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Research Paper

Variability in growth attributes of two pineapple (*ananas comosus*) cultivars grown in the basement complex soils of Southern Nigeria as influenced by different time of nitrogen side dressing application

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Two experiments were carried out in March 2013 and 2014 to determine the effect of time of N-fertilizer side dressing on two cultivars of pineapple (*Ananas comosus).* Nitrogen (100 kg Nha) as Urea was applied at seven different times and at different growth stages of smooth cayenne and Natal queen pineapple cultivars. The treatment effects were determined by plant height (cm), number of leaf blades per plant, Leaf Area (LA), specific leaf area ($^{LA}/_{LW}$), leaf extension rate, (cm/day) leaf production intervals (days) and root weight (g). The results showed that delaying time of N-application till 9-13 months showed the highest response in growth components during the study period. The cultivars did not differ significantly in their response to treatment. Seasonal effect showed that delaying side dressing till 13 months rather than 15 months after planting enhanced the formation of new leaves, and the expansion of the existing leaf blades for larger surface area for photosynthetic activities. Equally, side dressing of pineapple at 13 months was found to be the period in which plants efficiently utilized soil nutrients as evidenced in the value of the growth components measured as evidenced in plant height and root dry height recorded in this study. These results are discussed in light of variation in time of nitrogen side dressing on growth attributes of two cultivars of pineapple (*Ananas comosus Merrill L.*) grown on basement complex soil in southern Nigeria.

Key words: Nitrogen application, growth characteristics, pineapple, basement complex soils

INTRODUCTION

Pineapple *(Ananas comosus)* plants are known to respond favorably to N fertilization. However, when N is applied in excessive amount or at wrong stages and times of growth, increased vegetation growth, heavy lodging, increased damage from diseases, delayed maturity and reduced yield may result (Sins *et al.*, 1967; Ubi *et al.*, 2005). An important area of research has therefore been to establish the proper time to apply N

fertilizer at mid-season. Sins *et al.* (1967) reported that growth and yield of rice can be altered greatly by varying the application time of N fertilizer.

For some time now, the number of days after seedling emergence was used to indicate the proper time for mid-season N application but has been seen to be unreliable due to the fact that environmental factors affect the rate of plant development. Hall *et al.* (1968) proposed the use of internode elongation of primary stem as a guide to applying N-fertilizer and Wells and Johnson, (1970) used this criterion in increasing their yield by delaying N application until 50% of their crop had attained required internode lengths.

Literature relating to this study in Nigeria has not been much, and there is no definite recommendation as to the best time to apply N. There is lack of uniformity in the timing of N application to pineapple. In consideration of the significance of this study and the death of information on the concept, it has become necessary to carry out this research. The purpose of this study is to determine the best time to side-dress N-fertilizer on the growth and development components of pineapple planted on coastal acid sands of Cross River State, Nigeria. Such results could be used to formulate a definite recommendation on timing of N-fertilizer application in order to increase the production efficiency in pineapple farming.

MATERIALS AND METHODS

Two experiments were conducted in March 2013 and 2014 during the wet season at Iwuru, near Cross River State College of Education, Akamkpa Campus, to determine the effect of time of nitrogen fertilizer side dressing on two cultivars of pineapple *(Ananas comosus)*. The experimental site lies between 8^{o}14'N and 8°20'E longitude, 5°14'N and 5°18'E latitude with a rainfall of over 2,000 mm in the rainforest vegetation. In terms of land use, the area was previously cropped with cassava, followed by a four year fallow in which northern gamba grass (*Andropogon gayanus*) was the dominant fallow species. The site was manually cleared, and allowed to dry for some days, then gathered together and removed.

The trial was carried out on a randomized complete block design (RCBD), replicated three times. The main plot size was 3 x 12 m with a sampling area of 2 x 2 m. The pineapple propagules used were; smooth cayenne (characterized by smooth leaf) and Natal queen (characterized by spine leaf blades). Pineapple suckers which are ratoons from parent stock were planted at a spacing of 50 cm between rows and 30 cm within rows. At the beginning of the study, the soil was treated with 325.5 kg P/ha P_2O_5, (single super, phosphate), 112.5 kg K/ha K_2O (muriate of potash) and one month later, 100 kg N/ha in form of Urea. Nitrogen side dressing was done every two months with Urea fertilizer at the rate of 100 kg N/ha beginning at 3 months after planting. The treatments consisted of 100 kg N/ha of Urea and plant ages of 3, 5,7,9,11,13 and 15 months.

