Int. Agrophysics, 1992, 6, 153-160

RESPONSE OF PLANTAIN TO MULCH ON A TROPICAL ULTISOL: PART III. EFFECT OF DIFFERENT MULCHING MATERIALS ON CROP GROWTH AND YIELD*

O.A. Salau[1], *O.A. Opara-Nadi*[2**], *R. Swennen*[3]

[1] Department of Geography, University of Port Harcourt, P.M.B. 5323, Port Harcourt, Nigeria
[2] College of Agriculture and Veterinary Medicine, Imo State University, P.M.B 2000, Okigwe, Nigeria
[3] IITA, High Rainfall Substation, Onne, Port Harcourt, Nigeria

A b s t r a c t. The effects of five different mulches (elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood shavings, on growth and yield of plantain (Musa sp. AAB) were compared with unmulched plot of an Ultisol in the humid region of southeastern Nigeria. Surface mulch in general increased the height and girth of stem, rate of sucker and leaf production, total leaf area, growth and yield of both plant and ratoon crops. Plant height at 5 months after planting (MAP) was 207.6, 206.2, 185.6, 160.0, 150.2 and 138.4 cm for elephant grass, elephant grass on plastic, plastic on elephant grass, wood shavings, plastic and unmulched control, respectively. Leaf area measured at the same time was of the order: elephant grass on plastic > plastic on elephant grass > elephant grass > plastic > wood shavings > control. Total number of suckers at 8 MAP was highest under elephant grass on plastic and least under the control. Flowering of the crop plant was reduced by 16, 41, 35, 19 and 14 days in plots with elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood shavings, respectively in relation with the unmulched treatment. Although mulching significantly improved bunch yields of both plant and ratoon crops, yield of first ratoon was, on the average, about 57 % lower than that of the plant crop.

Significant ($P=0.05$, $r=0.77$) correlation between total bunch yield (t ha^{-1}) and soil exchangeable K (meq/100 g) measured at 6, 18 and 24 MAP was found. Similarly, plant height (cm) and leaf area (m^2) were also significantly correlated with exchangeable K measured at 6 MAP ($P=0.01$, $r=0.97$) and ($P=0.05$, $r=0.75$), respectively. The results emphasise the beneficial effects of mulching on growth and yield of plantain. However, none of the mulch treatments used in this study was able to prevent yield decline between the plant and ratoon crops.

INTRODUCTION

Increased crop yield may be attained by cultivating larger areas or by using improved crop and soil management practices such as mulching. Small farm holders in Nigeria and other parts of tropical Africa may not be able to afford larger areas for cultivation because of the system of land ownership. Consequently, soil and crop management practices on existing lands remain the only option to intensified and sustained crop production in many parts of tropical Africa. Protecting the soil surface with mulches helps to improve the soil environment for optimal crop growth and yield. In addition, an unprotected bare soil surface is prone to severe accelerated soil erosion [4] and overall degradation of the soil [5,7].

The effectiveness of mulch on crop yields in the tropics has been studied for a number

* Contribution from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

** Requests for reprints to be addressed to O.A. Opara-Nadi

of crops, soils and agroecological zones. Mulching has been reported to give higher and sustained yields in field-grown plantains [3,8,9,14]. Plantain mulched with sawdust was superior in vegetative growth to unmulched plot irrespective of the quantity of fertilizer applied [8]. In addition, mulching with sawdust stimulated rapid proliferation of suckers, enhanced early flowering and produced increased and sustained yields of plantain both for the plant and ratoon crops [9]. In another study Obiefuna [10] used different commonly available wastes as mulches and found that mulching with palm bunch refuse, sawdust, woodchips and cassava peel in that order resulted in 20-25 % improved crop establishment over the check and others mulched with either rice husk or brewer's waste. Sawdust and woodchips produced significantly 2-3 times the number of suckers than those plantains mulched with other mulches, exclusing cassava peels which developed similar numbers of suckers as the control. It was further reported that plantains mulched with palm bunch refuse, woodchips and sawdust produced similarly heavy bunches which were significantly superior to the yield of other plantains including the unmulched control. Mbuba [6] mulched plantain in Zaire using water hyacinth which is very rich in potassium but no beneficial effect was observed. Studies on the response of plantain to eupatorium mulch and fertilizer on an acid Ultisol in southeastern Nigeria [2] showed that at the end of the fourth year, the yield of mulched plot was four times that of unmulched fertilized plot (22.8 t ha^{-1} vs. 4.8 t ha^{-1}). Obiefuna [8] observed that sawdust mulch when used with large quantity of fertilizer enhanced vegetative growth of plantain. Yet other studies [3] showed that where plantains are mulched, fertilizer application may not be necessary. Swennen [14] and Swennen and Wilson [15] reported that the beneficial effect of mulch on plantain lies in stimulating better root and sucker development due to improved anchorage and soil moisture and nutrient absorption.

