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Nutrient dynamics in vegetative propagules of pineapple (*Ananas comosus*) cultivar as influenced by post N: P: K fertilizer application in Southern Nigeria

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Abstract

Experiment was conducted in 2014 and 2015 with smooth cayenne pineapple suckers, in Calabar, Southern Nigeria. The experiment was laid out in a 25x25m Latin square with sampling area of 2^2m per block. Fifty healthy disease free plants were randomly selected for the study after treatment of N:P:K: 20:10:10 fertilizer in two split doses in 2014. The dry matters of the plant material (crown, trunk, whole plant and roots) were estimated and their nutrient contents were determined in the ages of 3, 6, 9, 12, 15 and 18 months after planting. The cumulative dry matter contents of roots, trunk and crown with a plotted summation curve showed that the curves were essentially sigmoidal, comparable to normal biological growth pattern. There were however, important differences in growth pattern between the components, assessed thus: trunk>crown>roots. The nutritional contents of the various components showed that nitrogen deteriorated with age of the plant, thus nitrogen values in the plant components were relatively variable. Potassium levels in the trunk tended to be relatively higher than values obtained from crown, particularly early in the season, under similar experimental condition. The inner trunk had appreciably higher potassium content than the outer trunk especially in young plants. The phosphorus values were lowest of all the major nutrients, in absolute terms being generally 10-20% of those of nitrogen. The trunk tended to have higher values of phosphorous than the crown. Phosphorus levels in roots and trunk tended to decrease with increase in age of the plant. The inner trunk had higher values of calcium than the outer trunk and these values tended to be higher than those of either crown or those of roots. The magnesium content was higher in the inner trunk than in the outer trunk, decreasing with increase plant age. These results are discussed in light of nutrient contents in vegetative tissues of pineapple, after N:P:K: treatment.

Keywords: Nutrient contents, vegetative tissues of pineapple, NPK fertilizer

Introduction

Research to determine the nutrient composition of the various components of a crop has become necessary as to establish quantitative relationship between dry weight of these components and the various nutrient composition of the plant. Thus, Ng and Thomboo (1967) [7]. determined the nutrient composition of Dura plants and established quantitative relationship between plant dry weight of the reproductive organs and the total content of various plant nutrients. Their results enabled precised estimate of the amount of nutrients removed by fruit bunches and male inflorescence during cropping. This information constitutes one of the basic ingredients for formulating sound fertilizer schedule for different levels of production and soil type. However, such data by themselves are not entirely adequate for this purpose because in order to obtain a complete assessment, it is equally essential to determine the quantities of nutrients required for annual vegetative growth during the normal life-cycle in a crop, (Omaliko, 1980) [9]. Such an assessment involves destructive sampling of whole plant of varying ages. Zeller (1991) [20]. analyzed a single plant and with sufficient data, he was able to establish quantitative relationship between plant dry matter and nutrient composition of the plants. Equally, Tinker and Smilde (1963) [12]. carried out similar study involving destructive sampling of whole 20 plants of varying ages and established relationships between stem height and dry matter yield in log. Values and ages of plants and small curve were drawn through the plants obtained. Pineapple nutrition is attracting world interest today and the demand for the fruits is high. It is in consideration of the high demand and poor productive level of this crop that this research was carried out with N:P:K: 20:10:10 fertilizer in southern Nigeria to access nutrient contents of the vegetative parts and the uptake of nutrients and its relationship with dry matter.

Materials and Methods

The experiment was carried out in April 2014 and 2015, in Calabar, Southern Nigeria, which lies between latitude 05º32' and 04º27'N and longitude 07º15' and 09º28'E. The area is of humid tropical climate, characterized by high rainfall with two main seasons, dry and rainy seasons. The vegetation is tropical rain forest of the humid agro-ecological zone in Nigeria. According to USDA system of classification (Soil Survey Staff, 1998) [11], Calabar soils are typic paleudult. The soil is acid sands derived from coastal plain sands consisting sand deposits which lie across Cross River and underlain by massive deposits of limestone, quartz, Fe and Al oxides dominate the soil with kaolinite as clay mineral and the soil texture is sandy loam (Udo, 1977), (Fig. 1).

