Effect of irrigation and nitrogen on the growth and yield of pineapples (*Ananas comosus*) cv Smooth Cayenne.

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EFFET DE L'IRRIGATION ET DE L'AZOTE SUR LA CROISSANCE ET LE RENDEMENT DES ANANAS (*ANANAS COMOSUS*) CV CAYENNE LISSE.

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RESUME - Etude de l'action de la fertilisation à partir de cinq niveaux d'azote et suivant quatre rythmes d'irrigation sur la croissance et les rendements de l'ananas Cayenne lisse. Des doses croissantes d'azote jusqu'à 150 kg/ha augmentent les récoltes et ce, pour chacun des traitements d'irrigation ; le meilleur rendement a été obtenu avec 150 kg/ha de N et une irrigation hebdomadaire. Cette même dose de N est la plus significative en ce qui concerne les paramètres de croissance.

INTRODUCTION

Pineapple (*Ananas comosus*) is becoming an important crop in Nigeria. Its fruits are no longer only meant for the fresh market but also as a raw material for the fruit juice industry, for the manufacture of alcohol, wine and citric acid, and for export. Its medicinal use has been identified (Fouque, 1981), while its bromelain can be used as a meat tenderizer. The fruit residues and the foliage can be processed into bran of silage for animal feed.

The production of pineapple in Nigeria for export is a recent event, having begun in 1984. Fresh fruit export was about 250 tonnes in 1985 and 450 tonnes in 1986. With the present increased interest in the production of the crop, the export potential of the fresh fruit is projected to be over 3 000 tonnes in 1995.

The annual growth rate of local fruit juice industries utilizing pineapple is about 3.5%. This is sure to increase as more raw materials become available with increased cultivation of the crop. The fresh market demand has been on the increase because of the peoples' awareness and acceptance of pineapple. Its effect on the socio-economic life of the people is appreciable.

In Nigeria, the crop is grown mostly in the rainforest zone where the rainfall ranges from 700-2 000 mm per annum with 3-4 months of dry season. However, with adequate water supply, the crop can grow in the drier parts of the country. Furthermore, though the crop can survive long dry periods through its ability to retain water in the leaves, it is very sensitive to water deficit especially during the vegetative growth period, flowering and fruiting (Doorenbos and Kassam, 1979). Chapman *et al.* (1983) reported that as watering frequency was reduced, D leaf length and weight and whole plant weight were reduced within 4 months of planting.

The nutrient requirements of the pineapple is high and it makes only small demands on the natural nutrient reserves of the soil if it is supplied generously and correctly with fertilizers. Nitrogen is the nutrient which has the greatest effect on the yield (de Geus, 1973). Due to its dominant effect on growth and yield, nitrogen is used at rather high rates in pineapple growing all over the world.

Since water supply and nitrogen are important inputs in the production of pineapples ; there is need to develop

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a system that would allow for the efficient use of water and fertilizer. It is envisaged that a combination of irrigation frequency and N rates will improve crop production by reducing fertilization amount and cost of production of this crop.

MATERIALS AND METHODS

The study was conducted on the sandy loam soil (Ultisol) in the National Horticultural Research Institute, Mbato Sub-station, Okigwe, (05°35'N, 07°23'E). The area has *Amaranthus* sp. as the preceding crop with no nematicidal build up. The statistical design of the study conducted with the plant crop and first ratoon crop was a split plot replicated four times. The main effects were four irrigation levels and the sub-effects five N-fertilizer rates. Two of the irrigated treatments received 50% consumptive use less effective rainfall every 7 and 14 days ($0.5I_7$ and $0.5I_{14}$) respectively ; the third received 100% consumptive use less effective rainfall every 3 days ($1.0I_3$). Consumptive use is used here to mean losses due to evapotranspiration calculated from climatological data using Blaney-Criddle method. The daily consumptive use measured between 2.0 - 6.5 mm. There was also a non-irrigated control (I_0). Each sub-plot measured 1.0 m x 2.5 m and planted with pineapple suckers at the 10 leaf stage 0.5 m x 0.5 m apart. The sub-plots contain 18 suckers each, the middle four were monitored for growth and yield analysis, while the remainder served as guards. The plots were established in September 1984. At transplanting, the suckers were soaked in a 0.1% mixture of benlate (a fungicide) and water. Leaf area was measured using the planimeter and correlated with product of length and width of D leaf. Rate of leaf formation was used as an index of growth. Other parameters measured were days to 50% flowering and harvest for the two crops (plant crop and ratoon crop), potential and harvested yields, crown weight and stalk weight. The plants were not forced to flower.

