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ROOT ACTIVITY PATTERN OF PINEAPPLE (ANANAS COMOSUS) DETERMINED WITH RADIOACTIVE PHOSPHORUS DURING THE DRY SEASON

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ABSTRACT

An experiment was carried out at Iwuru, near Cross River States University of Technology, Akamkpa Campus to determine the root activity pattern of one year old pineapple plants, using the soil injection techniques and the 4th leaf as an index of root activity; with 32P labeled phosphorus solution. Activity was measured at 5, 10, 15 and 20cm distances from the plant and 10, 20, 30 and 40cm depths. The uptake of 32P was greatest at the 5cm distance and the 10cm depth, and was statistically significant (P>0.05) at all the sampling dates. About 65-85% of the root activity was confined within 10-15cm depth. The coefficient of variability of the treatment at all sampling dates showed that at the 6th and 8th weeks, the variabilities were similar and higher than the coefficient of variability at the 4th week. There was high activity obtained at the 20cm distance and this suggests that zones of high nutrient uptake extend far beyond the immediate precincts of the hole of the plant and the usual ring weeded area. For maximum efficiency of fertilizer utilization by pineapple plants at adult stage, it is suggested that fertilizer should be applied on the surface within a ring extending up to about 20cm radius from the plant. These results are discussed in light of root activity in pineapple nutrition and management.

KEY WORDS: Root Activity, radioactive phosphorus in pineapple.

INTRODUCTION

Plants generally depend on their root system for the uptake of water and nutrients. Outside the content of nutrients and moisture in the soil and the vigour of the root system, absorptive capacity is often determined by the distribution and extend of the root system (Schuurman and Goeded-Waagen 1971; Hassan and Leitch 2000). For maximum efficiency in fertilizer utilization, a knowledge of the root distribution and the zones of the root system that are active in nutrient uptake are of utmost importance. Equally, it is important to know the effects of climate, soil and cultural practices on the distribution and activities of the root, especially for phosphorus and nitrogen fertilization under tropical conditions due to the high fixation of the former and the high rate of leaching of the latter (Wilman *et al* 1999, Ubi *et al* 2005). However, standard field methods based on yield data for determination of best placement, time of application and chemical form of fertilizer can give direct measure of nutrient uptake by the plant, but they suffer from a number of limitations. Firstly, yield differences may not be due to treatment effect a lone but also due to the uptake of soil nutrients. In addition, there is the limitation and unlike annual crops which can be wholly harvested and the total nutrient uptake determined, total analysis of trees is impractical so that quantitative conclusions in the evaluation of fertilizer treatment are difficult to achieve. Such trials are expensive, laborious and are space and time consuming. These problems have led to the discovery of radioisotope tracer technique for measuring the root activity pattern of crops in situ. This method has the advantage that it is quick and direct. Ahenkorah (1975, 1976) used radioactive phosphorus to determined the distribution of root activity and the efficiency of fertilizer utilization of mature cocoa trees. The radio isotope technique has also been used to study the root activity pattern of other economic trees like rubber and apple tress (Broeshart and Nethsinghe 1971; Atkinson 1974; Jones 1990; Osodeke 1999). Phosphorus has the advantages that it is practically immobile in the soil and is cheap and has short-half life span thus making it comparatively safe for use. The choice of 32P for this study was based on the assumption that the results obtained with phosphorus would be applicable to other nutrient elements as well. This being the case has definitely been confirmed by double labeling roots with 32P and 15N Broeshart and Nethsinghe (1972). Work on radio isotope of annual crops such as pineapple had not been done. The objective of this study was to investigate the distribution pattern of root activity of pineapple in acid sands of Cross River State, Nigeria.

MATERIALS AND METHODS

The trials was carried out in 2002 and 2003 at Iwuru near Cross River State University of Technology, Akamkpa, which lies 8°14 and 8°20′E longitude and 5°14N and 5°14′N latitude. The trial was set up in a 4 x 4 factorial scheme in a randomized complete block design (RCBD) replicated four times. The pineapple cultivar used was smooth cayenne (with spineless and smooth leaves) planted on April 5th, 2001 at a spacing of 30cm within and 50cm between rows, prior to the experiment in 2002.

The four applications depth were 5, 10, 15 and 20cm, and the four distances were 10, 20, 30 and 40cm. Plot size was 5m x 40m, and the sampling area was 5m x 5m, from the pineapple stand.

The 32P labeling was done by the soil injection technique (IAEP TRS No. 170, 1975). Each plant was treated with 2.75, Ci 32P distributed in equal aliquots of approximately 172m Ci each in 5ml 1000 PM P solution (as KH2 PO4) at 10 equidistant holes in ring round the plant. This method ensures rapid translocation to all parts of the plant (Broeshart and Nethsinghe, 1972). The level of carrier 31P added was designed to nullify the effects of variations in labile-P in the soil profile so that uptake of 32P should be proportional to rooting density (Nye and Foster, 1961; Singh et al, 1972).