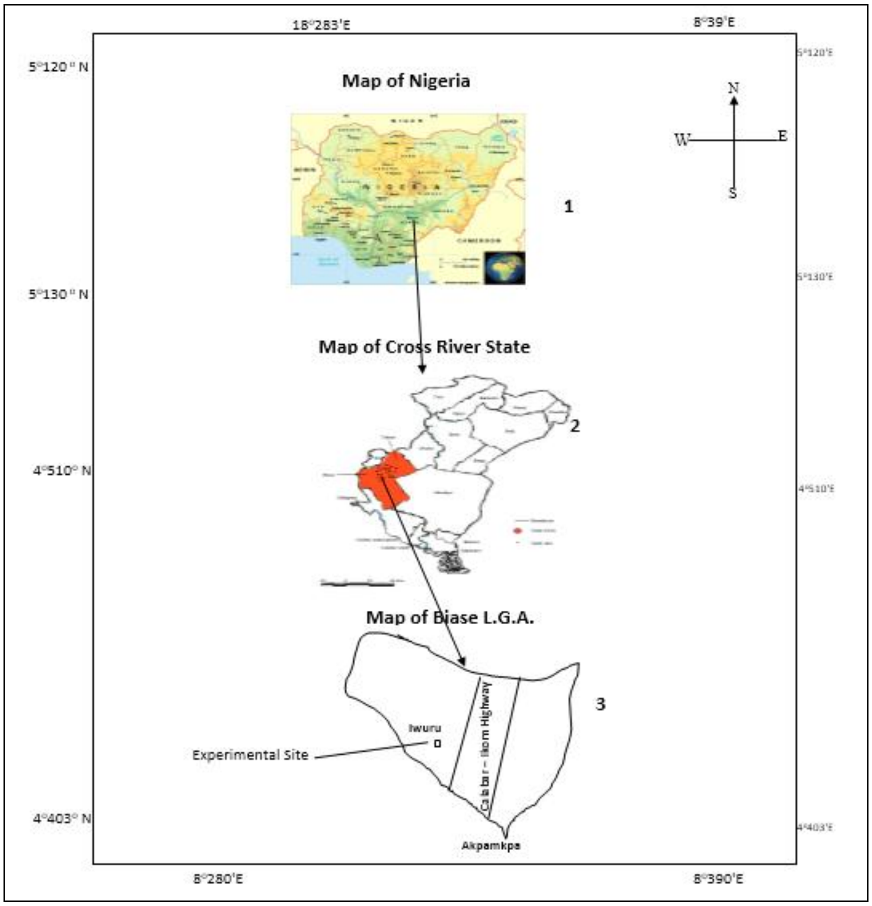


Fig 1: Maps showing experimental site

Soil Sample Collection and Analysis

Prior to the treatment application, the experimental site was cleared with a matchet and gathered together and removed. Soil samples were collected with the use of an auger in each plot at soil depth of 0-15cm and 15-30cm. The composite soil sample of each depth was air dried and sieved through a 2mm sieve and used for physical and chemical analysis. Soil physical and chemical characteristics were determined using standard analytical methods before planting the crop. The soil fertility class shown below was used to classify the level of nutrient availability (Table 1). The following are the various methods, used for the analysis. The particle size distribution was determined by Bouyoucos hydrometer method (Day, 1965) [4]. Soil pH was determined in a 1:25 soil water suspension using a glass electrode pH meter. Organic matter was determined by the dichromate wet oxidation method of Walkley and Black as outlined by Allison, (1965) [1]. Total N was determined by the micro Kjeldhal's method (Bremmer, 1965) [2]. Phosphorus was extracted by the ammonium molybdate blue method (Bray and Kurtz, 1945). Exchangeable bases of potassium, calcium, magnesium and sodium were determined from the extract obtained after leaching the samples with IN neutral ammonium acetate (NH_4OAC) solution. Exchangeable potassium and sodium contents were determined on the flame photometer while calcium and magnesium were determined by atomic absorption spectrophotometer. Exchangeable acidity was extracted with IN KCL (Mclean, 1964) while ECEC was by summation of the exchangeable, cations and exchangeable acidity. Base saturation was calculated as the sum of the bases (Total Exchangeable Bases TEB) dividedly by CES.

Experimental Design

The experiment was laid out on a 25x25m Latin square, with a sampling area of 2^2m from the plots to be used for the study and were randomly selected.

Determination of Nutrient Concentration in the Plant Parts: N:P:K:, Ca, Mg and Dry Matter

Plant leaves and roots of pineapple were variously collected from all the 2^2m area marked out in all plots for this study. The replicates of each plant were weighed for fresh weight and collected in polythene bags. In the laboratory, the plant materials were thoroughly washed under running tap to remove soil particles, and oven dried at a temperature of 80°C for 48 hours in a Gallen Kamp forced air laboratory Oven and then weighed. 500g sample fresh weight was taken, then dried with other samples and the dried weight taken. The percentage DMY was calculated thus: % DMY =

$$\frac{Dry\ Weight}{Sample\ \ fresh\ weight} \times \frac{100}{1}$$

The dried samples were pulverized to fine powder in a SNA 505 (Peppink Deventer) laboratory stainless grinder for chemical analysis. 2.0g of the ground samples were weighed into a clean crucible and ashed in the furnace for three hours at 600°C. The ashed samples were cooled to room temperature in a dessicator (drying agent was magnesium sulphate $MgSO_4$). The ash was completely dissolved in 5ml volumetric flask.

The solution was analyzed for contents of N, P, K, Ca and Mg, using Atomic Absorption Spectrophotometer (AAS).

Planting Materials

The primary consideration of this study was to ensure that the 50 pineapple plants used for this study were uniformly high yielding, healthy, nutrient and disease wise, and unaffected by heavy fertilization to avoid possible luxuriant uptake of nutrients.

Planting of Pineapple Suckers

Selected and good suckers were planted 30x30cm within the rows and 50cm between rows. Weeding was done as at when due, and all other cultural practices were carried out around the periphery to avoid attack from rodents and other destructive animals.

Fertilizer Application

The fertilizer used was N:P:K: 20:10:10 applied at the rate of 90kgha^{-1} (Ubi *et al.*, 2005) [14, 17] in two splits doses, at planting and six months after planting.

Plant Components

The pineapple suckers were conveniently separated into the following;

(i) crown,
(ii) roots
(iii) inner trunk
(iv) outer trunk
(v) trunk
(vi) whole plant.

In an investigation of the scale undertaken, sampling formed a major part of the programme. Thus, we have (a) field sampling and (b) laboratory treatment. Great precaution was taken to avoid soil contamination during field sampling and laboratory treatment.

Field Sampling

In every plot, an area of 2^{2}m was marked out from where sampling would be made. Within each unit, one healthy pineapple was selected at random for destructive sampling. Beginning from the surface, roots within each soil compartment were obtained by excavating the volume of soil and picking out all several living roots. As much soil adhering to the roots were removed as possible and the roots were placed in linen bags for laboratory analysis.