The fertilizer treatments were 0, 50, 100, 150 and 200 kg/ha of N as Urea (46%). A general dose of phosphorus (50 kg/ha of P_2O_5) and potassium (100 kg/ha of K_2O) were given to all plants. Fertilizers were given in three equal split doses at 3, 6 and 9 months after planting for the plant crop. For the first ratoon crop, the treatment dose was applied at 1, 2 and 3 months after harvest of plant crop. In the plant crop, fertilizer mixtures were applied by hand on the ground 5 cm from the plant while in the first ratoon crop they were applied in the basal axils of the older leaves. The meteorological data of the area during the crop growth are given in Fig. 1.

RESULTS

Growth.

Mean growth parameters of pineapple at five N rates are presented in Table 1. Increasing N rates up to 150 kg ha^{-1} $year^{-1}$ increased number of leaves and length of D leaf. Beyond the 150 kg ha^{-1} $year^{-1}$ rate, these parameters declined in value. Days to 50% flowering and harvesting were least at the 200 kg ha^{-1} $year^{-1}$ N rate. However, they were not significantly different from the values got at the 150 kg ha^{-1} $year^{-1}$ N rate. The same trend was ob-

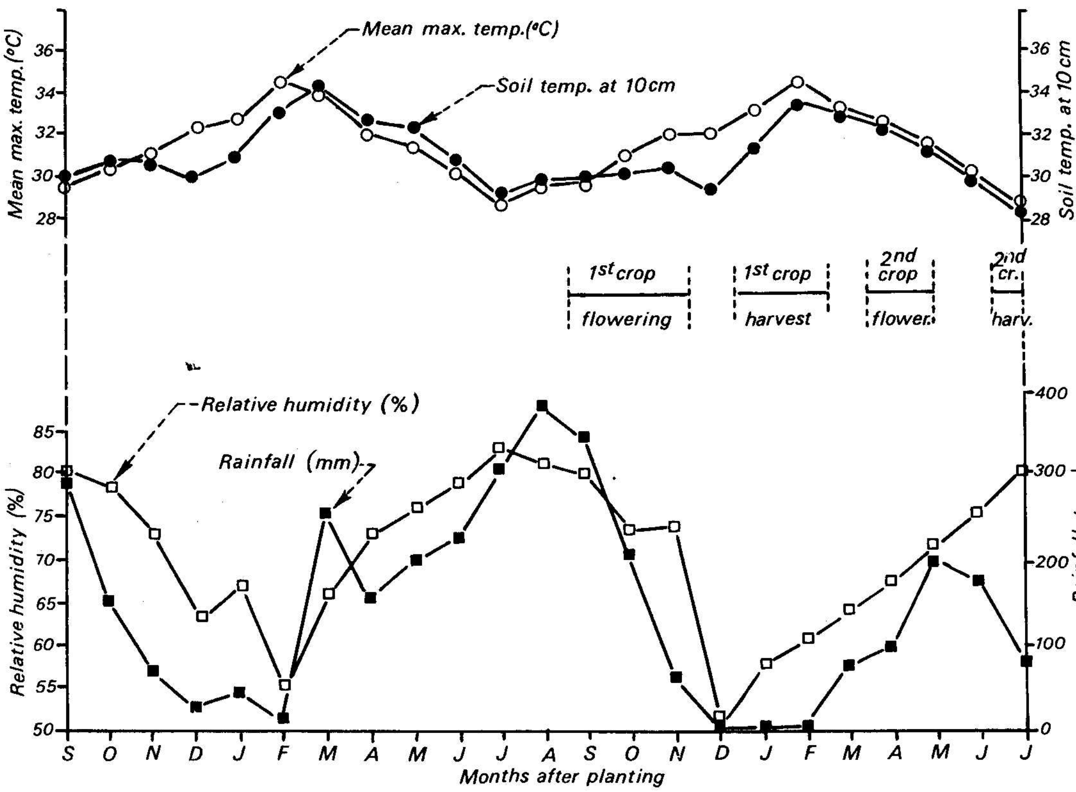

Figure 1 • METEOROLOGICAL DATA DURING THE GROWING PERIOD OF THE TWO CROPS.

TABLE 1 - Mean growth parameters of pineapple at five N rates for two crops.

Crop	Nitrogen applied (kg ha^{-1} $year^{-1}$)	No. of leaves at 50% flowering	Length of D leaf (cm)	Days to 50 % flowering	Days to 50% harvest
1	0	70.3	60.7	473.5	568.5
	50	74.9	63.2	466.3	556.6
	100	79.1	70.3	457.5	547.9
	150	86.6	71.8	440.7	529.6
	200	84.5	67.6	434.2	515.8
LSD (0.05)		5.5	2.4	10.2	18 5
2	0	62.6	56.5	647.3	737.6
	50	63.2	55.2	636.9	722.3
	100	67.5	62.9	631.5	720.8
	150	68.1	67.3	618.0	708.5
	200	65.3	71.7	607.8	698.2
LSD (0.05)		6.2	3.8	12.1	10.6

served during the second crop except that N rates had no significant effect on number of leaves.

The more frequent irrigation treatments (1.0_{I3} and 0.5_{I7}) significantly (P = 0.05) increased rate of leaf formation in pineapple (Table 2) but they were not significantly different from each other. The control (I_0) gave the least rate of leaf formation. Nitrogen in excess of 150 kg ha^{-1} $year^{-1}$ had no significant effect on rate of leaf formation even though the 200 kg ha^{-1} gave the highest numerical value of 4.86. There were significant differences in the interaction between irrigation and nitrogen.

