubers per plant.

2.3.8. Length of tuber

This was determined by measuring the length of tuber head to the tail of ten tubers per plot with a measuring tape and the mean calculated to the nearest whole number.

2.3.9. Tuber diameter

Was determined by measuring the circumference of ten tubers per plot at the middle portion with a veneer calipers. Tuber weight were determined with the aid of top load weighing balance the weights were later converted to tonnes per hectare.

2.3.10. Statistical analysis

Data collected were subjected to statistical analysis using analysis of variance (ANOVA) procedure [22]. Treatment means for statistical significance were separated using Fishers least significance differences (FLSD) at 0.05 probability level [23].

3. Results and discussion

Weather condition of the study area presented in Table 1 showed the month of July has the highest rain fall and fairly even rainfall distribution in the other six moths of May through October in the two cropping seasons of 2016 and 2017 respectively. The temperature and relative humility was relatively adequate for the growth of the crops.

The soil of the experimental site is sandy loam, slightly acidic and low essential plant nutrient elements especially, organic matter, total nitrogen potassium and phosphorus (Table 2). Early researchers in this area have also reported low soil plant nutrients and strongly recommended the application of NPK fertilizers to improve the soil fertility status and increase crop growth and yield [14]; [24]; [25]; [26].

The application of NPK 20:10:10 fertilizer significantly ($P \geq 0.05$) increased the growth of yam minisetts (Table 3). Plots treated with NPK 20:10:10 fertilizer gave more number of leaves per plant and leaf area index values than where fertilizer was not applied. At all periods of measurements either at 10 weeks after planting (WAP) or 20 WAP, the number of leaves and branches per plant, and leaf area index increased significantly with incremental application of NPK 20:10:10 fertilizer rate in both 2016 and 2017 cropping seasons. The highest number of leaves, branches per plant and leaf area index were obtained in plots that had 350kg/ha of NPK 20:10:10 fertilizer in the two cropping seasons. Similar effects of NPK 15:15:15 fertilizer was observed on the vine length of the yam minisetts where the vine length increased with increase fertilizer rates and the longest vine length recorded in plots with 340kg/ha NPK fertilizer. This result support the works of Agbede and Ojemiyi [27] who observed significant increase in vegetative growth (leaves, branches and vines) of Ipomea batatas treated with NPK 15:15:15 fertilizer. All cases of treatment with NPK fertilizer significantly produced higher dry matter weight of yam minisetts plant fractions (Table 4). Higher rates of NPK 20:10:10 fertilizer gave greater leaf, vine and root dry weight per plant than the lower NPK 20; 10; 10 rates. Throughout the two years of this experiment (2016 and 2017), yam minisetts dry matter weight of plant fractions (leaf, vine and root) per plant increased with the advancement in plant age (10 WAP to 20 WAP) and increases in NPK 20:10:10 fertilizer rate. The highest dry matter weight of plant fractions was attained at 20 WAP where 350kg/ha N P K fertilizer was applied in the two cropping seasons.

Agba and Enya [14] reported similar significant increase in dry matter yield of cucumber plant fractions influenced by nitrogen fertilizer application. Results showed that the application of NPK 20:10:10 fertilizer significantly increased the yield of yam minisetts (Table 3). Yam minisetts fresh tuber weight per plant increased significantly with successive increased in NPK fertilizer rate up to 300kg/ha beyond which the yam minisett weight per plant decreased. The effects of NPK 20:10:10 fertilizer on yam minisett tuber length and diameter per plant closely followed similar trend as their effects on the yam minisett tuber weight per plant. Higher NPK 20:10:10 fertilizer rate of 350kg/ha depressed yam minisetts fresh tuber yield per hectare. Least tuber yield was recorded in control plots that were not treated with NPK fertilizer. The highest yam minisetts tuber yield per hectare of 4.54t/ha and 4.85t/ha were obtained in plots treated with 300kg/ha in 2016 and 2017 cropping seasons respectively. The high fresh yam minisetts seed tubers yield (planting materials) recorded by this studies in both years (2016 and 2017) seasons can partly be explained from the fact that the fertilizer provide the nutrient and improved soil fertility which evidently leads to improved growth and yield of yam as reported by Ekoteren [28].

