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Effect of Split Fertilizer Application on Growth and Yield of False-Horn Plantains (Musa spp.) in the Rain Forest Belt of Nigeria

Wirkung einer mehrmaligen Düngergabe auf Wachstum und Ertrag von False-Horn Kochbananen (Musa spp.) im Regenwaldgürtel Nigerias

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1. Introduction

Plantain (Musa acuminata x Musa balbsiana AAB) is a very important staple food crop in the low land humid tropics. There is a recent awareness of the potential importance of plantains as cheap source of dietary carbohydrate in many tropical countries (Flinn & Hoyoux 1976; Olayide 1972). There is a great new emphasis being placed on plantain production in the national food production programmes of various tropical countries such as Nigeria (Flinn 1976), Ghana (Karikari 1972), Tanzania (Malima 1976), Ivory Coast (Guillemount 1976), the Republic of Cameroun (Fongyen 1976) and Philippines (Valmayor 1976).

In Nigeria, plantain production is emphasized in the Operation Feed the Nation (OFN) programme, and more farmers are now growing the crop in the rain forest areas. Plantain is a very highly prefered staple food among the urban dwellers in Nigeria because of the ease with which many delicious dishes may be prepared from it. It commands higher price per unit weight than most other staples.

Information on the production practices for plantain is rather scanty because suitable cultural management techniques have not been developed for this crop in Nigeria. Recommended practices for plantain production are often extrapolations from results obtained on bananas on which much research work has been done elsewhere (Annon 1977). There is need to adapt the results obtained on bananas or even plantains in other countries to the conditions prevailing in Nigeria before meaningful recommendations can be made to farmers.

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For banana production, it is recommended that fertilizer be applied in several small doses. As many as 5 splits for Nitrogen (N) and at least 3 splits for potassium (K) were recommended (Cann 1965; Oschatz 1962). Production labour costs are high but would be considerably reduced if it were found that fertilizer application to plantains in few large dressings is effective compared with several repeated small doses. To answer some of the growers questions on fertilizer pracitice for plantains in the rain forest belt of Nigeria, a number of experiments were designed (Ndubizu 1980). This report is an assessment of the advisability or otherwise of split fertilizer application to plantains.

2. Materials and Methods

The experiment was carried out at Nsukka lat. 06^{52N}, 400M latitude, starting in early May 1975. Plantains were planted on level well drained sandy loam Oxisol of the Nkpology series, with soil characteristics as shown in table 1.

Table 1. Summary of the chemical and physical properties of the Nsukka soil

Fine sand plus coarse sand %	66.4
Silt plus clay %	28.3
pH in Kcl	3.9
pH in water	4.6
Exch. K (ml/100 g soil)	0.24
Exch. Mg (ml/100 g soil)	0.21
Exch. Ca (ml/100 g soil)	0.89
Organic carbon %	1.34
C.E.C. (meq/100 g soil)	8.10

There was no concretions or hard pan within the 1.8 M of the profile. The field was under a four year fallow after a previous crop of cassava. The experimental design was randomized complete block (RCB) in six replicates. Each plot had 5 plants spaced at 3 x 3 meters square. A 30 cm bund surrounded each plot and a one meter grass strip was allowed between blocks to avoid fertilizer drifts between plots and blocks. Each plant received a fertilizer mixture comprising 300 g Ammonium sulphate, 670 g muriate of potash, 80 g super phosphate and 150 g magnesium sulphate giving a total of 1.2 kg of mixture per stand. This is in line with the fertilizer recommendations by the Imo State Ministry of Agriculture (Annon. 1977). The following treatments were compared:

Treatment 1. No split (all 1.2 kg fertilizer mixture per plant applied at planting.) All subsequent applications to ratoon plants were made in May each year. Ratoons received 75% of the original dose.

Treatment 2. No split (all 1.2 kg fertilizer mixture per plant applied 3 months after planting.) All subsequent applications to ratoon plants were made in July each year. Ratoons were given 75% of the original amount of fertilizer.

Treatment 3. Application of 1.2 kg fertilizer mixture per plant in two equal instalments, at planting and 3 months later. Ratoon plants received 75% of original amount of fertilizer split and applied in 2 equal instalments in May and July each year.