Like in other crops, the effects of mulch on growth and yield of plantains in the tropics vary with soils, crops, micro- and mesoclimate and other factors. It is therefore necessary to evaluate the effects of mulching on growth and yield of plantains in different soils and agroecological zones. In addition, the effectiveness of different kinds of mulch on growth and yield of plantain needs to be studied in relation to changes in soil physical, chemical and hydrological properties.

In the first two papers [11,13] of this study, the effects of different mulching materials on properties of a tropical Ultisol have been reported. The objective of this report, therefore, was to evaluate the effects of different kinds of mulch on growth and yield of plantain on an Ultisol in southeastern Nigeria.

MATERIALS AND METHODS

Location and experimental layout

Details of experimental layout and characterization of soil and environmental parameters have been reported in earlier papers [11,13].

Observations

Growth and yield parameters were monitored on plant crop and on first and second ratoon crops. These parameters were measured on each of the 20 plants selected for observation during planting. Logging of plants was prevented by adequate supports on both plants and bunches. The following growth parameters of plant crop were monitored: plant height and leaf area measured at 1, 2, 3, 4, 5 and 7 months after planting (MAP), plant height at flowering, girth of plant 50 cm above the ground at time of flowering and number of days to flowering. For the first ratoons, the following growth parameters were measured: plant height, girth of plant 50 cm above the ground at time of flowering and number of days to flowering.

Plant height was measured from the surface of the ground to the growing point of the plant. Leaf area was measured on 10 plants selected at random from each plot of every replicate.

The following yield parameters were monitored on plant and first ratoon crops: bunch yield, mean bunch weight, number of hands per bunch and number of fingers per hand. Bunch yield and other yield components were obtained from 20 plants in each plot of each replicate. Each crop was harvested when fully matured, that is when the terminal inflorescences of the bunch have died off. Additional growth and yield components which were monitored were total number of suckers at 8 MAP and height of biggest sucker at the time of flowering of plant crop.

RESULTS AND DISCUSSION

Plant crop

Crop growth

The data in Fig. 1 shows the height of plant crop measured at 1, 2, 3, 5 and 7 MAP for the different kinds of mulch and the unmulched control treatment. Plant height increased rapidly for all treatments up to the period of measurement (7 MAP). At this time, plant height was of the order: elephant grass = elephant grass on plastic > plastic on elephant grass > unmulched control > plastic = wood shavings. At 5 MAP, plant height was 207.6, 206.2, 184.6, 160.0, 150.2 and 138.4 cm for elephant grass, elephant grass on plastic, plastic on elephant grass, wood shavings, plastic and unmulched treatments, respectively. In general, there was no significant difference in plant height between unmulched control, plastic and wood shavings treatments for most of the period of measurement. Similarly, there was no significant difference in plant height between elephant grass, elephant grass on plastic and plastic on elephant grass treatments for most months.

Plant height (cm) at 6 MAP (interpolated from Fig. 1) and exchangeable K in the soil (meq/100 g) measured at 6 MAP were related by the expression:

$$\text{Plant height} = 97.06 + 367.59 \text{ (soil exch. K)}$$

$$r = 0.97 \text{ at } P_{0.01}.$$

Leaf area increased rapidly with time especially between 2 and 3 MAP and between 5 and 7 MAP (Fig. 2). In addition, significant differences in leaf area among treatments were evident from 2 MAP up to the end of the period of measurement (7 MAP). Leaf area measured at 7 MAP was 5.67, 5.64, 4.99, 4.88, 4.09 and 3.54 m^2 for elephant grass on plastic, elephant grass, wood shavings, unmulched control, plastic on elephant grass and plastic treatments, respectively. From 2 MAP, leaf area was highest in elephant grass on plastic mulch and lowest in unmulched treatment except at 7 MAP when leaf area was lowest in plastic mulch treatment. The increase in leaf area observed between treatments was associated with an increase in exchangeable K present in the soil.