Table 1: Experimental Sites Weather Data Summary of 2016 and 2017 Cropping Seasons

Months	Rainfall	Temperature(^{0}C)		Relative Humidity (%)
		Maximum	Minimum	
2016 Cropping Season				
March	58.3	34.1	27.2	72.2
April	163.2	34.5	25.8	81.1
May	263.1	31.3	22.1	83.1
June	537.1	30.1	23.1	87.7
July	637.5	32.3	24.3	90.8
August	389.8	29.2	25.1	85.3
September	421.5	28.1	26.4	87.2
October	301.2	30.4	20.1	75.5
November	187.1	29.5	20.1	84.1
December	15.3	29.5	20.1	65.7
Total	2974.1	308	239.5	812.7
Mean	297.41	30.80	23.95	81.27
2017 Cropping Season				
March	38.3	34.2	28.1	70.3
April	229.5	33.5	26.4	78.6
May	321.4	32.4	24.5	80.7
June	446.87	34.5	22.7	85.4
July	701.24	31.3	22.9	88.6
August	343.89	30.2	26.3	80.9
September	402.5	29.5	25.7	84.3
October	301.7	28.7	25.3	84.2
November	107.5	28.5	23.4	78.6
December	13.8	28.1	22.3	76.4
Total	2906.6	310.9	247.6	719.1
Mean	290.66	31.09	24.76	71.91

Table 2: Soil Physical and Chemical Properties of the Experimental Site before Planting in 2016 and 2017

Mechanical Properties	2016	2017
Coarse sand (%)	47	48
Fine sand (%)	26	25
Clay (%)	25	28
Silt (%)	2	5
Textural class	Sandy loam	Sandy loam
Chemical properties		
pH in water	4.4	4.6
pH in KCl	3.3	3.8
Organic carbon (%)	0.74	0.83
Organic matter (%)	1.35	1.46
Total nitrogen (%)	0.0074	0.00697
Total phosphorus (ppm)	8.7	8.5
Base saturation (%)	45	48
Exchangeable cation (Cmol /kg)		
Potassium	0.18	0.15
Magnesium	0.8	0.6
Sodium	0.9	0.7
Hydrogen	3.1	3.2
Aluminum	3.4	3.1
Calcium	2.2	2.6
Cation exchangeable capacity	8.1	8.4

Table 3: Effects of NPK 20:10:10 Fertilizer on the Vegetative Growth (Number of Leaves, Branches and Main Vine Length (Cm) of Yam Minisetts in 2016 and 2017 Cropping Seasons

NPK 20:10:10 Fertilizer Rate (kg/ha)	Number of leaves per plant		Leaf Area Index		Number of branches per plant		Length of Main vine (cm)	
	10 WAP	20 WAP	10 WAP	20 WAP	10 WAP	20 WAP	10 WAP	20WAP
2016 Cropping season								
0	10.1	20.3	0.23	1.00	2.1	4.1	57.3	81.4
80	13.3	26.2	0.37	1.12	3.3	6.0	61.4	113.4
100	15.1	29.1	0.41	1.21	4.1	7.1	66.7	121.5
150	18.2	32.3	0.46	1.24	4.2	7.3	69.2	143.1
200	20.2	38.1	0.49	1.26	4.4	7.4	73.1	154.1
250	22.1	41.1	0.52	1.28	4.5	9.1	75.4	171.4
300	22.3	47.2	0.55	1.33	5.1	11.1	80.6	203.2
350	24.1	52.3	0.61	1.35	5.4	12.2	93.4	231.5
LSD (0.05)	1.0	2.1	0.01	1.02	0.5	1.1	3.5	5.7
2017 Cropping season								
0	11.2	22.1	0.25	1.01	2.2	4.2	59.1	83.3
80	13.5	25.9	0.38	1.13	3.4	6.3	63.2	115.2
100	15.9	28.3	0.42	1.22	4.2	7.2	65.8	124.1
150	17.2	33.4	0.50	1.25	4.3	7.5	70.1	147.3
200	21.3	39.0	0.53	1.29	4.5	9.2	74.2	156.2
250	22.1	42.2	0.57	1.34	5.1	10.6	76.3	172.3
300	23.3	48.1	0.64	1.36	5.2	11.3	83.1	210.4
350	26.2	54.2	0.67	1.38	5.6	13.1	95.3	237.2
LSD (0.05)	1.1	2.2	0.01	0.02	0.5	1.2	3.6	5.8