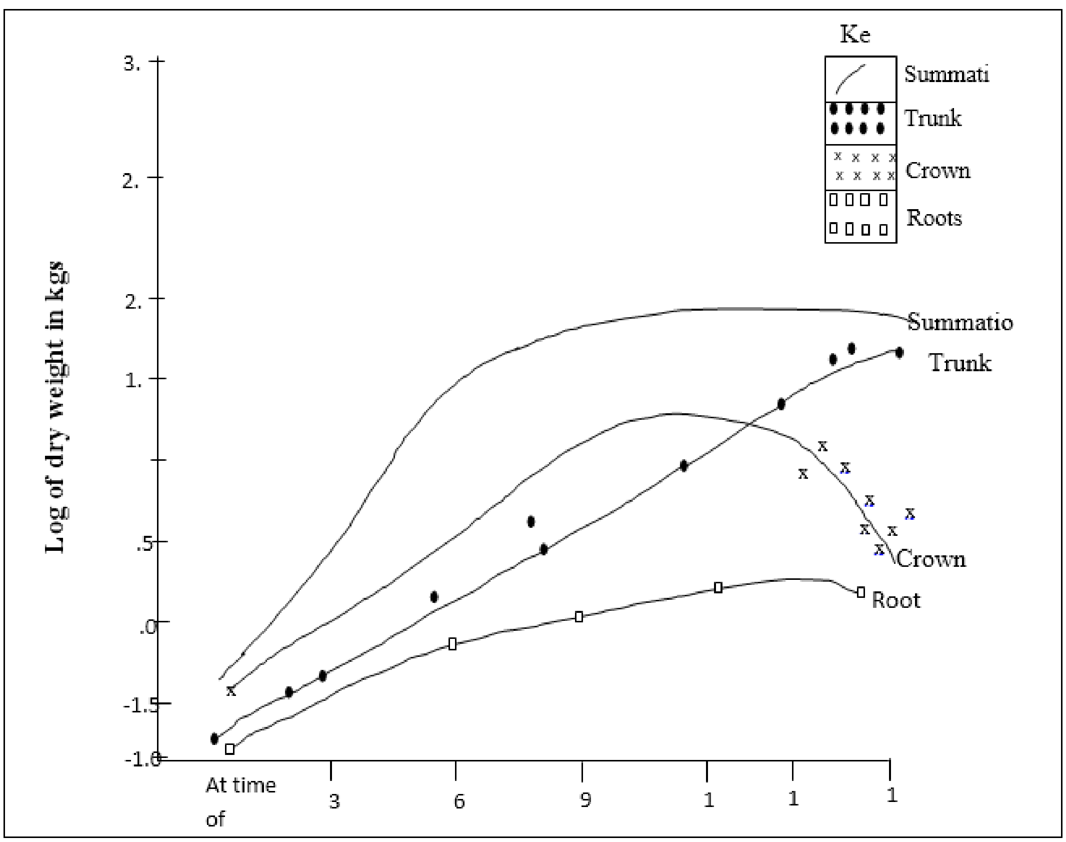
Statistical Analysis

Data was subjected to analysis of variance (ANOVA) and means compared using F-LSD (Wahua, 1999).

Results

Vegetative Dry Matter Production

To obtain a picture of the rate of net vegetative dry matter production, the dry matter contents of the components of the pineapple were plotted against age and ideal curves drawn through them. These curves are shown in fig I.



Field Age of Pineapple in (Months)

Fig 2: Cumulative dry matter contents in pineapple

As could be seen, the points were close enough to justify the idealized curves although the case of roots was less satisfactory. A summation curve was also plotted to depict total net dry matter production. The curves were essentially signmoidal, comparable to normal biological growth patterns. There were however, important growth patterns between the components.

Crown

As can be expected in the first few months, crown growth was prolific and up to about 12 months, crown tissues constituted the major proportion of total dry matter content in the plant. From then on, it took second place to trunk tissue, but it should be borne in mind that crown growth measured was not as it took account of the trunk.

Roots

Roots form the smallest component of pineapple throughout and the growth curve is rather similar to that of crown. Although it appears to take slightly longer period to reach steady growth rate. In absolute terms, roots were comparable to inner trunk in amount in mature pineapple.

Trunk

The curve for trunk shows quite precisely when it became the major component of the pineapple at 18 months. The notable feature of the curve was that after this stage, it maintained a higher relative growth rate than the crown or roots and this was the major contribution to total net dry matter increment of pineapple annually.

Summation Curve

As only seven pineapple plants were sampled for roots, the other points for the total curve were obtained by summation of the three curves for crown, trunk and roots. However, the summation curve was not closely related to that of trunk in the matured phase of the pineapple.

Table 1: Rating of soil fertility classes

Parameters	Low	Medium	High
Total N,kg^{-1}	<1.5	1.5>2.0	>2.0
Bray IP mgkg	<8	8-20	>2.0
Exchangeable Kcmol/kg^{-1}	<0.20	0.21-0.40	>0.40
Exchangeable Ca cmol/kg^{-1}	<5	5.0-10.0	>10.0
Exchangeable Mg cmol/kg^{-1}	<1.5	1.5-3.0	>3.0
Exchangeable Na cmol/kg^{-1}	<0.3	0.3-0.7	>0.7
Organic matter g kg^{-1}	<3.0	20-30	>30

Source: FMA, WR and RD 1989 FMA and NR (1990)

Table 2: Some physic-chemical properties of the soil used for the study

Location	Soil depth (cm)	Soil pH	Org. C (g/kg)	Org. matter (g/kg)	Total N (g/kg)	Bray-I P (mg/kg)	Exchangeable Bases Ca (cmol/kg^{-1} 11)	Mg	K	Na	Sand (%)	Silt (%)	Clay (%)	BS (%)	Texture
	0-15	4.6	22.8	34.9	2.1	9.2	2.42	0.5	0.4	0.3	86	7	8	29	SL
Calabar (Ikot Omin)	15-30	4.2	18.5	31.6	1.8	10.7	1.84	0.4	0.3	0.3	78	6	12	21	SL

Annual NET increment of Dry Matter in Pineapple

From the various curves in Fig. 2, the annual net increment of dry matter in respect of the major components of the pineapple were calculated (Table 3).

Table 3: Annual Net Dry Matter Increment (kg/plant) Type of Tissue Number of months in the field

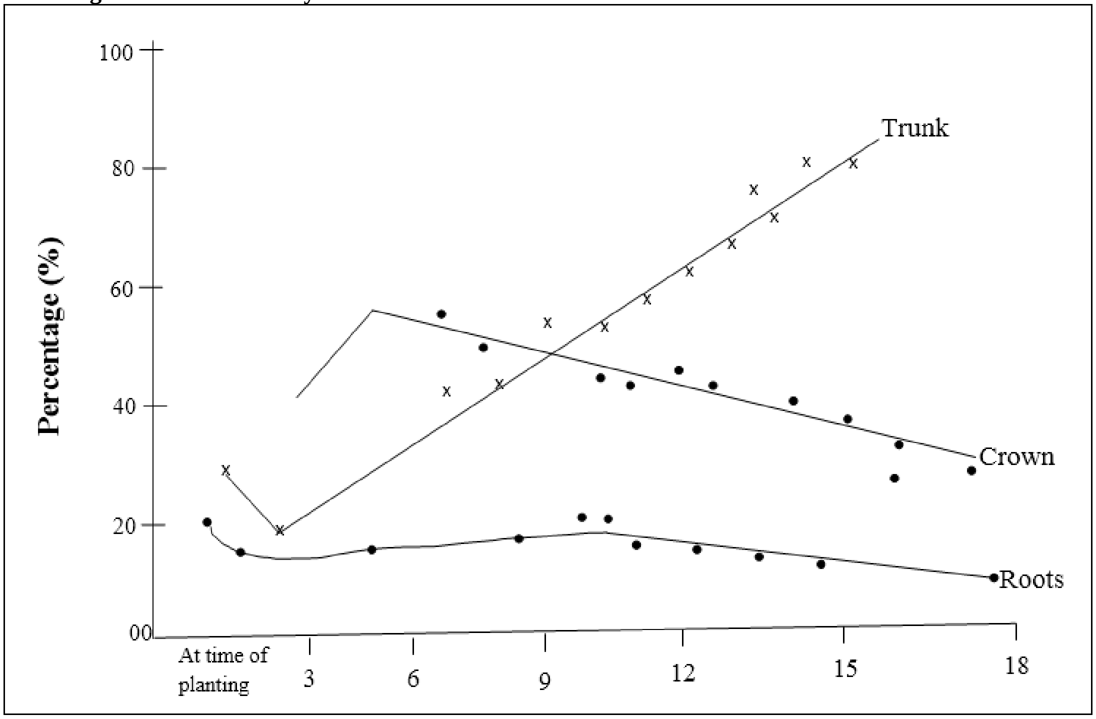
	3	6	9	12	15	18	**LSD (0.05)**
Crown	0.51	0.58	0.69	0.81	0.78	0.62	0.02
Trunk	0.65	0.71	0.83	0.98	0.83	0.71	0.03
Roots	0.36	0.39	0.46	0.52	0.41	0.31	0.02
Whole plant (from summation curve)	2.12	11.29	14.63	18.11	12.32	10.48	2.03
Relative growth rate Factor (whole plant)	1.12	1.05	0.08	0.05	0.05	0.03	0.03
Mean	0.95	2.80	3.34	4.09	2.88	2.43	-