The following observations were taken: plant height, number of leaf blades per plant, leaf area, specific root weight per plant. Plant height was taken by measuring from the base to the tip of each of the ten plants randomly selected from the sampling area; using a graduated meter ruler. Measurement was in situ from plant base to the leaf blade tip. Leaf area (LA) was determined by the use of leaf area (LA) meter (LI-COR model); specific leaf area was calculated as $^{LA}/_{LW}$ cm^2/g. The ten randomly selected plants for the leaf area study were also used to evaluate number of leaf blades per plant. Root weight was determined by carefully harvesting five plants from the sampling area and the roots carefully removed, and weighed then the average determined. The roots harvested from the ten randomly selected plants within the sampling area were weighed for fresh weight, and then oven dried at a temperature of 60°C for 48hours after which the root dry weight was determined.

Leaf extension rate

The date that a new leaf appeared was recorded and the initial length taken. The final leaf length was taken when the ligule appeared as this indicates full expansion. The additional length acquired over the number of days taken to attain that final leaf length was taken as the mean extension rate (Ubi and Omalike, 2005).

Leaf production interval

This was recorded as the interval between emergences of leaves on the marked plants and was followed from the appearance of the first leaf to that of the last leaf, (Ubi and Omaliko, 2005).

Statistical analysis

Statistical differences were determined by analysis of variance (ANOVA) and means, compared with Fisher's Least Significant Difference (LSD) at 5% probability, using the methods of Wahua, (1999).

RESULTS

Plant height

The results of plant height (cm), number of leaves per plant and leaf Area (LA) as influenced by treatments are

Table 1. Average effect of time of nitrogen side dressing on plant height (cm) leaf number, leaf area (LA) during the 2013 and 2014 planting seasons.

	Smooth cayenne			Natal Queen		
Plant age in which fertilizer was applied (months)	**Plant height (cm)**	**Number of leaves per plant**	**Leaf Area (LA)**	**Plant height (cm)**	**Number of leaves per plant**	**Leaf Area (LA)**
			2013			
3	23.40	10.0	55.1	24.6	11.8	60.1
5	35.21	16.3	72.0	37.1	17.2	72.2
7	42.5	20.1	86.2	40.30	21.0	85.0
9	50.17	26.5	112.4	50.11	27.6	114.1
11	56.65	32.6	145.6	54.22	32.4	141.4
13	63.40	38.8	162.0	60.12	37.1	159.0
15	63.51	44.2	124.0	60.14	43.8	122.3
LSD (0.05)	5*	6.0*	14.3*	NS	5.2*	12.0*
			2014			
3	24.6	13.1	63.9	23.4	10.7	61.4
5	37.1	17.9	79.2	36.0	16.0	75.6
7	40.6	27.0	87.0	44.9	20.8	86.1
9	48.0	29.2	113.1	50.1	26.0	115.2
11	55.6	34.1	147.2	56.8	32.6	143.0
13	63.2	40.9	164.0	62.4	38.0	160.4
15	68.3	43.6	121.8	67.1	44.2	123.0
LSD (0.05)	5*	5.3*	14.5*	5*	5.0*	13.1*

NS = Not statistically significant * Statistically significant ($p<0.05$) at 5 percent.

presented in (Table 1). The plant heights in the two cultivars consistently increased with increase in time of N-fertilizer side dressing throughout the planting season. Thus, the highest plant height in smooth cayenne, (63.51 cm in 2013 and 68.30 cm in 2014) were obtained from the 15 months old plants while the lowest (23.4 cm in 2013 and 24.6 cm in 2014) were obtained from the 3 months old plants. The values of plant height obtained in the two cultivars for the lowest height at the beginning of two planting seasons were similar.