Leaf area was significantly influenced by increased levels of irrigation and N rates for the two crops (Table 3). An annual rate of 150 kg ha^{-1} of N with 1.0_{I3} produced the largest leaf area in the first crop. The interaction between irrigation and nitrogen was not significant in the second crop. However, the highest nitrogen rate and the once a week irrigation produced the largest leaf area in the second crop. Leaf area in the second crop was found to be smaller than in the first crop.

YIELD

Increasing N rates significantly (P = 0.05) increased fruit weight (Table 4). However, there was no significant difference in fruit weight between the 150 and 200 kg ha^{-1} $year^{-1}$ N rate in both first and second crops. Crown weight was unaffected by increased N rates beyond 100 kg ha^{-1} $year^{-1}$, however, the 200 kg ha^{-1} $year^{-1}$ N rate produced the heaviest crowns in both crops. Stalk weight was not significantly influenced by N rates though the 100 kg ha^{-1} $year^{-1}$ rate produced the heaviest stalks in both crops. The percentage of fruits harvested increased with increase in N rates but in the second crop it declined with the 200 kg ha^{-1} $year^{-1}$ rate.

Potential and harvested yield of the two crops are presented in Table 5. Increasing N rates was most effective in increasing both potential and harvested yield at the most frequent irrigation (1.0_{I3}).

TABLE 2 - Mean rate of leaf formation at the 10th month of the plant crop at five N rates and four I levels.

Nitrogen applied (kg ha^{-1} $year^{-1}$)	Irrigation treatments I_0	0.5_{I14}	0.5_{I7}	1.0_{I3}	Nitrogen mean
0	2.61	3.08	4.39	4.82	3.73
50	3.02	3.49	4.48	5.09	4.02
100	3.17	3.83	5.29	5.35	4.41
150	4.03	4.45	5.44	5.18	4.78
200	4.25	4.75	5.35	5.09	4.86
Irrigation mean	3.42	3.92	4.99	5.11	

I_0 : non-irrigated control

0.5_{I7} and 0.5_{I14} : irrigation treatment receiving 50% consumptive use less effective rainfall every week and two weeks, respectively

1.0_{I3} : irrigation treatment receiving 100% consumptive use less effective rainfall every three days.

