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MINERAL NUTRITION OF TWO PLANTAIN (MUSA, AAB GROUP) CULTIVARS OF THE FRENCH AND HORN TYPE

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INTRODUCTION

Although plantains provide an important source of starches in the Caribbean, in most parts of the region they are not grown intensively on a plantation scale. Also, most of the crop is consumed locally and any export trade is for the most part between the various territories of the Caribbean. Maybe because of this, in the past there has been little systematic research on the cultivation practices required for efficient production. This is in marked contrast to the large volume of work on other types of banana produced for the export market.

Most of the published work in the Caribbean area has been conducted in Puerto Rico where a sizeable industry in processed plantain products has been developed. Investigations into plantain production there have often been concerned with the effect of agronomic practices on characteristics which are important in processing (SANCHEZ NIEVA et al, 1971) but others on plant density (VINCENTE-CHANDLER and FIGALLA, 1962; CARO-COSTAS, 1968), and mineral nutrient requirements (CARO-COSTAS et al, 1964; HERNANDEZ MEDINA and LUGO LOPEZ, 1969; SAMUELS et al, 1973) have been carried out. These latter have shown the need for both magnesium and micronutrients (especially iron and zinc) for maximum yield on some of the soils in Puerto Rico.

In other parts of the West Indies few field fertilizer trials have been carried out, and it is usually assumed when giving fertilizer recommendations that the requirements for plantain would be the same as other banana cultivars.

In any case, fertilizer trials as normally designed do not give all the information needed for a crop like banana where requirements for the plant crop are different from those for ratoon crops (TWYFORD and WALSLEY, 1973). Taking into account these circumstances it should be possible to obtain the mineral needs of a plantain crop, at least to a good approximation, from total plant analysis. Therefore, the object of the present study was to determine the total uptake of the major nutrient elements into two cultivars of plantain commonly grown in Trinidad at various stages throughout their life cycle in order to get an estimate of the total nutrient requirements on a field basis.

EXPERIMENTAL

Cultivars: Two cultivars of the plantain sub-group of the Musa, AAB Group (see SIMMONDS, 1966) were used, one of the French type (called locally Green French plantain, Banane creole, Platano congo etc.) and one of the Horn type (Horse, Banane corne, Platano comun etc.).

Site: The plants for the experiment were grown on the University Field Station, Trinidad, where the soil is of the River Estate series described by CHENERY (1952) and BROWN and BALLY (1970).

Although the surface soil is loam there is a silty clay subsoil of poor drainage. The clay content of the surface soil is low and so therefore is the cation exchange capacity. The soil is acid with pH 5-6, calcium and magnesium are usually in adequate supply and although potassium tends to be low, cations are released from weathering silt in the soil. Organic matter is very low and crop responses to phosphorus have been recorded.

Rainfall at the site between planting in Oct/Nov 1971 and harvesting in Nov 1972 was 1350 mm, the months of February, March, April and August having less than 10 mm.

Field techniques: Two stands of about one fifth of a hectare of each cultivar were established on adjacent areas. Planting was on cambered beds at 1.8 m x 1.8 m i.e. a density of 3000 plants per ha.

Planting material was selected from known 'pure' stands of the two cultivars. 'Sword' suckers of as uniform a size as possible were first pared to remove any rotted or discoloured superficial corm material (due to damage by borers, Cosmopolites sordidus or nematodes) and then dipped in a solution of Nemagon (6 g per l.) and Aldrin (10 g per l. of 25 per cent), for borer and nematode control.

Planting holes (60 cm x 60 cm x 60 cm) were treated with 50g of 2 per cent Aldrin dust per hole. Soil was replaced in the holes and the suckers planted about 15cm below the surface.

Weeds in the early stages were controlled as necessary by hand cutting or paragnat sprays. Fertilizers applied were 200kg N per ha per year as ammonium sulphate, 120 kg P as triple super phosphate and 750 kg K as muriate of potash, given in four applications.