Also included are values derived from the summation curve. Theoretically, these later values should be equal to the aggregates of the three values for crown, trunk and roots. In fact they are not. The aberrations are due to imperfections in deriving the various curves but anyhow, the deviations are not large, being in the region of 5% or less. However, the more interesting figure is the relative growth rate factor for the whole pineapple which is simply defined as;

$$\frac{\textit{Net dry matter increment in pineapple in the nth month}}{\textit{Total dry matter content in pineapple at the begining of nth month}}$$

These values are given in the last column of the table. The newly planted pineapple increased in its dry matter content consistently until it got to the 12th month when there was decrease, up to the 18th month. Over 60% of this increase was accounted for by trunk tissue.

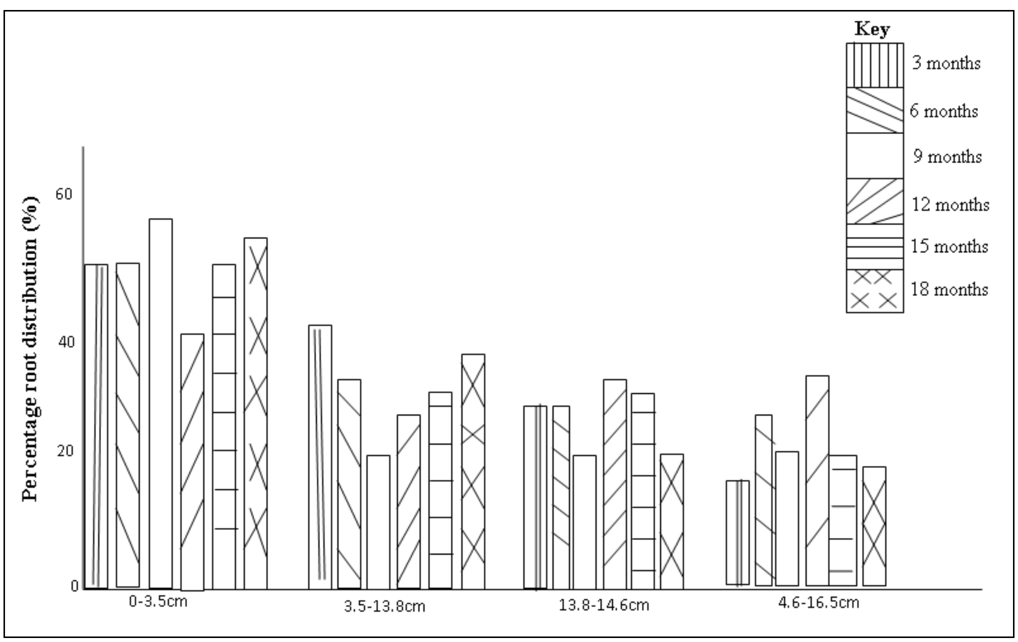
Percentage Distribution of Dry Matter Content



Field Age of Pineapple (months)

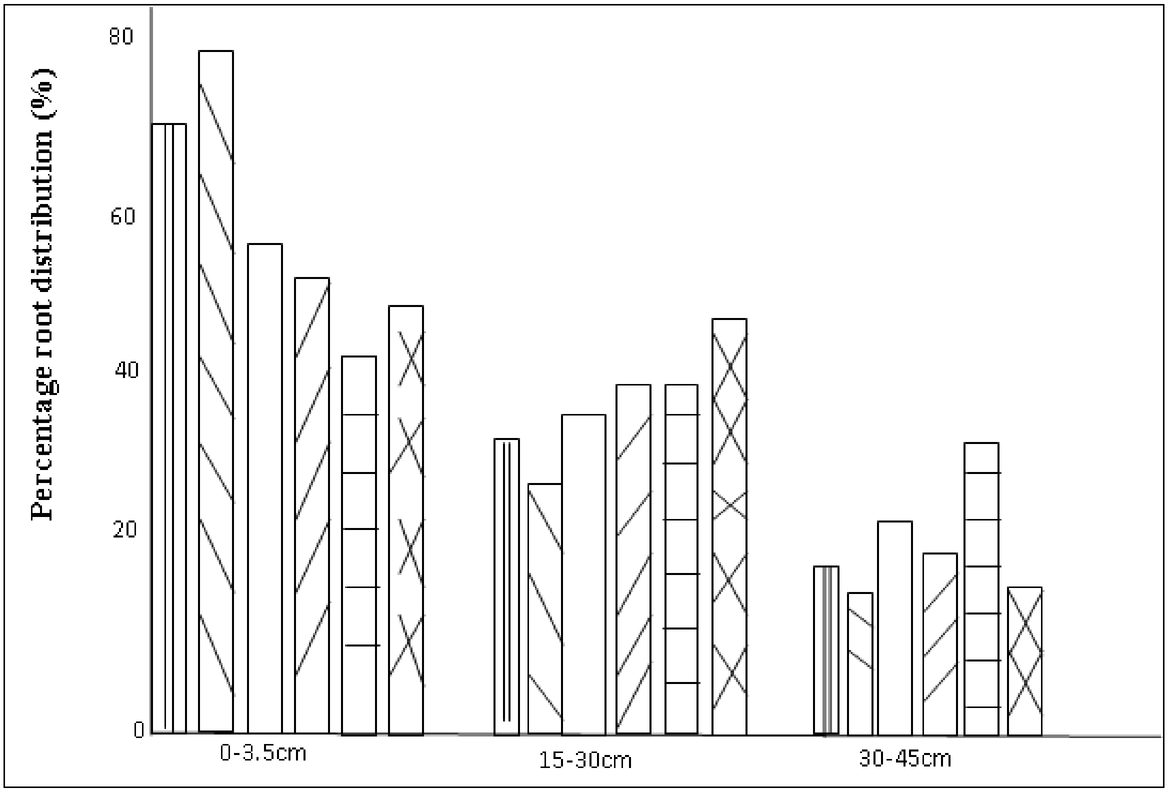
Fig 3: Distribution of total dry matter in pineapple

