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Full Length Research Paper

Effect of nitrogen fertilizer on some growth, yield and fruit quality parameters in pineapple (*Ananas comosus* L. Merr.) plant at Ado-Ekiti Southwestern, Nigeria

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Abstract

Commercial production of pineapple, a vitamin rich fruit crop in the tropics is gaining popularity in Nigeria. However, scanty information on the nutritional requirements of pineapple is one of the major constraints to the expansion of its cultivation in Nigeria. Field trial was conducted to determine the effects of nitrogen fertilizer rates on the growth, yield and fruit quality of pineapple at the Teaching and Research Farm, Ekiti State University, Ado-Ekiti, Nigeria. Treatments consisted of N from urea fertilizer at 0, 50, 100, 150 and 200kg Nha^{-1} arranged in randomized complete block design (RCBD) were replicated three times. Results showed that N fertilizer application up to 200kg Nha^{-1} significantly (P=0.05) increased the number of leaves, D-leaf length and leaf area of both plant crop and ratoon crop. The highest yield of 23.0t ha^{-1} and average fruit weight of 1.63g plant^{-1} were obtained at 150kg Nha^{-1} and beyond which there was reduction. Fruit yield components [fruit length, fruit diameter and core diameter] increased, but fruit quality [Total soluble solid (TSS), percentage acidity and Vitamin C] decreased with increasing rates of N application. Application of 150kg Nha^{-1} is required for maximum fruit yield and quality parameters.

Keywords: D-leaf length, ratoon, Nitrogen fertilizer, Pineapple *(ananas comosus).*

INTRODUCTION

Pineapple (*Ananas comosus* (L.) Merr.), a member of the family *Bromeliaceae* is cultivated predominantly for its fruits that is consumed fresh or (as canned fruit and juice) between latitudes 30^{o} N and 34^{o} S (Batholomew and Kadzimin, 1977). It dominates the world trade of tropical fruits, accounting for 51% of world global fruit market (FAO, 2008) and gains popularity in Nigeria due to fruit juice importation ban. However, only 5% of the output is exported by producing countries and for Nigeria fruit are not even exported commercially (FAO, 2010). It is the only source of bromelain, a proteolytic enzyme commonly used in the pharmaceutical industry and as a meat tenderizing agent (Fougue, 1981). Pineapple plays a vital role in the improvement of diet of mankind. It is a good source of vitamins C, minerals and calories found in the juice.

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Among the major constraints to expansion of pineapple cultivation in Nigeria is lack of sufficient information on its nutritional requirement (Asoegwu, 1988). According to FAO (2000) nitrogen plays an important role in the growth and development of plants. Soil fertility is also dependent on organic matter content, which accounts for the use of poultry manure as fertilizer. Organic manure as a source of fertilizer is a very essential input in crop production therefore, its application is necessary for enhancing the soil nutrient status and increasing crop yield (Akanbi et al., 2005); It also act as a store house for cation exchange capacity and as a buffering agent against undesirable pH fluctuation. Pineapple requires nutrients such as nitrogen (N), phosphorus (P), and potassium (K) for fertility maintenance and crop production. These nutrients are specific in function and must be supplied in sufficient quantity to plant at the right time. Nitrogen fertilizer has been reported to give a yield increase in okra (*abelmoschus esculentum)* (Babatola, 2006). Generally, fertilizer recommendation for most of

the fruits and vegetables grown in Nigeria is between 50-200 kg N ha^{-1}, 20-100kg P_2O_5 ha^{-1} and 60kg K_2O ha^{-1} (Babatola *et al*., 2002). Also, intensive research studies Alasiri *et al*., 1998; Adebayo and Adoun, 2002; Akanbi *et al*., 2002), had been carried out in the country on the effects of N fertilizer treatments on various crops except pineapple. Because of this exception this study was done to evaluate the effects of N rates on growth and yield parameters of pineapple (*ananas comosus).*

MATERIALS AND METHODS

Location of the Experiment

A field trial was conducted at the Teaching and Research Farm of the Ekiti State University, Ado-Ekiti (7^o40" N and 5^o15" E) between May, 2005 and July, 2007. The soil of the study site is an Alfisols (SSS, 2003) of the basement complex, highly leached and with low to medium organic matter content. The site had previously been cultivated to some arable crops such as maize, cassava, cocoyam, yam and melon before it was left to fallow for some years.