LSD (0.05) between two mean I levels = 0.28

LSD (0.05) between two mean N rates = 0.35

LSD (0.05) between two mean I x N interactions = 0.69

TABLE 3 - Leaf area of pineapple at 50% flowering at five N rates and four irrigation levels.

Nitrogen applied ($kg\ ha^{-1}\ year^{-1}$)	Irrigation treatments									
	I_0	0.5_{I14}	0.5_{I7}	1.0_{I3}	N mean	I_0	0.5_{I14}	0.5_{I7}	1.0_{I3}	N mean
	First crop				Leaf area (cm) x 10^3				Second crop	
0	2.53	2.88	3.35	3.60	(3.09)	2.36	2.41	2.62	2.85	(2.56)
50	2.68	2.92	3.79	4.33	(3.43)	2.48	2.50	2.64	2.50	(2.53)
100	3.05	3.53	4.49	5.05	(4.03)	2.65	2.82	3.34	3.51	(3.08)
150	3.59	4.16	4.85	5.44	(4.51)	2.91	3.23	3.58	3.56	(3.32)
200	3.62	4.18	4.42	4.34	(4.14)	3.07	3.21	3.76	3.52	(3.39)
I mean	3.09	3.53	4.18	4.55		2.69	2.83	3.19	3.19	

I_0 : non-irrigated control

0.5_{I7} and 0.5_{I14} : irrigation treatment receiving 50% consumptive use less effective rainfall every week and two weeks, respectively

1.0_{I3} : irrigation treatment receiving 100% consumptive use less effective rainfall every three days.

LSD (0.05) between two mean I levels = 0.32

LSD (0.05) between two mean N rates = 0.20

LSD (0.05) between two mean I x N interactions = 1.5

DISCUSSION

The trial was established during the late season which was followed by 3-4 months of dry season. This might have caused the significantly (P = 0.05) low rate of leaf formation in spite of increasing N rates, applied to the non-irrigated plots. More frequent irrigation beyond 0.5_{I7} did not significantly increase rate of leaf formation. In effect, at the 150-200 $kg\ ha^{-1}\ year^{-1}$ N rates, rate of leaf formation decreased at the most frequent irrigation treatment. This may be due to lack of contrasting soil moisture stress during the rainy season coupled with leaching when this record was taken (Fig. 1). An annual rate of 150 $kg\ ha^{-1}$ N produced the highest rate of leaf formation at the 0.5_{I7} irrigation level.

Increasing N rates increased number of leaves produced in the plant crop but had no significant effect on leaves produced in the ratoon crop. They also influenced leaf area. However, no significant differences were observed in the mean leaf areas obtained at the two highest N rates and the two most frequent irrigation levels for the plant and first ratoon crops. The lower values obtained for leaf number and leaf area for the first ratoon crop may have been because most of the vegetative growth took place during the dry season with high mean maximum temperatures and low relative humidity during the harmattan months. Fletcher *et al.* (1966) attributed differences in growth and yield of peas planted at different dates to differences in mean maximum temperature during the period of growth. Seasonal pattern of N mineralization, especially in acidic soils (Davy and Taylor, 1974) may also have contributed to the differences in vegetative growth of the two crops.

Nitrogen, in excess of 100 $kg\ ha^{-1}\ year^{-1}$ produced no significant additional increases in bunch weight except for small but significant reductions in times of flower emergence and harvesting. Similar results have been observed in banana (Lahav *et al.*, 1981). This rate of N application was most effective in increasing stalk weight at both crops. Fruit development in the plant and first ratoon crops occurred during the dry and rainy seasons respectively. This may have contributed to the differences in yield

TABLE 4 - Mean yield parameters of pineapple at five N rates for two crops.