Leaf area (m^2) measured at 6 MAP (interpolated from Fig. 2) and exchangeable K in the soil determined at 6 MAP were related by the expression:

$$\text{Leaf area} = 1.34 + 8.18 \text{ (soil exch. K)}$$

$$r = 0.91 \text{ at } P_{0.05}.$$

The above results reflect the fact that exchangeable K in the soil may be a major element affecting the above ground growth of plantain (*Musa* sp. cv. AAB) on an Ultisol in a high rainfall region. The importance of potassium to plantain lies in stimulating good vegetative growth and bunch yield [12]. Although many soil properties were measured, exchangeable K was the only one that gave good correlation with plant growth and yield.

Height of plant crop at flowering, girth of plant crop 50 cm above the ground at flowering, number of days to flowering and height of biggest sucker at time of flowering of plant crop were significantly affected by mulching

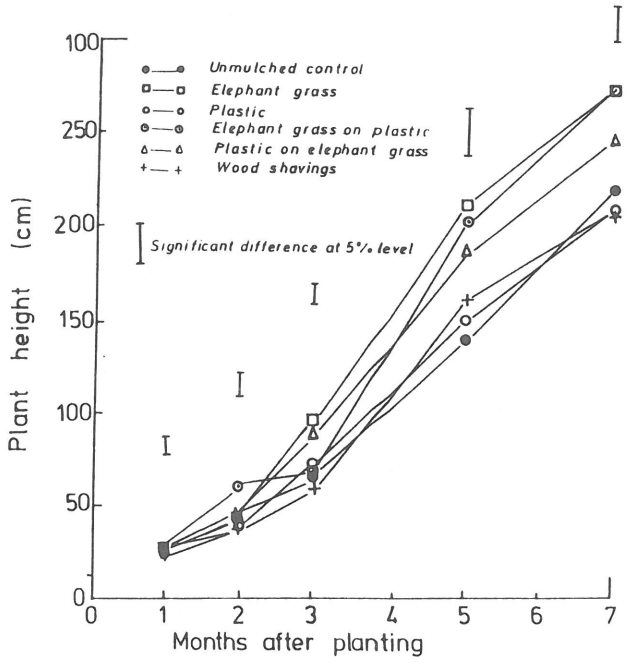

Fig. 1. Effect of different mulching materials on height of plantain (plant crop).

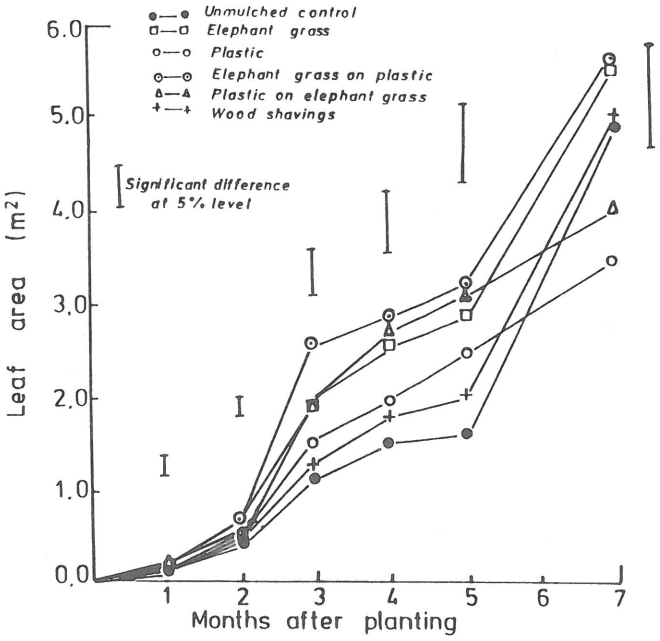

Fig. 2. Effect of different mulching materials on total leaf area of plant crop.