Sampling techniques: Samples were taken of the planting material from each cultivar. Subsequently, 10 plants of each cultivar were dug up at the following stages of growth:-

1) 'Young' plants with two broad leaves - about two months from planting
2) 'Small' plants with six broad leaves - about four months from planting
3) 'Large' plants with 15-20 broad leaves - about six months from planting
4) 'Shooting' plants - at the first appearance of the flower
5) 'Shot' plants - with immature fruits about half way to harvest (1.5 months old)
6) 'Harvest' - plants at the time of reaping the bunch. At each stage the plants were dissected into their organs; roots were neglected. These organs were,

   a) In the vegetative phase; unemerged leaf (i.e. developing leaf tissue inside the pseudostem), leaf lamina, leaf midrib, petioles, pseudostem, meristem and corm. In the early stages meristematic tissue was included with the corm.

   b) Shooting plants: leaf lamina and midrib, petioles, pseudostem, corm, internal fruit stalk and the inflorescence.

   c) Shot and harvest plants, leaf lamina and midrib, petioles, pseudostem, corm internal fruit stalk, external fruit stalk, fruits and inflorescence. Where the remnants of the inflorescence were very small this material was included with with the external stalk.

Each part was weighed fresh and a representative sample taken (cf TWYFORD and WALMSLEY, 1968). The samples were weighed fresh, then dried in the oven at 80°C re-weighed and the percentage oven dry matter and the total dry weight of the whole part calculated.

After grinding, each sample was analysed separately for N, P and K.

RESULTS AND DISCUSSION

Dry matter production

For both cultivars there was only small production of dry matter until about few months from planting at which age the plants had six unfurled leaves. By the next sampling date in the late vegetative phase the French plants had increased considerably and this rate of increase continued to the shooting stage. After shooting further dry matter was produced right up to harvest.

The Horn type plants began their period of rapid growth later than the French at about five and a half months when they had about 12 broad leaves; only a small amount of dry matter being produced between the six and 12 leaf stages. However, after that stage, growth increased at a more rapid rate than for the French plants and by shooting they had produced more dry matter than the French. Although this rate of increase diminished somewhat up to the shot stage, subsequent increases ensured that they contained about 35 per cent more dry matter at harvest than the French.

Distribution of dry matter within the plant

At harvest for both types, the fruits had more dry matter than any other part, with pseudostem and leaves making up the bulk of the rest of the material, Much of the difference in the total plant dry weights for the cultivars was due to the amounts assimilated in the leaves and pseudostem although generally all vegetative parts of the French contained less dry matter than the counterparts of the Horn type.

It is interesting to note that although the Horse plants accumulated more total dry matter the amount in the fruits was almost the same for both cultivars. The mean fresh weights of fruits produced from these plants were 12.1 kg for Horn and 13.5 kg for French i.e. the fruits produced by the French were heavier only because they have a higher percentage of water.

Concentration of mineral nutrients

In the vegetative stages of growth nitrogen and phosphorus were most concentrated in the actively differentiating tissues, the unemerged leaf and meristem. Nitrogen concentrations were also high in the leaf lamina during this phase. Potassium was concentrated in the young leaf tissue but in the earlier stages, the conducting organs, midribs, petioles and pseudostem were also rich in potassium. In the later stages of vegetative growth potassium concentrations in these latter tissues decreased considerably probably due to a dilution effect as the tissues had by then increased greatly in bulk. This effect was particularly noticeable in the French type.

In the fruiting phase nitrogen and phosphorus were still concentrated in leaf lamina, and also in the inflorescence, and fruit stalk. The tissues where potassium was most concentrated in this phase were inflorescence and fruit stalk. Thus here again the nutrients tended to be concentrated in the new tissues which were rapidly developing during this time except that the fruits themselves had only low concentrations. This may be due to the fact that it is material in the 'skins' which is actively concerned with producing new tissue and not the pulp. Since these were not analysed separately this effect could not be demonstrated in these studies.

Nitrogen

Both cultivars showed a similar pattern of distribution amongst the organs. In the vegetative phase nitrogen taken up appeared mainly in the leaf lamina; pseudostem and corm having the next highest amounts.

In the fruiting phase, whilst the leaves continued to be a major depository, a high proportion of the nitrogen in the plant was to be found in the fruits at harvest.