The holes were made ready a day to the application using a screw auger. The radioactive solution was prepared in Winchester quarts fitted with automatic tubing fitted to the dispenser and via a glass tube placed in the hole. This was to ensure that there was no contamination of soil with 32P above the depth of interest. Application was done on the 5th of April, 2004. The holes were refilled with the soil augured out and injection points were labeled. Each 32P treated plant was

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surrounded by fifty contact plants to avoid poaching. From around each treated plant, soil samples were taken at each specific depth and distance for moisture determination, deploying the methods of Black (1965).

In the leaf sampling, leaf 4 was chosen as the index of root activity, equally leaves 10 and 15 were sampled from the sampling area in order to compare the 32P uptake in these leaves with leaf 4. The leaf samples were taken 4, 6 and 8 weeks after the application of the 32P to the soil. A leaf sample consisted of leaflets taken from either side of the stem, from the top, middle and based positions.

Samples were cleaned in the laboratory and the leaflets were chopped, mixed and oven dried at 80°C for 36-48 hours. The oven-dried samples were milled and thoroughly mixed. About 10g of the found sample was dried ashed at 50°C for 3 hours. The ashed materials was digested with 20% nitric acid and made up to volume in a 50ml volumetric flask, (IITA, 1979).

About 1ml of the digest was counted in 15ml liquid scintillation cocktail (INSTAGL) in a Packard Tricarb Beta Liquid scintillation counter. Samples from four non-treated plants were also prepared and counted for background radioactivity. All counts were corrected for decay to a common time. Phosphorus in the samples was determined by the molybdenum blue method using the Technician Autoanalyser (Mehlich, 1984).

STATISTICAL ANALYSIS

Field and laboratory data were subjected to analysis of variance (ANOVA) and means compared with Fisher's Least Significant Difference (LSD) at 5% probability level according to Wahua (1999).

RESULTS

The results of 32P uptake at four depth distances are shown in Tables 1 and 2 respectively for the 4th, 6th and 8th sampling dates. The results showed that at all the distances and depths tested, the roots were active in 32P uptake. In general, at all sampling dates, 32P uptake was highest at the 5cm distance and decreased thereafter with the least at the 15cm distance and a further increase at the 20cm distance. The pattern of uptake with depth was not consistent. In many cases uptake of 32P was highest at the 10cm depth and was significantly ($P<0.05$) higher than those of all other depths throughout the study period. The statistical analysis of the data showed that at the 4th, 6th and 8th weeks (Table 1) and at all the sampling dates (Table 2) the uptake of 32P at the 10cm depth and 5cm distance was significantly ($P<0.05$) higher than the other depths and distances tested when given similar treatment.

The treatment means for the total P content are shown in Table 3. All the treatments showed similar P content at all the sampling dates. In order to obtain a root activity profile, the mean 32P uptake was expressed as a percentage of the integrated counts down the profile at each distance. The results are presented in Table 4. They showed that in the dry season about 65-85% of the active roots in the 10 to 40cm depth zones is located within the 10 to 30cm depths, with 60-75% concentrated within the 10-20cm depth. The mean radioactivity in leaves 4, 10 and 15 of the fifty randomly selected plants is presented in Table 5. At all the sampling dates, the 32P content of the 4th and 10 leaves were similar and significantly ($P<0.05$) higher than the 32P content of the 15th leaf.

DISCUSSION

The significantly higher uptake of 32p at the 5cm distance and 10cm depth implies that during the dry season in which this experiment was conducted, the most active roots in nutrient uptake for these one year old plants were at the 5cm distance and 10cm depth. The pattern of the uptake with depth was not consistent and this was attributed to the fact that moisture differences with depth influenced uptake and agrees with the results of Broeshart (1959); Hassan and Leitch (2000).

In both the wet and dry season studies in the Ivory Coast (IAEA TRS No. 1975) highest root activity was at the 0 and 20cm depths, the activity at both positions being similar. The main effects of depth reached statistical significance at all sampling dates but there were insignificant differences between the various distances (5, 10, 15 and 20cm) tested. In this study, the high activity obtained at the 20cm distance suggests that zone of high nutrient uptake extend far beyond the immediate precincts of the hole of the plant and the usual ringweeded area and is in agreement with the results of Purveys 1956. Ahenkorah (1979). Thus, for matured plant of pineapple there is need to extend the area of fertilizer application to a much larger circle (up to 20cm radius) than is currently practiced. Such a practice would enhanced fertilizer utilization efficiency by the entire plant because more feeding roots would be exploiting the applied nutrients (Wool-house, 1992). Equally, leaching losses of mobile nutrients of soil would be minimized due to reduced fertilizer concentration per unit area while P which because of strong adsorption is confine to a small soil volume would now be exploited by more roots of pineapple in the expanded circle. Thus, apart from efficiency in the use of the applied fertilizers, the plant would be exploiting more of the available soil nutrients and would stimulate root proliferation into new areas of all classes, show a positive tropism towards superior conditions of water and nutrients as reported by Harley (1977).