The proportion of trunk and crown tissues were practically inversed while root pattern followed crown in the first 6 months, but there after the percentage of roots declined as crown. Trunk tissue exceeded 50% of the total from about 6 months onwards and the proportion reached 82% at about 15 months. This value would continue to increase with time. Crown tissue declined only proportionally with age of pineapple but not in absolute values as stated previously. It is interesting to note that in the mature pineapple, roots comprised about 20-15% of the total dry matter in a declining trend, from about the 6th month.



Distance from pineapple plant

Fig 4a: Horizontal root distribution of pineapple



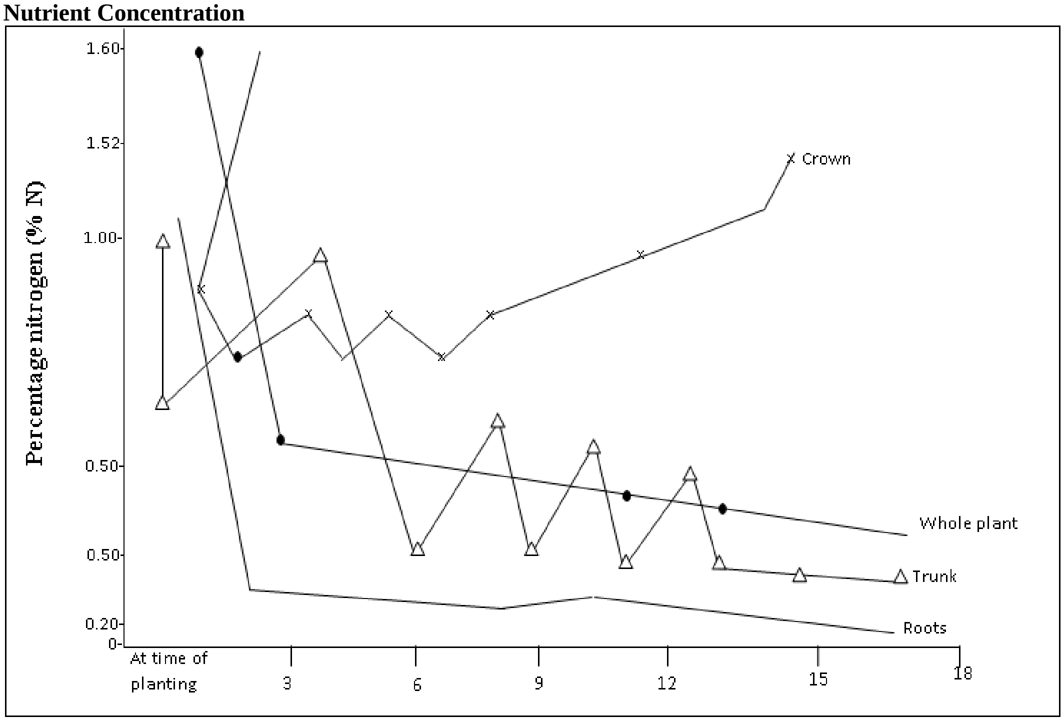
Soil Depth (cm)

Fig 4b: Vertical root distribution of pineapple

Horizontal wise, about 50-70% of the total roots were located within 13.8cm of the pineapple base, the roots of which appeared to be more evenly spread. As far as distance was concerned, the roots seemed to have extended beyond 16.5cm, but there was no conclusive evidence that the roots were evenly distributed with increasing plant age (Fig 4a).

Vertically, the majority of the roots where found in the first 15cm of the soil and as the pineapple grew older, more roots tended to develop in the second horizon. On the average, only about 15% of the roots were found below a soil depth of 30cm (Enwezor *et al.*, 1981).

Nutrient Concentration



Field Age of Pineapple (Months)

Fig 5: Nitrogen concentration in pineapple of different ages

Nitrogen

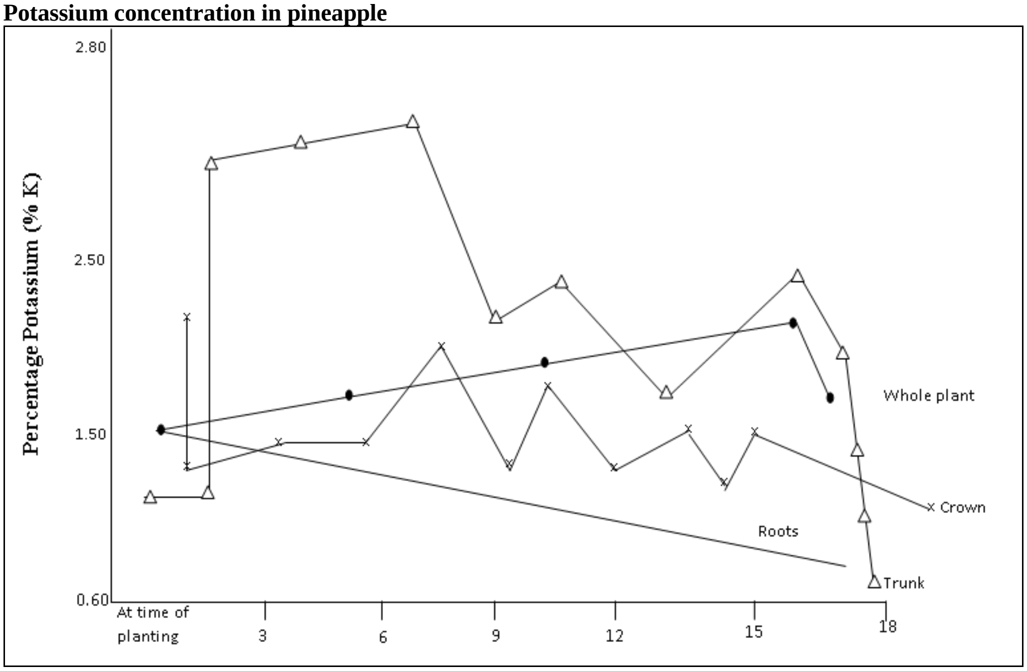
The crown maintained the highest concentration of nitrogen than trunk while root had the lowest. The highest nitrogen concentration in the region of the growing point of pineapple was not surprising, thus the order of concentration was as follows: crown>whole plant>Trunk>Roots.