Treatment 4. Application of 1.2 kg fertilizer mixture per plant in 3 equal instalments at planting, 3 months and 6 months after planting. 75% of the original amount of fertilizer were applied to the ratoons in 3 equal split doses and applied in May, July and September each year.

Routine manual weed control was carried out monthly. For the crop plant, the following observations were taken: monthly growth in height, stem diameter and leaf area for the first four months, monthly leaf counts, flowering date and number of functional leaves at flowering. A maximum of two follower plants were allowed in each stand and these followers were selected at the time of shooting in each stand. Yield records only were kept in the first and second ratoon crops. Each stand was harvested at 92 days from date of flowering. At harvest, (for crop and ratoons) the number of fingers, bunch weight and weight of edible materials were determined.

3. Results and Discussion

Pre-Flowering growth phase — Plant Crop

The effects of the various treatments on the growth of plantains up to flowering are summarized in table 2. Application of fertilizer in three equal splits produced significantly better response in terms of mean plant height and leaf area during the early and active vegetative growth phase of the plants than any other mode of application. Similarly, application in two equal instalments gave significantly better growth than the once-over either at planting time or three months later. Stem diameter did not reveal any significant differences between treatments. Results from leaf area analysis followed similar pattern as growth in height with the 3-split and one-time application 3 months after planting giving the highest and least values respectively. The 3-split application led to faster leaf production presumably because the nutrients were made available as needed by the plant.

Table 2. Plantain Growth Response to Split Fertilizer Application, — Plant Crop

Treatment	Mean hight (cm) after 4 months	Stem Diameter (cm) after 4 months	Leaf Area cm^2 x 1000 after 4 months	Days from planting to flowering	Time for 50% flowering (T50) in months
1	50.87	5.986	7.14	372.3	14
2	45.68	6.05	5.30	360	14
3	51.31	6.083	7.04	333.5	13
4	60.05	6.08	11.07	281.3	10
$LSD_{0.05}$	8.25	1.943	3.918	52.566	

Leaf production was more even in the 3-split application than in the other treatments leading to early flowering (Table 3). In the first 3 months of growth, plants produced on the average, 3—4 leaves per month in all the treatments. In the 3-split treatment, leaf production averaged above 4 per plant per month through October. Leaf production was slow at first in the treatment receiving once-over application 3 months later but reached maximum rate soon after fertilizer application in July,

thus compensating for the slow start in May/June period. Presumably, by this time the roots were already well established and able to make effective use of the fertilizer applied.

Table 3. Mean monthly leaf production by plantains under different frequencies of fertilizer application. Plantains were planted May 1975

	Treatment			
	1	2	3	4
Month	All fertilizer applied once at planting	All fertilizer applied once 3 months later	Fertilizer applied in two equal splits at planting and 3 months	Fertilizer applied in three equal splits at planting, 3 months and six months
May 1975	2.70	2.55	1.90	3.30
June	4.75	3.96	4.65	4.56
July	3.84	4.41	3.35	4.15
August	3.49	3.21	4.05	4.69
September	3.10	4.18	3.34	3.75
October	3.10	4.05	4.17	4.23
November	2.90	2.60	2.24	2.60
December	0.80	1.00	1.45	0.61

The effect of the different treatments on the total leaf production between May and December is presented on Table 4. Observations on the growth patterns of Nigerian false horne plantains in Nigeria (Ndubizu and Okafor 1976) suggest that the plants produced on the average one leaf in 5–7 days under very favourable growing conditions and one leaf in 14–30 days under adverse (drought) conditions. Thus these experimental plants established at Nsukka in May should produce about 810 leaves at the end of December. Assuming this therefore, the 3-split treatment (table 4) resulted in enhanced leaf production and therefore early flower initiation and flowering. The mean number of leaves that survived on the plants at the time of flowering are shown in table 4. The number of functional leaves at flowering, a component of leaf area was considered an important yield determining factor since plantain is a determinante plant. The plants under the different treatments flowered at different periods with those treatments receiving 3-split application flowering early during the dry season. The significance of the effect of this treatment on leaf

Table 4. Effect of different frequencies of fertilizer application on plantain leaf production in the plant crop after 9 months of growth

Treatment	Total number of leaves observed April–December*	Time taken for 50% flowering (T50) in months	Mean number of functional leaves/ plant
1. One application at planting time	744	14	11
2. One application 3 months later	774	14	12
3. Two split applications	762	13	12
4. Three split applications	832	10	13

* A total of 30 plants were observed per treatment

survival is underscored by the fact that even those plants in the 3-split treatment which flowered during the dry months of January–March when the leaf number on the plantain plants is usually minimal (Ndubizu & Okafor 1976), had more leaves than those plants in the other treatments which flowered later in May, June and July when moisture conditions were adequate.