Crop	Nitrogen applied ($kg\ ha^{-1}\ year^{-1}$)	Fruit weight (kg)	Crown weight (kg)	Stalk weight (kg)	Harvest (%)
1	0	1.5	0.09	0.06	78.5
	50	1.8	0.13	0.08	80.4
	100	2.3	0.21	0.12	86.9
	150	2.8	0.22	0.08	86.7
	200	3.0	0.22	0.09	87.2
LSD (0.05)		0.45	0.09	ns	-
2	0	1.4	0.10	0.05	80.2
	50	1.9	0.12	0.07	84.6
	100	2.2	0.18	0.09	87.8
	150	2.6	0.16	0.06	87.3
	200	2.4	0.19	0.07	86.5
LSD (0.05)		0.28	0.06	ns	-

ns : not significant

TABLE 5 - Total potential and harvested yield of two crops of pineapples at five N rates and four irrigation levels.

Nitrogen applied ($kg\ ha^{-1}\ year^{-1}$)	Irrigations treatments									
	I_o	$0.5I_{14}$	$0.5I_7$	$1.0I_3$	N	I_o	$0.5I_{14}$	$0.5I_7$	$1.0I_3$	N
	Potential yield ($t\ ha^{-1}$)				Mean	harvested yield ($t\ ha^{-1}$)				Mean
0	96.5	107.2	126.9	133.4	116.0	76.5	85.0	100.7	105.8	92.0
50	133.0	147.2	154.4	157.4	148.0	109.9	121.6	127.4	129.9	122.2
100	155.3	171.0	193.4	200.3	180.0	135.6	149.3	168.9	175.0	157.2
150	188.5	208.0	238.7	228.8	216.0	164.0	180.9	207.6	199.1	187.9
200	197.3	214.5	227.6	224.6	216.0	171.4	186.4	197.7	195.2	187.7
I mean	154.1	169.6	188.2	188.9		131.5	144.6	160.5	161.0	

I_o : non irrigated control

$0.5I_7$ and $0.5I_{14}$: irrigation treatment receiving 50% consumptive use less effective rainfall every week and two weeks, respectively

$1.0I_3$: irrigation treatment receiving 100% consumptive use less effective rainfall every three days.

LSD (0.05) between two mean I levels = 28.2

LSD (0.05) between two mean N rates = 30.5

LSD (0.05) between two mean I x N interactions = 46.9

parameters since pineapple requires less moisture for fruits maturity. However, the percentage of harvested fruits in the first ratoon crop were higher than in the plant crop. Mean potential and harvested yield were similar at 150 and 200 kg ha^{-1} $year^{-1}$ N rates and $0.5I_7$ and $1.0I_3$ irrigation levels and were numerically highest at 150 kg ha^{-1} $year^{-1}$ and $0.5I_7$ treatment combination. This nitrogen/irrigation combination may likely have a more profitable cost benefit ratio when we observe that $0.5I_7$, and $1.0I_3$ out yielded I_o by 106.2% and 88.2% respectively at the same 150 kg ha^{-1} $year^{-1}$ N rate in terms of harvested yield. In a no irrigation (I_o) situation, 200 kg ha^{-1} $year^{-1}$ N rate produced similar harvested yield as 100 kg ha^{-1} $year^{-1}$ N at $1.0I_3$ irrigation. This result is interesting. It demonstrates that with irrigation, fertilizer requirement may be reduced to give similar yield results. The delayed growth with stunted plants that produced small fruits that was observed in the low N rates and less frequent irrigation goes to show that nitrogen and irrigation had a dominant effect on growth and yield of pineapple. Though higher N rates improved growth and yield appreciably, the 150 kg ha^{-1} $year^{-1}$ N rate and the $0.5I_7$ irrigation level seems more attractive on the basis of costs and benefits. It is possible that without irrigation higher N rates may be required to produce the same yield.

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ERRATUM :

Une erreur s'est glissée dans l'article de J.L. SARAH :
«Influence des traitements nématicides sur la production des rejets d'ananas»
paru dans la revue FRUITS de février 1987, vol. 42, n° 2, p. 74.
TABLEAU 4 - renvoi en chiffre : 2 et 3 : il faut lire milliers au lieu de millions