Table 1. Effects of mulching materials on growth of plantain

Treatment	Height of plant crop at flowering (cm)	Girth of plant crop 50 cm above ground at flowering (cm)	Days to flowering of crop plant	Height of biggest sucker at the time of flowering of plant crop (cm)
Unmulched control	311.6a[1]	67.6ab	312.5a	97.2a
Elephant grass	346.4b	67.5ab	296.9a	118.3b
Plastic	263.5c	54.5a	271.9b	84.4c
Elephant grass on plastic	345.5b	85.0b	277.7bc	116.4bd
Plastic on elephant grass	319.8a	62.1ab	294.2ac	106.2ad
Wood shavings	317.9a	61.9ab	298.5a	107.3ac

1 Mean followed by the same letter in the same column are not significantly different at the 5% level of Duncan's multiple range test.

treatments (Table 1). Height of plant crops at flowering and height of biggest sucker at flowering of plant crop were greatest under elephant grass treatment and lowest under plastic mulch treatment. Girth of plant crop 50 cm above the ground at flowering was biggest for elephant grass on plastic treatment and smallest for plastic treatment. Shortest length of time to flowering by plant crop was recorded for plastic treatment, while the longest time to flowering occurred in unmulched plots. Weight and girth of the plant are important plant parameters which determine the susceptibility of the plant to logging during storms accompanied by high velocity winds. Data presented in Table 1 indicate that mulching produced significantly better vegetative growth and decreased the number of days to flowering for plantain.

Yield

The effects of mulching on the yield components of plantain (plant crop) are presented in Table 2. The data show that bunch yield in mulched treatments were significantly higher than that in the unmulched treatment. Among the mulched treatments, highest bunch yield was obtained for the elephant grass treatment. However, there was no significant difference in yield between elephant grass on plastic, plastic on elephant grass, wood shavings and unmulched treatments. Mean bunch weight was significantly affected by mulching. Mean bunch weight was highest for elephant grass treatment and lowest for plastic treatment. The other treatments had mean bunch weight between those of elephant grass and plastic treatments. Number of hands per bunch and number of fingers per hand were also significantly higher in elephant grass treatment than other treatments. The lowest number of fingers per hand was obtained for the plastic treatment; while the lowest number of fingers per hand was obtained for both plastic and unmulched treatments. Total number of suckers at 8 MAP was 152, 134, 112, 109, 96 and 89 for elephant grass on plastic, elephant grass, wood shavings, plastic on elephant grass, plastic and unmulched treatments, respectively (Table 2).

Ratoon crops

Crop growth

Significant differences in height of first ratoon at flowering, girth of first ratoon 50 cm above the ground at flowering, number of days to flowering and height of second ratoon at flowering and harvesting the first ratoon were observed among treatments (Table 3). The best growth parameters of the first and second ratoon crops were measured for elephant grass treatment compared with the other treatments. Height of first ratoon and girth at 50 cm above the ground at flowering were 388 and 76 cm for

Table 2. Yield of plantain (plant crop) as affected by mulching

Treatment	Bunch yield (t ha^{-1})	Mean bunch weight (kg)	Number of hands per bunch	Number of finger per hand	Total number of suckers at 8 MAP
Unmulched control	12.56a[1]	9.72a	7.5a	34.6a	89.0a
Elephant grass	17.60b	11.82b	8.3b	42.1b	134.3bc
Plastic	12.71a	8.44c	7.0c	34.6a	95.5a
Elephant grass on plastic	18.88b	11.63bd	7.7a	37.5a	151.5c
Plastic on elephant grass	15.70ab	10.62ad	7.4a	36.3a	108.8ab
Wood shavings	15.86ab	10.73ad	7.4a	36.7a	111.5ab

1 - For explanation see Table 1.

elephant grass, 366 and 72 cm for plastic on elephant grass, 344 and 67 cm for unmulched, 337 and 66 for wood shavings and 308 and 60 cm for plastic treatments. On the other hand, the shortest number of days to flowering was recorded for elephant grass treatment while the longest number of days was recorded for wood shavings treatment. All the other treatments were in between. At flowering of first ratoon, the tallest second ratoon was measured for elephant grass treatment, while at harvesting of second ratoon, the tallest second ratoon was measured for elephant grass on plastic treatment. However, there were no significant differences between number of days to flowering of first ratoon and height of second ratoon at flowering and harvesting of first ratoon among the treatments.