Soil Sampling and Analysis

Before sampling, ten core soil samples randomly collected from 0-15 cm top-soil were bulk to form a composite. Samples were air dried, crushed and allowed to pass through a 2mm sieve. Particle size distribution was carried out by the Hydrometer method, while soil pH in soil solution ratio 1:2 in 0.01M $CaCl_2$. Soil organic carbon was determined by the Walkey and Black method and the total N by the micro-kjeldahl digestion method (Bremner and Mulraney, 1982). Available P was determined by Bray and Kurtz (1955) extraction method; Exchangeable bases were extracted with neutral 1M NH40AC at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer. Exchange acidity was determined by titration of 1M KCl extract against 0.05M NaOH to a pink end point using phenolphthalein as indicator (McLean, 1982)

The experiment was laid out in a randomized complete block design (RCBD) and replicated three times. Treatments consisted of N applied at 0, 50, 100, 150, and 200 kg ha^{-1} as urea (46% N). Basal dose of phosphorus (at 50kg P_2O_5 ha^{-1}) as single super phosphate and potassium (at 100kg K_2O ha^{-1}) as muriate of potash (KCl) was given to all plants, including those in the control plots. The N fertilizer treatments were applied in three equal doses at planting as well as 3 and 6 months after planting time. Six-leaf stage pineapple plantlets were sown at 0.5 x 0.5m spacing on 3.0 x 3.0m plots separated by 1.0m. All initial plantlet roots were removed at transplanting while weeding was done manually with hand hoeing at two weeks after planting. Length of D-leaf (longest central leaf) (cm), number of leaves, root length (cm) and leaf area (cm^2) were determined at 10 MAP while fruit yield as well as fruit quality characters; Total soluble solid (TSS) in Brix was obtained by a temperature self compensating digital refractometer (AOAC, 2005), acidity and vitamin C were determined at maturity according to the method of Sinclair, (1993). All data were subjected to Analysis of Variance (ANOVA) as described by SAS (2006) and the differences between treatment means separated using Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Data on the Soil physico-chemical properties of soil at the site of experiment is presented in Table 1. The data indicated that the soil is a sandy loam and very low in N and available P, their values were below critical values. its characterization indicated pH 5.82 in water, 0.11 gkg^{-1} N, 2.20g kg^{-1} organic C, 3.70 mg kg^{-1} available P and 0.38 cmol kg^{-1} K. Particle size distribution were 732g kg^{-1} sand, 146 g kg^{-1} clay and 121g kg^{-1} silt. It is expected that the test soil and pineapple would benefit from added fertilizer since N limit pineapple production.

The height of a plant is an important growth character directly linked with it productive potential in terms of fodder, grains and fruit yield which is positively correlated with plant productivity (Saeed *et al.,* 2001). The effects of N fertilizer rates on growth characters of pineapple are indicated in Table 2. There was significant ($P<0.05$) response of the plants to N fertilizer application. Pineapples treated with 200kg Nha^{-1} were taller (95.6cm) than those that received lower rates of application (82.5, 88.4 and 94.6cm). The trend was such that 200kg Nha^{-1} gave 45% and 35% increases over the control in plant and ratoon crops, respectively. This observation is in agreement with the findings of Babatola et al. (2002) who reported that increasing level of fertilizer application was observed to increase growth and yield of crops. The significant increase in D-leaf length reflects the effect of nutrient N. The untreated pineapple plants were almost stunted in growth as they had to rely on the native soil fertility which, from the result of chemical analysis was deficient in nutrient N. The number of leaves per plant was dependent on fertilizer rate as it increased with increase in fertilizer rate. Plant fertilized with 200kg Nha^{-1} had the highest number of leaves (91) which is 26% relative to the untreated plants. These findings are in line with the views of Reindhart *et al.,* (2003) and Stefano et al. (2004) who reported that fertilizer application resulted in luxuriant growth with excessive leaves.