Table 4: Effects of NPK 20:10:10 Fertilizer on the Growth Dry Weight of Plant Fractions (Leaf, Vine and Root (G)) Per Plant during 2016 and 2017 Cropping Seasons

NPK 20:10:10 fertilizer rate (kg/ha)	Leaf dry weight Weight per plant(g)		Vine dry weight per plant (g)		Root dry weight per plant (g)	
	10 WAP	20 WAP	10 WAP	20 WAP	10 WAP	20 WAP
2016 Cropping season						
0	3.35	10.12	2.12	5.32	1.44	3.23
80	5.41	16.61	3.32	9.18	2.12	5.13
100	7.36	18.23	4.12	10.45	3.13	6.42
150	8.23	21.12	5.16	12.13	3.46	7.11
200	9.14	23.41	6.23	15.32	4.12	8.24
250	10.21	25.12	6.67	16.13	5.18	10.35
300	11.12	27.33	7.13	18.11	5.67	11.12
350	12.36	30.14	8.33	23.57	6.12	12.35
LSD (0.05)	1.5	2.3	0.5	2.1	0.4	0.6
2017 Cropping season						
0	3.41	11.07	2.33	4.98	1.46	3.41
80	5.51	16.58	3.41	9.32	2.13	5.22
100	7.43	19.11	4.51	10.57	3.21	6.31
150	9.01	21.34	5.24	12.35	3.51	7.42
200	9.61	23.19	6.16	15.41	4.32	9.33
250	10.32	26.03	7.01	16.26	5.17	10.42
300	11.44	27.45	8.11	19.31	6.32	11.51
350	12.41	31.22	9.03	24.09	7.11	13.12
LSD (0.05)	1.6	2.4	0.5	2.2	0.4	0.7

Table 5: Effects of NPK 20:10:10 Fertilizer on the Yam Minisetts Tuber Yield during 2016 and 2017 Cropping Seasons.

NPK 20:10:10 fertilizer rate (kg/ha)	Number of tuber per plant	Weight per tuber (g)	Length of tuber (cm)	Tuber Diameter (mm)	Tuber yield per hectare (t/ha)
2016 Cropping season					
0	1.0	48.3	5.2	73.3	0.67
80	1.0	64.1	9.4	91.2	1.03
100	1.0	71.3	10.3	109.7	1.54
150	1.0	77.4	11.2	111.6	2.01
200	1.0	81.2	11.5	132.3	3.23
250	2.0	86.5	12.6	145.8	4.54
300	2.0	91.3	13.7	149.9	2.81
350	1.0	78.4	11.1	121.2	2.17
LSD (0.05)	0.01	3.2	1.3	8.7	0.03
2017 Cropping season					
0	1.0	49.2	5.4	74.1	0.69
80	1.0	65.3	9. 2	93.4	1.04
100	1.0	73.1	10. 3	110. 2	1.55
150	1.0	78.3	11. 4	116. 5	2.07
200	1.0	80.9	11. 6	134. 4	2.31
250	2.0	88.2	12. 3	146. 3	3.62
300	2.0	93.1	13. 5	151. 1	4.85
350	1.0	79.2	11. 3	122. 3	2.22
LSD (0.05)	0.01	3.3	1. 3	8.5	0.04

4. Conclusion

The application of NPK 20:10:10 fertilizer at the rate of 250-300kg/ha significantly produced the highest fresh tuber yam minisetts yield while higher fertilizer rate of 350kg/ha and above promoted higher vegetative growth were low tuber yield. Therefore, based on this research findings, 250-300kg/ha of NPK 20:10:10 fertilizer should be applied in the cultivation of yam minisetts for optimum growth and yield production of seed yam tubers (planting materials) is recommended to farmers to adopt for large scale production of seed yam tuber to be used as planting material.

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