Yield

The effect of mulching on the yield components of the first ratoon crop is shown in Table 4. The data show that bunch yield in the mulched treatments was significantly higher than that in the unmulched treatment. Bunch yield was 65 %, 43 %, 78 %, 120 % and 83 % higher in elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood shavings treatments, respectively, than in the unmulched treatment. The higher yield in mulched treatments may be attributed to more favourable hydrothermal regimes under mulch cover than in the unmulched plots. When compared with the plant crop, bunch yield of first ratoon crop decreased by 67 %, 62 %, 54 %, 52 %, 43 % and 53 % for unmulched, elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood

Table 3. Growth of 1st and 2nd ratoons for different mulching materials

Treatment	Height of 1st ratoon at flowering (cm)	Girth of 1st ratoon at 50 cm above ground at flowering (cm)	Days to flowering of 1st ratoon	Height of 2nd ratoon at flowering of 1st ratoon (cm)	Height of 2nd ratoon at harvesting of 1st ratoon (cm)
Unmulched control	343.8ab[1]	66.8a	560.6a	80.2a	149.4a
Elephant grass	388.2c	76.2b	549.4a	94.3a	152.4a
Plastic	307.9d	60.1c	556.0a	74.4a	127.9a
Elephant grass on plastic	366.0e	72.0d	589.6a	88.8a	154.2a
Plastic on elephant grass	356.8ae	71.7d	583.1a	87.8a	152.5a
Wood shavings	336.5b	66.0a	591.5a	92.4a	148.4a

1 - For explanation see Table 1.

Table 4. Yield of plantain as affected by mulching (1st ratoon)

Treatment	Bunch yield ($t\ ha^{-1}$)	Mean bunch weight (kg)	Number of hands per bunch	Number of fingers per hand
Unmulched control	4.09a[1]	7.69a	8.0ab	32.6a
Elephant grass	6.75bc	10.15b	8.8c	46.6b
Plastic	5.86ac	7.22a	7.4a	33.0a
Elephant grass on plastic	7.26bc	9.94b	8.3c	38.2a
Plastic on elephant grass	8.99b	9.94b	8.2bc	37.8a
Wood shavings	7.47bc	7.42a	7.6a	33.6a

1 - For explanation see Table 1.

shavings treatments, respectively. Decreasing phosphorus availability, such as it was evident from 6 to 24 MAP, may be the cause of lower yield of first ratoon than plant crop.

Mean bunch weight, number of hands per bunch and number of fingers per hand of the first ratoon crop were significantly higher under elephant grass mulch treatment than under all the other treatments (Table 4). On the other hand, mean bunch weight and number of hands per bunch were lowest under plastic mulch treatment, while number of fingers per hand was lowest in unmulched treatment. There was no significant difference in mean bunch weight and number of hands per bunch between elephant grass, elephant grass on plastic and plastic on elephant grass treatments.

Total yield (plant crop and 1st ratoon)

Total bunch yield of both plant crop and first ratoon crop was 16.65, 24.35, 18.57, 26.14, 24.69 and 23.33 t ha^{-1} for unmulched, elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood shavings treatments, respectively. Mean bunch weight was 8.71 kg for unmulched treatment, 10.98 kg for elephant grass, 7.83 kg for plastic, 10.79 for elephant grass on plastic, 10.28 kg for plastic on elephant grass and 9.08 kg for wood shavings treatments. When compared with the unmulched treatment, elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood shavings treatments increased total bunch yield by 46, 12, 57, 48, and 40 %, respectively. The increase in bunch yield observed with mulch application was attributable to more favourable soil properties under mulched treatments than unmulched treatment. Total bunch yield and exchangeable K measured at 6, 18 and 24 MAP were related by the expression:

$$\text{Total yield} = 8.87 - 14.02\ (\text{soil exch. K, 6 MAP}) + 54.57\ (\text{soil exch. K, 18 MAP}) + 23.14\ (\text{soil exch. K, 24 MAP})$$

$$r = 0.77 \text{ at } P_{0.05}.$$

CONCLUSIONS

1. Mulch treatments, with the exception of plastic mulch, significantly increased the height and girth of stem when compared with the unmulched treatment.

2. Total leaf area and number of suckers produced were lowest in unmulched plot and highest under elephant grass on plastic mulch.

3. Mulching significantly increased bunch yield and mean bunch weight of both plant and ratoon crops. Increase in total yield (plant crop plus first ratoon) was 46, 12, 57, 48 and 40 % under elephant grass, plastic, elephant grass on plastic, plastic on elephant grass and wood shavings mulches, respectively when compared with the unmulched treatment.