The results do however show the extent of plant-to-plant variability in nutrient uptake. These variations may be due to actual differences in root activity patterns coupled with localized soil heterogeneity. The inconsistent coefficients of variability obtained particularly between the 4th week on one hand and the 6th and 8th weeks on the other hand are probably due to the fact that even an individual plant fluctuates in its capacity to absorb the P applied during the relatively short experimental period (IAEA TRAS NO 170, 1975).

The observed differences in 32P uptake between the younger leaves (4 & 10) and the older leaf 15 suggest differences in translocation rate of this element to leaves of different ages.

CONCLUSION

The index of root activity used in this study for all the plants was leaf 4 and so, comparisons between plant remain valid. Further investigations on this subject, particularly the interactions if any between leaf type and root position are needed for effective conclusion to be drawn.

Table 1: 32P content of 4th leaf in counts 1mm per 10g dry material means of 4 replicates

Sampling interval (Wks)	Depth (cm)	Distance (cm)				LSD (0.05)
		5	10	15	20	
		2002				
4	10	64.0	25.0	17.0	29.0	4
	20	55.0	40.0	16.0	22.0	6
	30	34.0	23.0	20.0	24.0	3
	40	25.0	21.0	16.0	20.0	3
	Mean	44.5	27.3	17.3	23.8	-
6	10	86.0	57.0	48.0	74.0	9
	20	74.0	66.0	36.0	64.0	8
	30	69.0	65.0	39.0	34.0	5
	40	35.0	51.0	24.0	17.0	6
	Mean	66.0	59.8	36.8	47.3	-
8	10	281.0	155.0	118.0	126.0	8
	20	220.0	135.0	101.0	100.0	34
	30	165.0	118.0	85.0	45.0	33
	40	140.0	80.0	41.0	25.0	15
	Mean	202.3	122.0	86.3	74.0	-
2003						
4	10	66.0	23.0	19.0	27.0	4
	20	57.0	42.0	18.0	20.0	8
	30	36.0	25.0	24.0	26.0	8
	40	27.0	19.0	18.0	20.0	5
	Mean	46.5	27.3	19.8	23.8	-
6	10	88.0	59.0	50.0	78.0	9
	20	70.0	66.0	34.0	66.0	22
	30	69.0	65.0	37.0	32.0	12
	40	33.0	53.0	26.0	19.0	77
	Mean	64.5	60.8	36.8	48.8	-
8	10	289.0	157.0	122.0	130.0	8
	20	228.0	137.0	101.0	102.0	20
	30	168.0	112.0	87.0	41.0	25
	40	142.0	82.0	43.0	23.0	20
	Mean	206.7	122.0	88.3	74.0	-

Table 2: Mean specific activities 32P contents/Min. per MGP (Mean of 4 Replicates)

Sampling interval (Wks)	Depth (cm)	Distance (cm)				LSD (0.05)
		5	10	15	20	
		2002				
4	10	5.60	2.70	1.60	1.70	0.51
	20	5.40	2.87	1.73	1.90	0.53
	30	3.16	2.16	1.58	1.90	0.42
	40	0.10	2.63	1.20	1.61	0.30
	Mean	3.57	2.59	1.53	1.77	-
6	10	9.20	7.10	4.86	6.40	1.20
	20	6.72	6.40	2,74	5.18	2.14
	30	5.10	4.60	2.11	4.20	1.12
	40	3.10	3.44	2.00	3.00	0.34
	Mean	6.03	3.38	2.9	4.6	-
8	10	31.10	18.60	6.95	8.60	2.40
	20	18.26	13.40	4.10	7.20	3.18
	30	12.10	12.18	2.00	6.28	3.10
	40	10.28	8.10	1.58	3.30	1.25
	Mean	17.95	13.07	3.65	6.35	-
2003						
4	10	5.64	6.60	1.70	1.74	0.61
	20	5.42	2.87	1.73	1.90	0.74