The mean number of days from planting to flowering varied from 281 in the 3-split to 372 days in the once over treatments (table 2). A comparison of the split vs the non split applications showed that there is highly significant reduction in the growth period from planting to flowering due to split application of fertilizer ($LSD_{0.01}$ = 72.6). Thus about 3 months were gained by the 3-split application over the once-over application either at planting or 3 months later (table 2).

The distribution of the shooting dates in the different treatments is presented in Table 5. The 3-split application reached peak flowering in January (ca. 31%) and by the end of February, over 50% of all the plants in that treatment had flowered. The time from planting to 50% flowering (T50) for the 3-split treatments was 4 months earlier than the once-over treatments (table 4). Each plantain stand was harvested 92 days from its date of flowering. Thus, harvesting was displaced three months forward from flowering. Plantain fruits are highly seasonal in Nigeria with less than 25% of the total annual harvests occurring between February and May (Ndubizu & Okafor 1976). Market prices for plantains are usually high during the off season period (February–May). It is therefore apparent that split fertilizer application can broaden the time of plantain availability. The potential financial benefits to the farmer can hardly be ignored.

Table 5. Average monthly percentage flowering by plantains under different frequencies of fertilizer application. Plantain established in May 1975

	Treatments			
	1	2	3	4
Months of Flowering	All fertilizer applied once at planting	All fertilizer applied once 3 months after planting	Fertilizer applied in two splits at planting and 3 months later	Fertilizer applied in three splits – at planting, 3 and six months later
December 1975	0	0	0	11.0
January 1976	4.5	7.5	12.0	31.0*
February	4.0	3.0	0.0	10.0
March	3.5	6.5	10.5	9.0
April	8.0	4.0	10.0	3.0
May	25.0*	22.5*	19.0*	11.0
June	12.5	11.0	8.0	12.0
July	21.0	18.0	8.0	3.0
August	3.5	2.5	12.0	2.0
September	7.5	3.0	12.0	7.0
October	3.5	3.0	4.0	0
November	0.0	3.0	0	0
December	3.0	10.0	4.5	0

4. Fruit Yields

There were no significant differences in bunch yield between treatments in the plant crop. However, the plants receiving 3-splits of fertilizer produced bigger bunches, more fruits/bunch and greater edible material (table 6). Cann 1965 observed that banana primodia are formed in the sucker 4–6 months after planting and the amount of nutrients available to the plant determined the number of fingers per bunch. He further stated "For this reason, young banana plants should receive their fertilizer ration for the year during the first six months after planting. This is best applied in small doses at about monthly intervals." From this, it would appear that plantain fruit primodia were formed between the 16th and 24th leaf stage. Thus those treatments with higher mean finger numbers per bunch, reflecting better early vegetative growth were on the way to yielding bigger bunches. However, final bunch size was determined not only by the number of fingers per bunch but also by the weight of the individual finger (Ndubizu & Okafor 1976). Peak flowering in the 3-split treatment occurred between January and March with harvests occurring at the tail end of the dry season. These plants flowered at the least favourable environmental period for bulking (Ndubizu & Okafor 1976) and thus were unable to express their full bunch weight potential.

Table 6. Effect of different frequencies of fertilizer application on yield of plantains

Treatment	Mean weight of edible material per ha (tons)	Mean bunch weight per plant (kg)	Mean bunch weight per ha (tons)	Mean number of Finger per plot
1	5.314	5.747	9.196	100
2	5.64	5.592	8.945	134
3	5.682	5.357	8.571	125
4	5.523	6.178	9.884	145
$LSD_{0.05}$	0.788	2.174	1.813	14.42

Treatment 2 (all fertilizer applied 3 months after planting) had the next highest yield probably because plants received their fertilizer late when good root establishment had taken place leading to peak flowering between May and July. Treatment 3 (two splits) gave the highest total edible material per hectare. It is possible that this arose from the fact that nearly 50% of the plants flowered between July and October, when moisture and insolation were ideal for bulking. Tables 7 and 8 show the yields from the first and second ratoon crops. Yield reductions of 15.3% and 22.2% occurred in the once-over applications (treatments 2 and 1) during the first ratoon crop. Split fertilizer application on the other hand resulted in yield increases of 6.2% and 8.0% in treatments 3 and 4 respectively in the first ratoon crop (tables 7 and 8). Mean bunch weight per plant was generally higher in the 1st ratoon crop than in the plant crop but the over-all output was slightly lower because some plants with bunches were blown down pre-maturely by the early season wind. Yield of total edible material per hectare was similar in the first ratoon crop as in the plant crop.