4. Yield of first ratoon crop was on the average about 57 % lower than that of the plant crop.

5. Number of hands per bunch and number of fingers per hand were significantly higher under mulch covers than in unmulched treatment.

6. Although the highest total yield (plant crop plus first ratoon) was recorded under elephant grass on plastic mulch (26.14 t ha^{-1}) compared with elephant grass mulch (24.35 t ha^{-1}), a cost-benefit ratio analysis showed that elephant grass on plastic though effective in increasing yield was more expensive than elephant grass alone.

7. Significant ($P_{0.05}$, r =0.77) correlation between total bunch yield and soil exchangeable K measured at 6, 18 and 24 MAP was found. Similarly, plant height and leaf area were also significantly correlated with exchangeable K measured at 6 MAP ($P_{0.01}$, r=0.97) and ($P_{0.05}$, r=0.75), respectively.

8. The results emphasise the beneficial effects of mulching on growth and yield of plantain. Higher yields obtained from treatments with mulch suggest that mulching can be used to improve productivity. However, none of the mulch treatments used in this study was able to prevent yield decline between the plant and ratoon crops. Similar observation has been made by Wilson *et al.* [16]. This study and other studies [1], therefore, indicate that the effect of mulch does not lead to ratooning similar to that of banana or that of compound-grown plantain.

REFERENCES

1. **Braide J., Wilson G.F.**: Plantain decline: a look at possible causes. Paradisiaca, 4, 3-7, 1980.
2. **IITA.** International Institute of Tropical Agriculture Annual Report for 1980. Ibadan, Nigeria, 1981.
3. **IITA.** International Institute of Tropical Agriculture Annual Report for 1982. Ibadan, Nigeria, 1983.
4. **Lal R.**: Soil erosion problems on an Alfisol in Western Nigeria and their control. IITA Monograph Series No. 1. IITA, Ibadan, Nigeria, 1976.
5. **Lal R.**: Soil erosion from tropical arable lands and its control. Adv. Agron., 37, 183-248, 1984.
6. **Mbumba N.**: Mulching plantains with water hyacinth. Proc. Annual Meeting of W. African Regional Cooperative for Research on Plantains. IITA, Ibadan, Nigeria. December 5-9. 1983.
7. **Nye P.H., Greenland D.J.**: Changes in soil after clearing a tropical forest. Plant Soil., 21, 101-120, 1964.
8. **Obiefuna J.C.**: The effect of sawdust mulch and increasing levels of nitrogen on the growth and yield of plantain (Musa AAB). Proc. Annual Meeting of W. African Regional Cooperative for Research on Plantains. IITA, Ibadan, Nigeria. December 5-9, 1983.
9. **Obiefuna J.C.**: The effect of monthly planting on yield, yield pattern and yield decline of plantains (Musa AAB). Scientia Hortic., 29, 47-54, 1986 a.
10. **Obiefuna J.C.**: Crop wastes and plantain (Musa AAB) production in the tropical rainforest of Nigeria. 8th Annual Conf. Hortic. Soc. Nigeria, NIHORT, Ibadan, Nigeria. November 9-15. 1986b.
11. **Opara-Nadi O.A., Salau O.A., Swennen R.**: Response of plantain to mulch on a tropical Ultisol: Part II. Effect of different mulching materials on soil hydrological properties. Int. Agrophysics, 6, 1-2, 55-66,1992.
12. **Pursegbove J.W.**: Tropical Crops. Monocotyledons. Longmans, London, 1972.
13. **Salau O.A., Opara-Nadi O.A., Swennen R.**: Response of plantain to mulch on a tropical Ultisol: Part I. Effect of different mulching materials on soil physical and chemical properties. Int. Agrophysics, 6, 1-2, 55-66, 1992.
14. **Swennen R.**: A physiological study of the sucker behaviour of plantain (Musa AAB). Dissertations De Agriculture, Katholicke Universitat de Leuven, 1984.
15. **Swennen R., Wilson G.F.**: Flamingia congesta as a live cover plant for plantain. Banana News Letter, 8, 17, 1985.
16. **Wilson G.F., Swennen R., De Lange E.**: Effects of mulch and fertilizer on yield and longevity of a medium and giant plantain and a banana cultivar. Int. Assoc. for Research on Plantains and Bananas. Proc. 3rd Meeting, Abidjan, Cote d'Ivoire. May 27-31 , 1985.