However, taking the mean of plant heights (cm) during the first year of study, for smooth cayenne, for instance, values obtained later in. the season compared with obtained earlier in the season were double in some cases and almost double in others. Thus there were plant height increases with every increment in months of fertilizer treatment. Comparing 9 months with 3 months, 11 months with 5 months, 13 months with 3 months and 13 months with 15months, we have the following:

Unit increases = $\frac{50.17 - 23.40}{23.40} \times 100$ = 114.40%; $\frac{56.60 - 35.21}{35.21} \times 100$ = 60.75%, $\frac{63.40 - 23.40}{23.40} \times 100$ = 170.94% and $\frac{63.51 - 36.40}{36.40} \times 100$ = 74.5% Unit increases for smooth cayenne in the first planting season. The values of plant height obtained in the 13 months compared with 15 months did not show any significant difference (Table 1). Equally the average number of leaves produced per plant increased consistently with plant age in both cultivars, throughout the experimental period. Thus highest number of leaves per plant in smooth cayenne, (44.2 in 2013 and 43.6 in 2014) were obtained from the 5 months old plants and these values were significantly ($p<0.05$) higher than those of all other treatments throughout the study period.

Leaf area (LA)

The leaf Area (LA) consistently increased with increase in both age of plant and time of N-fertilizer side dressing in the two cultivars throughout the study period. In smooth cayenne for instance, the highest leaf areas (162 cm² in 2013 and 164 cm² in 2014) were obtained from the 15 months old plants and these values were significantly ($P<0.05$) higher than all other values obtained from other treatments, given similar experimental conditions. The results of Natal queen cultivar followed the same trend with that of smooth cayenne. Thus, the two species were not significantly ($p<0.05$) different in their respond to treatment. In effect, in both species, there were consistent increases in plant heights, number of leaves per plant and the leaf areas for every addition of 100 Kg N/ha every two months, from the 3 months stage to the 15 months stage**,** throughout the study period. There was

Table 2. Average effect of time of nitrogen side dressing on leaf extension rate (cm/day), leaf production interval, specific leaf area ($^{LA}/_{LW}$) and root weight (g) cultivars.

Plant age in which fertilizer was applied (months)	Smooth Cayene Leaf extension rate (cm^3/day)	Leaf Production interval (days)	Specific leaf area	Root weight (g)	Natal Queen Leaf extension rate (cm^3/day)	Leaf production interval (days)	Specific leaf area	Root weight (g)
				2013				
3	1.25	8.0	385.1	0.033	1.23	8.4	376.0	0.031
5	1.39	10.6	352.0	0.052	1.27	10.2	341.1	0.053
7	1.47	8.2	318.5	0.078	1.38	8.1	312.0	0.075
9	1.56	12.6	281.4	0.121	1.46	12.8	284.1	0.012
11	1.82	14.8	245.6	0.195	1.78	14.6	241.0	0.019
13	1.88	15.5	210.0	0.208	1.81	15.4	209.2	0.206
15	1.36	15.4	175.6	0.184	1.31	15.1	171.4	0.178
LSD (0.05)	0.06*	2.1*	31.2*	0.035*	0.05*	2.0*	30.1*	0.032*
				2014				
3	1.23	8.9	381.2	0.032	1.20	8.1	369.1	0.032
5	1.36	11.2	338.4	0.048	1.26	10.4	342.0	0.049
7	1.39	9.6	317.0	0.081	1.39	8.2	321.5	0.079
9	1.51	12.4	289.8	0.124	1.50	12.6	279.2	0.122
11	1.84	14.6	236.5	0.192	1.76	14.7	260.1	0.185
13	1.92	15.4	206.8	0.204	1.82	15.2	201.5	0.201
15	1.41	15.1	165.4	0.182	1.30	15.6	174.2	0.177
LSD (0.05)	0.06*	2.0*	30.4*	0.034*	0.05*	2.1*	30.3*	NS

NS = Not statistically significant; *statistically significant ($p<0.05$) at 5 percent.

on the average a significant increase in Leaf Area due to increase in leaf size (Ubi, 2004).

Leaf extension rate

The results of leaf extension rate (cm^3/day), leaf production interval (days) specific leaf area ($^{LA}/_{LW}$) and roots weight (g) are presented in (Table 2). In both cultivars and during the two planting seasons, leaf extension increased consistently from 3 months to 13 months then dropped significantly with the addition of 100 kg N/ha at 15 months. Thus, highest leaf extension rate for smooth cayenne (1.88 in 2013 and 1.92 cm^3/day in 2014) were obtained from the 13 months old plants and these values were significantly ($p<0.05$) higher than all other values during the study period. The results of leaf production interval followed the same trend with that of leaf extension rate, except that in both cultivars both 13 months and 15 months old plants produced similar values which were on the average significantly ($p<0.05$) higher than all other values throughout the study period. The cultivars were not significantly different in this treatment.