Table 4: Mean nitrogen concentration in pineapple tissue (% dry matter)

Age of plant (months)	Crown	Inner trunk	Outer trunk	Trunk	Roots	Whole plant
3	1.840	0.652	0.758	0.956	0.478	0.815
6	1.652	0.410	0.616	0.825	0.381	0.752
9	1.605	0.312	0.581	0.792	0.363	0.701
12	1.201	0.983	0.502	0.716	0.322	0.682
15	0.914	0.878	0.435	0.659	0.286	0.591
18	0.922	0.811	0.384	0.586	0.215	0.486
Mean	1.36	0.674	0.546	0.755	0.341	0.671
LSD (0.05)	0.081	0.062	0.102	0.110	0.026	0.038

In the trunk, the inner softer portion was on the average richer in nitrogen than the outer portion especially in the early season. The variation of nitrogen levels in major components and the whole plant is illustrated in fig 5. All the major components of crown, trunk, roots and whole showed a sharp drop in nitrogen level. While there was decline more gradually in trunk, roots and whole plant, the crown tended to maintain its rising level from the 6th month throughout the study period. The difference between the behaviour of trunk and crown implies that depletion of nitrogen stock in the plant was not well reflected in the crown which suggests that trunk analysis does not necessarily detect a drain of nitrogen reserves. The values of nitrogen concentration relative to plant age decreased with increase in plant age particularly in the whole plant, trunk and roots. The drop of nitrogen from one age of the plant to another in all the parameters studied was consistent, except for crown.

Potassium concentration in pineapple



Field of age of pineapple (months)

Fig 6: Potassium concentration in pineapple of different ages

Table 5: Mean potassium concentration in pineapple (% dry matter)

Age of plant (months)	Crown	Inner trunk	Outer trunk	Trunk	Roots	Whole plant
3	1.78	3.65	2.11	2.12	1.09	2.46
6	1.66	3.27	1.84	2.05	1.17	2.21
9	1.42	2.83	1.36	2.86	0.91	1.87
12	1.51	2.89	1.72	2.14	1.18	1.78
15	1.68	3.77	2.58	2.86	1.36	2.47
18	1.24	2.14	1.08	1.10	1.05	1.66
Mean	1.55	3.09	1.78	2.18	0.96	2.08
LSD (0.05)	0.27	0.32	0.06	0.03	0.04	2.68

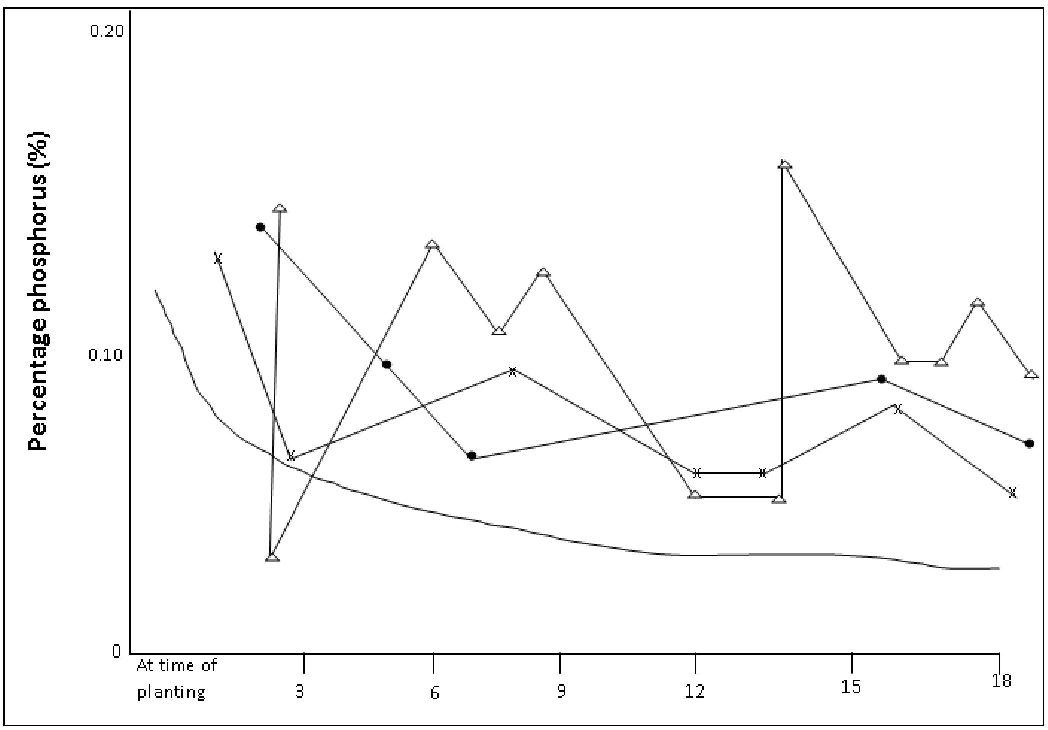
Potassium levels in the whole trunk were generally higher than those of crown, particularly early in the season, and the lowest was recorded in roots. For the various tissues the order was trunk > whole plant > crown > roots. Values of trunk and whole plant were almost double the values of roots and significantly (p<0.05) higher than values of crown. In the trunk the inner trunk had appreciably higher potassium levels than the outer portion especially in the younger plants. The potassium concentration decreased with age up to the 9th month then began to increase from the 12th month and then dropped in the 18th month. This indicates that the tissues of pineapple are more able to store potassium later in the season to a point, than early in the season. Equally, the striking decrease in potassium concentration with age and in the inner trunk indicates the potential storage capacity of this tissue. Mean values for whole plant in terms of potassium were two to three times more than values of nitrogen in many cases. The course of potassium levels in the composite components of the pineapple plant is illustrated in fig. 6. The levels were relatively more variable than those of nitrogen. Potassium in the crown tended to fluctuate around a mean of about 1.5% after the drop in the first year. Potassium in roots steadily declined with age of plant. In the trunk, there was considerable buildup of potassium concentration early in the season of the experiment than late in the season. Subsequently, until the 12th month, the potassium concentration declined quite rapidly. Although the levels of potassium increase up to the 15th month and then dropped suddenly in the 18th month at plant maturity, in which potassium values tended to be the lowest compared with values obtained from all other months under similar experimental condition.