Leaf area per plant increased significantly with N fertilizer treatment. The highest N application rate (200 kg Nha^{-1} resulted in the highest leaf area (242.36 cm^2)

Table 1. The physical and chemical properties of soil in the study site prior to cropping

Parameters	Values
pH	5.82
Organic carbon (g kg^{-1})	2.21
Total nitrogen (g kg^{-1})	0.11
Available phosphorus (mg kg^{-1})	8.36
Exchangeable Bases (cmol kg^{-1})	
K	0.38
Ca	0.60
Mg	0.45
Na	0.38
Exch. Acidity	0.40
Effective cation exchange capacity	2.21
Particle size analysis (g kg^{-1})	
Sand	732
Silt	147
Clay	121

Table 2. Effect of nitrogen fertilizer application rates on some growth parametersof pineapple plants at 10 months after planting.

Fertilizer Kg N ha^{-1}	Number of leaves	D-leaf length (cm)	Root length (cm)	Leaf area a(cm^2)
		Plant Crop		
0	65.36b	79.50c	30.12d	41.57e
50	65.45b	82.51b	40.30c	97.61d
100	75.67b	88.36b	45.05bc	122.30c
150	76.36b	94.56a	49.76b	205.43b
200	91.03a	95.57a	52.44a	242.36a
SE±	0.27		0.75	4.90
		Ratoon Crop		
0	62.53c	73.30d	17.20d	50.20d
50	63.51b	76.81c	29.30c	112.61c
100	65.47b	82.27b	30.77c	153.86b
150	73.36b	94.56a	35.98b	215.43b
200	98.20a	97.33a	41.46a	240.46a
SE±	0.85		1.48	3.98

Means with the same letter in each column are not significantly different ($p<0.05$) using DMRT.
SE: Standard Error
D-Leaf: Longest centrally position leaf.

followed by 150kg Nha^{-1} (205.43cm^2) while the least (41.57 cm^2) was observed in the control plots. The least growth in the control plots (0 kg Nha^{-1}) was probably due to N deficiency which could probably reduce number of functional leaves and subsequently the photosynthetic efficiency (Lahav, 1972). Okwuowulu, (1995) had also reported that unfertilized plants had lower leaf area and this was due to less number of leaves resulting from premature leaf fall and early vine senescence.

The effects of N fertilizer rates on fruit yield and other yield components of pineapple in both plant and ratoon crops are presented in Table 3. Fruit yield increased significantly with N fertilizer rates up till 150kg Nha^{-1}, which gave 23.0t ha^{-1} in the plant crop and 19.4t ha^{-1} in the ratoon crop. Beyond this N application rate, there was significant reduction in yield (8.4% in plant crop and 27.9% in ratoon crop). The response to N fertilizer application might be due to the fact that N is needed in photosynthesis and in the formation of carbohydrates. Vegetative growth is also known to be encouraged at the expense of yield at high N rates (Py and Teisson, 1987). One of the effects of excess N is delay in food production and beyond the optimum level, toxicity could be expected. At this level, application of

Table 3. Effect of nitrogen fertilizer application rates on fruit yield and nitrogen use efficiency of pineapple plants

N kg ha^{-1}	Plant Crop		Ratoon	
	Fruit yield (t/ha)	NUE (g/g)	Fruit yield (t/ha)	NUE (g/g)
0	13.92c	28.4	12.98c	30.9
50	14.20c	0.28	13.91c	0.27
100	20.38ab	0.20	14.89b	0.15
150	23.00a	0.15	19.46a	0.13
200	19.36b	0.09	17.28b	0.08
SE±	3.24		1.14	
	Fruit weight (g/plant)	NUE (g/g)	Fruit weight (g/plant)	
0	0.87c	1.77	0.60c	1.42
50	0.91c	0.02	0.95b	0.01
100	1.50ab	0.01	1.26a	0.01
150	1.63a	0.01	1.58a	0.01
200	1.44bc	0.07	1.30a	0.01
SE±	0.12		1.10	

Means with the same letter(s) in each column for each parameters are not significantly different ($p<0.05$) using DMRT.
NUE: Nitrogen use efficiency
SE: Standard Error

more nutrients is undesirable. In this study, response to applied N fertilizer was obtained due to initial poor soil fertility of the experimental site. With low soil N level, pineapple response to added N is expected and is consistent with the findings of Veloso *et al.* (2001) and Teixeira *et al.* (2002). The N use efficiency of the pineapple plants also decreased as applied N fertilizer rates increased.