Table 7. Yield response of plantain ratoon crops to different modes of fertilizer application – (First ratoon crop)

Treatments	Mean edible material tons/ha	Mean bunch wt. per plant (kg)	Mean bunch yield tons/ha	Mean number of fingers/plot
1 One application at planting time	5.473	6.436	7.150	88
2 One application 3 months later	5.723	6.822	7.579	117
3 Two split applications	5.852	8.332	9.257	100
4 Three split applications	6.517	10.498	11.664	132

Table 8. Yield response of plantain ratoon crops to different modes of fertilizer application – (Second ratoon crop)

Mean Edible material tons/ha	Mean bunch wt. per plant (kg)	Mean bunch yield tons/ha	Mean number of finger per plot	Total bunch yield over 5 years (tons/ha)
5.342	5.876	6.528	101	22.874
5.112	4.872	5.412	98	21.936
5.852	4.983	6.501	100	23.404
5.253	5.252	5.834	119	26.216

Further and significant yield reductions occurred in the second ratoon crop in all treatments. These yield reductions arose partly from early season wind damages and from increased incidence of insect infestation. Some plants especially in the 3-split application were infested by Cosmopolites sordidus. The over-all yield from the different treatments over the 4–5 year period of the study showed clearly that split application of fertilizer in 3 equal instalments gave 3.342 (14.8%) to 4.280 tons (19.5%) higher yields over the non split application.

These yield increases of 14.6% to 19.5% arose from 6 extra applications in 4–5 years period over the non-split application. This represents a 2.4 to 3.25% yield increase for every split in fertilizer application. When the extra labour costs in applying the fertilizer in split doses is compared with the yield increase (2.4–3.25%) arising from the split application the extra effort and cost in applying fertilizer in 2 or 3 split doses appear amply justified.

5. Summary

The same quantities of mixed fertilizer N, P, K, Mg were applied to plantains by four different treatments. In the first treatment, plant received all the fertilizer in one application at planting. In another treatment, fertilizer was applied all in one dose at 3 months after planting. The other two treatments consisted of split application given in two or three equal dressings. Growth analysis showed that the split application of fertilizer resulted in significantly better early growth which did not persist until maturity. However, the plants which received fertilizer in three equal

dressings flowered and fruited 3 months earlier than those that received their fertilizer in one application. There were no statistical differences in yields of fruits between the four methods of fertilizer application in the plant crop. In the ratoon crops however, split application resulted in higher yields. Overall yield increases due to split fertilizer application were 15–20% higher than in the non-split treatments during a period of 4–5 years.

Zusammenfassung

In 4 verschiedenen Versuchen wurden Bananenstauden mit der gleichen Menge NPK- und Mg-Dünger gedüngt.
Im 1. Versuch wurde die gesamte Düngermenge auf einmal beim Pflanzen ausgebracht, im 2. Versuch 3 Monate später. Die 2 anderen Versuche bestanden darin, den Dünger in 2 bzw. 3 Teilmengen in den Boden zu bringen.
Bei der Untersuchung des Wachstums wurde festgestellt, daß die Bananenstauden, die mehrmals kleinere Düngergaben erhielten, eine bedeutend bessere und frühere Entwicklung aufwiesen. Diese bessere Leistung hielt jedoch bis zum Reifezeitpunkt nicht an. Trotzdem lag der Zeitpunkt der Blüten- und Fruchtbildung dieser Stauden um 3 Monate früher als bei denjenigen, die den Dünger als einmalige Gabe erhielten.
Bei den 4 Versuchen kam es zu keinem Ertragsunterschied. Bei einer 4–5jährigen Nutzung jedoch hatten die Bestände, die mehrmals kleine Düngermengen bekamen, Erträge, die um 15–20% höher lagen.

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