	30	3.12	2.16	1.50	1.80	0.31
	40	0.10	1.63	1.30	1.61	0.20
	Mean	3.57	3.32	1.55	1.76	-
6	10	9.30	7.16	4.86	6.42	1.20
	20	6.72	6.44	2.70	5.18	1.14
	30	5.20	4.62	2.11	4.28	0.52
	40	3.10	3.00	2.10	3.30	0.20
	Mean	6.08	5.31	2.94	4.79	-
8	10	31.18	18.64	6.95	8.66	1.60
	20	18.26	13.48	4.10	7.00	2.85
	30	12.14	12.10	2.20	6.20	4.00
	40	10.28	8.14	1.50	3.00	2.12
	Mean	17.76	13.09	3.68	6.22	-

Table 3: Total P Content of 4th leaf in MGP/10g dry matter (Mean of 4 replicates)

Sampling interval (Wks)	Depth (cm)	Distance (cm)				LSD (0.05)
		5	10	15	20	
		2002				
4	10	13.70	14.10	18.32	16.14	NS
	20	15.56	12.60	12.00	13.05	NS
	30	13.70	11.00	14.28	14.16	NS
	40	12.00	15.30	14.22	12.60	NS
	Mean	15.29	13.25	14.70	13.98	-
6	10	14.30	14.36	12.14	14.72	NS
	20	18.14	14.00	11.25	12.50	NS
	30	12.10	12.82	12.18	12.36	NS
	40	11.24	12.74	12.20	13.00	NS
	Mean	13.99	13.48	11.94	13.15	-
8	10	13.26	13.70	13.54	14.14	NS
	20	14.42	12.18	14.18	12.01	NS
	30	14.50	10.10	14.06	12.26	NS
	40	11.08	10.00	14.00	12.54	NS
	Mean	13.32	11.50	13.95	12.74	-
2003						
4	10	13.74	14.12	18.30	16.10	NS
	20	15.00	12.60	12.02	13.05	NS
	30	13.72	11.20	14.20	14.16	NS
	40	12.30	15.00	14.20	12.68	NS
	Mean	13.69	13.23	14.68	13.99	-
6	10	14.40	14.36	12.10	14.70	NS
	20	18.10	14.30	11.25	12.50	NS
	30	12.18	12.80	12.18	12.30	NS
	40	11.20	12.70	12.24	13.00	NS
	Mean	13.97	13.54	11.94	13.20	-
8	10	13.26	13.74	13.50	14.10	NS
	20	14.40	12.18	14.18	12.01	NS
	30	14.56	10.18	14.06	12.26	NS
	40	11.08	12.20	14.10	12.50	NS
	Mean	13.33	12.08	13.96	12.72	-

Table 4: Mean 32P uptake expressed as percentage of the relative counts in the 4th leaf at four different depths and distances

Sampling interval (Wks)	Depth (cm)	Distance (cm)				LSD
		5	10	15	20	
		2002				
4	10	40.0	18.0	23.0	27.0	5
	20	39.0	29.0	25.0	20.0	6
	30	20.0	23.0	29.0	28.0	4
	40	10.0	21.0	24.0	23.0	3
	Mean	27.3	22.7	25.3	24.5	-
6	10	39.0	33.0	36.0	36.0	NS
	20	26.0	24.0	28.0	27.0	NS
	30	24.0	25.0	27.0	25.0	NS
	40	18.0	14.0	18.0	15.0	NS
	Mean	26.8	24.0	27.3	25.8	-
8	10	39.0	34.0	37.0	35.0	NS
	20	26.0	25.0	26.0	23.0	NS
	30	19.0	20.0	23.0	22.0	NS
	40	14.0	16.0	13.0	15.0	NS
	Mean	24.5	23.8	24.7	23.8	-
2003						
4	10	42.0	16.0	21.0	29.0	5
	20	37.0	31.0	23.0	22.0	6
	30	20.0	25.0	31.0	24.0	4
	40	10.0	19.0	24.0	25.0	3
	Mean	27.3	22.8	24.7	25.0	-
6	10	35.0	35.0	36.0	34.0	NS
	20	24.0	28.0	26.0	25.0	NS
	30	22.0	27.0	27.0	23.0	NS
	40	19.0	14.0	18.0	17.0	NS
	Mean	24.7	26.0	26.7	24.8	-
8	10	37.0	36.0	35.0	33.0	NS
	20	28.0	27.0	24.0	25.0	NS
	30	21.0	22.0	24.0	20.0	NS
	40	16.0	16.0	15.0	17.0	NS
	Mean	25.5	25.3	24.5	23.7	-

NS = Non Significant

Table 5: 32P content of leaves 4, 10 and 15 in counts/min. per 10g dry material (mean of 50 randomly selected plants)

Sampling interval (wks)	Leaf number			
	4	10	15	LSD (0.05)
4	36	35	18	5
6	37	38	24	6
8	106	105	68	25
Mean	59.6	59.3	36.6	

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