Phosphorus

Phosphorus levels were the lowest of the major nutrients in absolute terms being generally 10-20% of those of nitrogen.

Table 6: Mean phosphorus concentration in pineapple tissues (% dry matter)

Age of plant (months)	Crown	Inner trunk	Outer trunk	Trunk	Roots	Whole plant
3	0.144	0.218	0.131	0.148	0.130	0.139
6	0.072	0.247	0.086	0.046	0.047	0.094
9	0.085	0.159	0.072	0.134	0.038	0.086
12	0.091	0.136	0.067	0.115	0.035	0.085
15	0.096	0.102	0.069	0.121	0.031	0.057
18	0.102	0.083	0.052	0.105	0.030	0.043
Mean	0.088	1.158	0.079	0.112	0.052	0.084
LSD (0.05)	0.020	0.030	0.021	0.032	0.023	0.021



Field Age of Plants (Months)

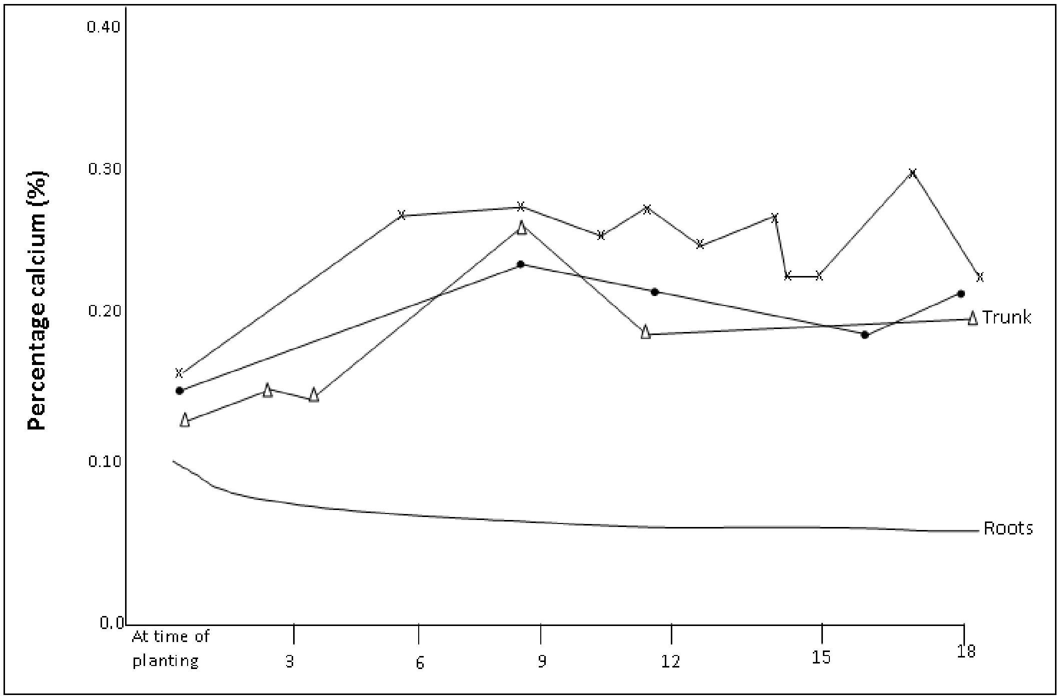
Fig 7: Phosphorus concentration in pineapple of different ages

As it was the case of potassium, crown was richest and roots were poorest in phosphorus. The crown tended to have higher values of phosphorus than the trunk. Thus, the order of phosphorus concentration was crown > whole plant > trunk > roots (Figure 7). The inner trunk was richer in phosphorus than the outer trunk. For the plant as a whole, phosphorus concentration declined with age of the plant. Phosphorus levels in trunk and roots decreased with the age of the plant, but this trend was not obvious for crown, the peak occurring in the 18th month (Table 6). This is in total contrast to the report on potassium but similar to the report on nitrogen. Phosphorus levels on the whole were less variable than those of nitrogen and potassium.

Calcium

Table 7: Mean calcium concentration in pineapple tissues (% dry matter)

Age of plant (months)	Crown	Inner trunk	Outer trunk	Trunk	Roots	Whole plant
3	0.149	0.752	0.315	0.130	0.118	0.143
6	0.376	0.684	0.284	0.142	0.086	0.162
9	0.366	0.567	0.265	0.158	0.072	0.174
12	0.348	0.434	0.192	0.176	0.063	0.181
15	0.311	0.318	0.176	0.189	0.054	0.188
18	0.285	0.214	0.133	0.210	0.041	0.191
Mean	0.306	0.495	0.228	0.167	0.072	0.173
LSD (0.05)	0.034	0.044	0.022	0.021	0.023	0.032



Field Age of Plants (Months)

Fig 8: Calcium concentration in pineapple of different ages

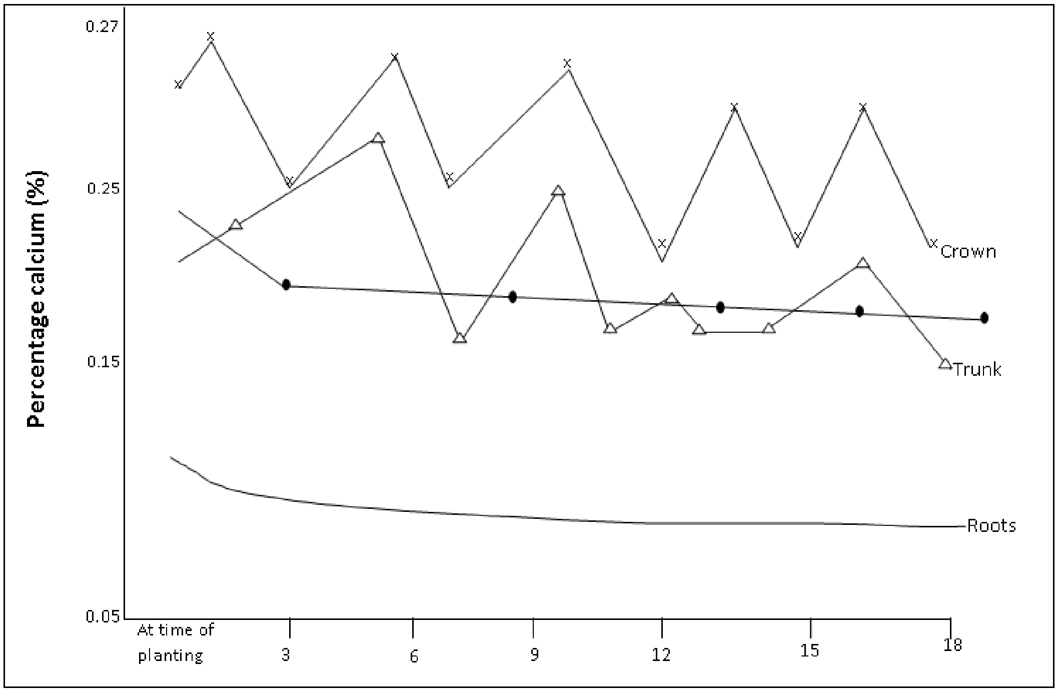
Calcium values from plant tissues are presented in table 7 and Fig. 8. The values of calcium obtained from crown were significantly ($p<0.05$) higher than values obtained from either whole plant or trunk, while values from roots were the lowest. The inner trunk had higher values of calcium than the outer trunk and the differences were significant ($p<0.05$), under similar experimental condition.