The total plant uptake increased slowly up to the six leaf stage but the French plants took in more nitrogen than the Horn during this period. For the French plants there was then a very rapid increase in uptake up to the sampling time at the late vegetative or 'large' stage and the nitrogen content increased eight-fold over this period. There was a dimunition in uptake rate from then up to the shooting stage and from shooting to harvest no further nitrogen was taken into the plant; at the shot stage there was an apparent decrease from the shooting stage. Since any dead leaves were retained as far as possible in the experiment it may be assumed that this was due to losses from flowers, bracts and other parts of the inflorescence which fell off but were not collected for analysis.

The Horn type showed a much less rapid uptake between the six-leaf and late vegetative stage than the French but between the latter stage and shooting uptake had increased to such an extent that the content of nitrogen was somewhat higher in the Horn plants. In this sense nitrogen uptake followed the dry matter production pattern. At harvest the Horn plants had accumulated more nitrogen than at the shooting stage, but again these plants showed an apparent loss at the shot stage compared with shooting, probably for the reasons stated above, the greater loss being due to much more of the inflorescence being shed in this type of plantain.

In the French plants no further net nitrogen was taken into the plant after shooting and nitrogen used in the development of the fruiting parts came mainly from the leaves.

In the Horn type some net nitrogen uptake was recorded after shooting but this was insufficient for the development of the fruiting parts. Small losses to make up this deficiency were recorded from other parts of the plant mainly leaves and corm.

Phosphorus

The distribution pattern of phosphorus amongst the organs was similar for both cultivars. As for nitrogen, in the vegetative phase, most of the plant's phosphorus was contained in the leaves, pseudostem and corm. By shooting leaves still contained the most phosphorus followed by pseudostem. At this stage the French inflorescence contained more phosphorus than the corm but in the Horn plants, the corms had twice as much phosphorus as the inflorescence. At harvest the fruits had much more phosphorus than any other part of the plant.

Total phosphorus uptake into the plant followed the nitrogen pattern during the vegetative phase with a more rapid uptake by the French plants in the earlier stages and with an accelerated increase in the Horn plants in the late vegetative phase so that by shooting the Horn plants contained more phosphorus than the French. There was only a small uptake between shooting and harvest for both cultivars. This was insufficient to supply the amount needed for fruit development. The deficit was made up by redistribution from other parts of the plant, mainly the leaves and pseudostem; the corm also supplied a substantial amount in the Horn plants only.

Potassium

In the very early vegetative phase the corms contained more potassium than other organs but this pattern changed as growth continued so that in the late vegetative stages pseudostem was the biggest repository, leaves the next, with corm in third place. This pattern was the same at shooting.

At harvest the fruits had by far the greatest amount of potassium. In the Horn plants, pseudostem and leaves still contained substantial amounts but in the French these organs had been considerably depleted.

The pattern of total uptake for the two cultivars differed markedly. Up to the six leaf stage the Horn plants appeared to have taken in no potassium at all from the soil. On the other hand the French cultivar showed a steady intake with a very rapid increase from the six leaf stage up to shooting. The Horn plants increased their potassium content relatively more slowly from the six leaf stage but then there was a very rapid uptake between the 'large' stage (12 broad leaves) up to shooting.

As was observed for nitrogen uptake from shooting to shot there was an apparent decrease in total potassium which was assumed to be due to loss of flower bracts. Further uptake was recorded from shot to harvest resulting in a net uptake from shooting for both cultivars, the Horn type having the greater total uptake.

For both cultivars the net uptake from the soil after shooting was not sufficient to supply the potassium needed for fruit formation. In the French plants losses were recorded from vegetative parts of the plant mainly the pseudostem and leaves. In contrast, in the Horn plants little redistribution took place from the leaves and pseudostem; corm supplied the largest amounts of potassium for this purpose.

Nutrients in Fruits

The fruits of the French plants contained 60 per cent of the total potassium in the plant, compared to 35 per cent for the Horn.

Comparable figures for nitrogen are 39 and 22 per cent and for phosphorus 47 and 36 per cent. Thus although the Horn plants take in more total nutrients, the proportion used in fruit production is much lower than for the French cultivar. In this sense the French is more efficient than the Horn.