Specific leaf area

The specific leaf area was highest at 3 months with values of 385.1 in 2013 and 381.2 in 2014 for Natal queen, and these values were significantly ($p<0.05$) higher than all other values throughout the study period. There was no significant difference between the two cultivars in terms of specific leaf area during the experimental period, and as it may he expected, they cultivars had their minimum specific Leaf Area later in the season when plants were 15 months old. Both leaf extension rate and specific leaf area declined when time of N-fertilizer was side dressed at 15 months. The effect of time on N-fertilizer side dressing, on the leaf production interval during the 13 and 15 months were similar throughout the study period. The delay in leaf production later in the season was compensated by the large leaf

area surface, enhancing photosynthetic activities in the tissues of pineapple leaves during the period of study. The dry weight of roots presented in (Table 2) showed a significant effect of side dressing on pineapple. Side dressing pineapple 13 months after planting had the highest root dry weight (0.208 (g) in 2013 and 0.204 (g) in 2014 for smooth cayenne and 0.206 g in 2013 and 0.201 g in 2014 for Natal queen) and these values were significantly ($P<0.05$) higher than those of all other treatments throughout the period of study. There were 99.79% and 174.67% unit increases in root dry weight of smooth cayenne during the first year when comparing 13 months with either 3-5 or 7 months respectively.

DISCUSSION

In this study, plant height (cm) number of leaf blades per plant, leaf area, leaf extension rate, leaf production interval specific and the root weight increased significantly ($p<0.05$) at 13 months of N-fertilizer side dressing in the cultivars throughout the study period. These results are similar to those of Evatt (1964), Hall *et al.* (1968), Ubi and Omaliko, (2004) and Ubi *et al.* (2005). The cultivars similarities in response to time of side dressing obtained in this study for all the growth parameters studied indicate that the growth pattern of both cultivars must be given similar consideration when N-fertilizer side dressing is being contemplated. It also shows that it is unrealistic to base the time to apply N-fertilizer mid-season .purely on the number of months after planting. This is because factors such as weather conditions, soil nutrient status and incidence of disease may delay the rate of growth of a cultivar and therefore affect the precise stage of growth for optimum utilization.

Ubi and Omaliko, (2004) found that the application of low level of nitrogen in leaf 5 for northern gamba grass recorded 2.10 cm/day extension rate which was equal to that obtained leaf 3, where 300 kg N/ha was applied. This indicates that N-fertilizer application at low rates could be used to increase leaf extension rate in certain leaves and some species. They also observed that interval of leaf production was more prolonged when the plants were relatively old and tall than in the early growth stage as it was the case in this study.

Various explanations advanced from this study showed that high response to delayed side dressing of nitrogen fertilizer at 13 months enhanced pineapple growth and development and is in agreement with earlier results (Sins *et al.,* 1967; Murata, 1969; Wells and Johnson, 1970; Hassan and Leitch, 2000).

Roots formed the smallest component of pineapple vegetative dry matter and yet the function of this fraction over-rides those of other plant components in terms of nutrient uptake, which was well expressed 13 months after planting, as evidenced in the root weight values during the study (Wilman and Mohammed 1981, Wilman *et al.,* 1999; Ubi *et al.,* 2005).

The display of the photosynthetic surface area in the study favored leaf production and extension with delayed side dressing of N-fertilizer, but how long this effect will last as to enhance good fruiting is a subject of another investigation.

Conclusion

This study has brought to light the effect of time of nitrogen side dressing on pineapple as it affects the crop growth and development. From the results of this study, delaying side dressing with N-fertilizer later in the season enhanced formation of new leaves and the expansion of existing leaf blades for a larger surface area for photosynthetic activities. This benefit over-rides the delay in leaf production rate recorded later in the season. Side dressing of pineapple with N-fertilizer at 13 months tends to favor optimum growth and development for maximum yield. The results of this study show that the best timing for nitrogen side dressing for pineapple (100 kg N/ha), is from 9 months to 13 months after planting, this result if adopted will bring better economic returns to the farmers and will bring encouragement.

Authors` declaration

We declare that this study is an original research by our research team and we agree to publish it in the Journal.

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