The variation of calcium concentration in composite components with age is presented in Fig. 8, in which calcium values obtained from crown were significantly ($p<0.0$) higher than all other calcium values throughout the study period. The order of concentration among the composite components is reported thus: crown> whole plant > trunk > roots.

Magnesium

Table 8: Mean magnesium concentration in plant tissues (% dry matter)

Age of plant (months)	Crown	Inner trunk	Outer trunk	Trunk	Roots	Whole plant
3	0.231	0.936	0.156	0.194	0.171	0.217
6	0.264	0.749	0.134	0.208	0.168	0.214
9	0.256	0.538	0.122	0.224	0.149	0.211
12	0.231	0.396	0.119	0.238	0.131	0.202
15	0.198	0.284	0.108	0.241	0.126	0.189
18	0.179	0.215	0.102	0.269	0.108	0.164
Mean	0.231	0.522	0.123	0.219	0.142	0.199
LSD (0.05)	0.043	0.051	0.020	0.042	0.024	0.033



Field Age of Plant (Months)

Fig 9: Magnesium concentration in pineapple at different ages

Of all the tissues, crown was again the richest in magnesium, although the average level is lower than values obtained for nitrogen and potassium. The data for magnesium values are presented in table 8 and fig. 8 accordingly. Roots recorded the lowest value of magnesium and these values were significantly (p<0.05) lower than all other values obtained from either crown, or whole plant and trunk given similar experimental condition. The order of magnesium concentration in pineapple is: crown > whole plant > trunk > roots. In the trunk, the inner portion tended to have higher values of magnesium early in the season, then dropped letter in the season. The whole plant magnesium values were about 20-30% above nitrogen levels. Fig 9, illustrates the variation of magnesium concentration in major composite components with age. In the crown the level of magnesium percentage increased by 10.8% units $\frac{(0.264-0.231)}{0.231} \times \frac{100}{1}$, it then decreased consistently from the 6th month to the 18th month, such that there was 47.5% unit drop $\frac{(0.264-0.179)}{0.179} \times \frac{100}{1}$, comparing the 6th month with the 18th month. Interestingly, the inner trunk and the outer trunk decreased consistently from the 3rd month to the 18th month, while the main trunk rather increased consistently from the 3rd month to the 18th month. The roots and the whole plant decreased consistently, such that their highest values were from the 3rd month while their lowest values came from the 18th month.

Discussion

Dry Matter Production

The method of plotting generalized curve through the individual points prove satisfactory and no undue errors were introduced. Infact, a more correct picture of dry matter production was obtained in this fashion. The dominance of crown component and its quicker build up in the 18th months in the field suggests that measurement of crown tissue in the immature months would be a useful guide for studying dry matter production rate in pineapple. (Sail *et al.*, 1999; Ubi and Igwe 2005; Ubi *et al.*, 2007a) [10, 14, 17, 15].

Approximately half of the total amount of roots was located within the 5.5cm from the base and the next highest proportion was found between 5. 5 to 6.5cm. Thus, the preponderance of roots occurred within the weeded circle of the pineapple. However, Ubi and Osodeke (2007b) [15] by studying the roots activity of pineapple found that the majority of the feeding roots of pineapple in southern Nigeria were within the 6.5cm of the weeded portion from the base of the plant. More investigations are necessary to establish unequivocally the location of feeding roots in pineapple. Such investigation should involve nutrient placement in the soil and the use of tracer techniques. Vertically, it was notable that majority of roots were found within the first 0-15cm of soil. This indicates that root development was affected more by water and nutrient conditions within the soil profile rather than soil depth alone, (Nye, 1961; Omaliko 1980; Ubi *et al.*, 2016) [8, 9, 13].

Nutrient Concentration

If the results are to have wide application, it is a prerequisite that the pineapple analyzed is neither deficient nor luxuriant in nutrients. This condition, to all intents and purposes has been satisfied as judged by nutrient levels of crown (Ubi *et al.*, 2008). For the pineapple as a whole, the order of nutrient concentration is: K>N>Ca/Mg>P, and confirms the pre-eminent position of K in the nutrition of pineapple in the trunk plays a vital role. That the trunk is a storage organ is best illustrated by the decline of potassium and nitrogen levels in the inner trunk as the plant age increased.

Potassium and nitrogen results show that large fluctuations in concentration in the trunk were not correspondingly reflected in the crown. This suggests the mobilization of this nutrient from the trunk to the crown to maintain levels there. The upward trend of calcium levels with plant age contrary to the common pattern of other major nutrients raises the question whether the same degree of confidence can be attached to the use of calcium levels. Fortunately, calcium deficiency has not been found to be a problem in pineapple cultivation so far. The nutrient content curves were closely related to those of dry matter showing the relationship between these two factors (Sail *et al.*, 1999; Wilman and Dong, 1999; Ubi *et al.*, 2008) [10, 19, 16].

Conclusion

The cumulative dry matter curve for various tissues and whole plant showed that negative growth was of an exponential like form. Roots accounted for the smallest proportion amongst the major components. The crown formed the major part of the dry matter content. Between 60-75% of roots were found within 6.5cm of the base of plant within average weeded circle. Nutrient uptake data suggest they can be used for assessing quantitative requirement of pineapple. The pre-eminent position of potassium in pineapple nutrition was clearly established, together with nitrogen, form the key elements in the quantitative nutrition of pineapple. It is suggested that more investigation should be carried out up to fruiting, so that the results will enable precised estimates of the amounts of nutrients removed by fruits to be computed.

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