NPK requirements

a) First year

If we consider the development of a newly planted field of plantains at a density of 3000 plants per ha and assume that all plants have been harvested within the first year then the field would produce about 40 tonnes of fruit for the French plants but only about 30 tonnes for the Horn type. In the experiment the mean weight of fruits per plant was 13.5 kg for French and 12.1 kg for Horn but from a larger sample from the same area taking the mean of 100 bunches mean weight of fruits produced was 13.7 and 10.0 kg respectively.

Thus basing the fertilizer requirement on the higher producing French cultivar assuming that during the first year enough should be supplied for 3000 plants up to harvest, 3000 ratoon plants which at the end of the first year may be taken to be at the 'large' or late vegetative stage and 300 suckers (which would eventually form the second ratoon) at the 2 leaf stage, it can be calculated that 286.5 kg of N, 79.6 kg of P and 724.6 kg of K would be needed. In this calculation the nutrients in the planting material are ignored. If supplies from the soil are also assumed to be negligible which of course would not always be the case then net uptake can be computed in terms of fertilizer. This would give a fertilizer ratio of 1:0.3:2.5.
The quantity of NPK fertilizer required on this basis assuming no losses, would be approximately 3000 kg of 10:3:25 or 1 kg of this grade fertilizer per stool. There would be losses due to fixation and leaching. To allow for phosphate fixation the fertilizer grade could be changed to 10:10:25. To compensate for nitrogen and potassium losses the dose per stool could be increased somewhat.

b) Ratoon years

In the second year the situation is somewhat different as residues from the previous crop contribute to the nutrition of the ratoon. After the bunch is cut the plant has completed its life and its nutrients are released.

The pseudostem is usually cut at about 1.5 meters from the soil surface and 'crown' (upper pseudostem, leaves petioles and part of the external fruit stalk) begins to rot on the soil surface. Nutrients from the rotting plant can then be used by the roots of the developing ratoon plants. Nutrients from the other parts of the harvested plants i.e. the standing pseudostem with the internal fruit stalk, can pass directly into the developing ratoon (WALMSLEY and TWYFORD, 1963) or become available after rooting.

Thus the ratoon crop receives a substantial quantity of nutrients from plant crop residues, only those in the bunch being removed from the field. Also by the end of the first year the root system is well developed and more efficient is absorbing nutrients and we can therefore assume that losses by leaching and fixation would be smaller.

Fertilizer to be applied in the second and subsequent years can therefore be based on the amount of nutrients removed in the bunches. For the French cultivar the nutrients exported are 66 kg N, 24 kg P and 323 kg K. A suitable NPK fertilizer ratio to replace these nutrients would be 1:0.4:3.9. This has about twice as much potash as that required for establishment of the field so either a different compound fertilizer would be needed or the same one could be used and supplementary muriate of potash given. To supply N and P about 700 kg per ha of the 10:10:25 would be needed or say 230 g per stool. In addition about 250 kg per ha of muriate of potash would be needed.

Thus it can be seen that although heavy dressings of fertilizer are needed for the establishment of the field in the ratoon years the requirements are markedly reduced and over a period of three or more years no more total fertilizer would be required than is normally recommended. Therefore a higher expenditure on fertilizers is not involved only a re-arrangement with time.

It is possible that with more fertilizer than that suggested here, higher yields than 40 tonnes per ha would be obtained.

CONCLUSIONS

1) The fruits of the French type contain a higher percentage of mineral nutrients, especially potassium, than the Horn plantains.

2) A higher percentage of the total nutrients taken into the plants is used in fruit production in the French type than the Horn.

3) From total plant analysis, fertilizer rates for a soil of low nutrient status should be high in the first year when the field is being established. Rates in subsequent years can be reduced considerably since plant residues contribute substantially to the nutrition of ratoon crops.

   a) For the French cultivar, calculations show that a hectare with 3000 plants would require of the order of three tonnes of 10:10:25 fertilizer (1 kg per stool) in the first year.

   b) In the second and subsequent years this could be reduced to about 700 kg per ha (230 g per stool) but supplementary potash would be needed (250 kg KCl per ha) since proportionally more potassium than either nitrogen or phosphorus is removed in the bunches exported from the field.

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