Average fruit weight per plant also increase with N application levels up to 150kg ha^{-1} and thereafter declined (Table 3). The biggest pineapple fruits weighed 1.63kg in the plant crop and 1.70kg in the ratoon crop, while reduced fruit weight resulted beyond 150kg Nha^{-1} fertilizer treatment. This trend is similar to the significant linear increase in fruit weight per plant (as N application rate increased up to 280 kgha^{-1}) reported by Dalldorf (1993) as well as Selemat and Ramlah (2003). The 200 kg Nha^{-1} treatment gave the highest fruit lengths (24.6 cm in the plant crop and 21.7cm in the ratoon), except that fruit produced by 100 and 150kg Nha^{-1} treatments were of similar lengths (22.2 and 22.3 cm, respectively to the 24.6 cm in the plant crop (Table 4). Also, application of N increased fruit diameter with the highest values (14.53 cm) obtained at 150kg N ha^{-1} in the plant crop while the highest core diameters (2.14 and 2.30 cm) were obtained with 200kg N ha^{-1} in plant and ratoon crop respectively. The values were, however, similar to the core diameters (2.14 and 2.21cm) of pineapple plants treated to 150kg N ha^{-1}.

The effects of N fertilizer rates on fruit juice quality of pineapple are indicated in Table 5. TSS increased significantly as N rates increased. Bussi and Amicot (1998) reported that high N fertilizer application rate has positive effect on the TSS content. The highest TSS of 17.01% was, however, obtained in the plant crops that received 50kg Nha^{-1}, which gave similar TSS (16.23 and 15.07%) in respect of 100 and 150kg Nha^{-1} treatments after which there was a decline. Percentage acidity decreased as N fertilizer rates increased such that there was 40.1% reduction in plant crop and 51.4% reduction in the ratoon crops relative to control. The effects of applied N fertilizer levels on Vitamin C (Table 4) followed the same trend, declining by 18.8% in plant crop and 23.8% in the ratoon crop with the application of 200kg Nha^{-1}. The significant decreases in TSS and Vitamin C with the highest N application level (200kg Nha^{-1}) confirm the report by Ademar *et al.,* (2004). Teixeira *et al.* (2002) also noted that N application had a positive effect on fruit yield but decreased TSS.

CONCLUSION

The growth parameters (number of leaves, D-leaf length and leaf area) in field grown pineapple plants could be enhanced with the application of 200kg Nha^{-1}. However, for peak production (high yield and good quality) of the fruits, nitrogen should not be applied beyond 150 kgha^{-1} rate.

Table 4. Effect of nitrogen fertilizer application on some fruit characters of pineapple plant.

Fertilizer rates (kgN ha^{-1})	Fruit length (cm)	Fruit diameter (cm)	Core diameter (cm)
		Plant Crop	
0	13.33c	9.53c	1.52c
50	15.14b	10.34bc	1.81b
100	22.20a	11.87b	1.92b
150	22.30a	14.53a	2.14a
200	24.60a	13.77ab	2.14a
SE±	1.05	0.73	0.17
		Ratoon	
0	14.66d	10.47b	1.60b
50	15.07d	10.93b	1.68b
100	17.07bc	11.60ab	1.70b
150	18.20b	13.56a	2.21a
200	21.67a	13.73a	2.30a
SE±	1.00	0.74	0.08

Means followed by the same letter(s) in each column are not significantly different ($p<0.05$) using DMRT.
SE: Standard Error

Table 5. Effects of nitrogen fertilizer application rates on some fruit quality parameter of pineapple plant.

Nkg ha^{-1}	Plant Crop	Ratoon Crop
	Total soluble solid (g/kg)	
0	9.37c	8.63c
50	17.01a	19.60a
100	16.23a	15.43a
150	15.07a	14.07a
200	12.23b	11.86b
SE±	0.39	0.40
	Acidity (%)	
0	1.67a	1.53a
50	1.43b	1.45b
100	1.38b	1.34b
150	1.22c	1.15c
200	1.00d	0.84d
SE±	0.22	0.04
	Vitamin C (mg/kg)	
0	151.57a	155.57a
50	148.30b	149.30ab
100	145.10b	143.10b
150	140.23c	135.66c
200	122.97d	118.53d
SE±	1.44	0.89

Means with the same letter in each column are not significantly different ($p<0.05$) using DMRT.
SE: Standard Error

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