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Effects of organic and inorganic soil amendments on growth performance of plantain (*Musa paradisiaca* L.)

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A field experiment was conducted to investigate the comparative effects of organic and inorganic soil amendments on growth and performance of plantain (*Musa paradisiaca*). The experiment was established in March 2011 and repeated in February 2012. The treatments consisted of nine soil amendments (NPK sole, Jatropha sole, palm kernel cake (PKC) residue sole, Sunshine organo-mineral sole, NPK + Jatropha husk 50:50, Sunshine organo-mineral + Jatropha husk 50:50, PKC residue + NPK 50:50, PKC residue + Sunshine organo-mineral 50:50, and Control) experiment was laid out in a randomized complete block design, and replicated thrice. No significant (P < 0.05) difference obtained in the two trials, nevertheless, NPK 15:15:15 produced the highest response to leaf area, leaf numbers and stem girth. Sunshine organo-mineral also showed higher response in stem girth, while the combination of decayed Jatropha husk and NPK fertilizer applied at the ratio of 50:50 had the highest plant height. To facilitate the scaling up of these fertility options, future research and development needs to address recommended application rates, impacts and the method by which crops can be intensively farmed to provide a natural progression out of poverty. Sustaining the findings of this research will enhance good soil management quality, increase farmers productivity as well as improves farmer's standard of living.

Key words: Fertilizers, growth parameters, organo-mineral, plantain and soil amendments.

INTRODUCTION

Plantain is a major food in Equatorial Africa and Andean regions (USDA, 2009). The attractiveness as food is that they fruit all year round; making plantain all reliable more season stable food. Plantain is grown as a rain fed crop in Nigeria. Its production is limited as it is committed mostly in the hands of subsistence farmers, who cultivate plantain to protect or shield other crops such as cocoa (*Theobroma cacao*) at the early stage of their vegetative growth to prevent cacao from wilting due to low soil moisture experienced in the dry season. Plantain production in Nigeria has been estimated to be 1,855,000 metric tonnes and they are produced in large quantities in Edo, Delta, Ogun, Ondo, Oyo, Osun, Rivers, Cross River, Imo, Anambra, Lagos, Kwara, Benue, Plateau, Kogi, Abia and Enugu states (Wilson, 1983; Swennen, 1990; FAO, 1997). In Nigeria plantation production has gone seriously on the decline due to diseases (Ramsey et. al., 1990), depleted soil nutrients and inadequate and

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indiscriminate use of soil amendments (Rosati et al., 2000).

Soil nitrogen mineralization and availability has a direct and significant influence on plant vitality, which has been highly depleted (Rosati et al., 2000).

Soils in South Western and Southern part of Nigeria where plantain are mostly cultivated are acidic due to the nature of the parent material, heavy leaching and weathering. In addition to acidity, the soils suffer from nutrient deficiency (Owolabi et al., 2003). Plantain requires deep and fertile soil which contributes to rapid leaf production and optimum nutrient uptake (Obiefuna, 1984). Also, late flowering has been attributed to low soil fertility status. Bunch mass and yield component of plant and ratoon crops except the number of hands per bunch respond to potassium, phosphorus and nitrogen at various levels (Obiefuna, 1984).

Efficient soil management through organic and inorganic soil amendments, crop rotation, planting cover crops will boost further production and overcome hazardous practices on the soil from the environment such as bush burning and overgrazing. Yield increases can be attributed to soil quality improvements, including increased soil organic matter and water-holding capacity, better soil structure and water infiltration, and decreased erosion compared to continuous cropping or even following green manure cover crops (Wright et al., 2002). Soil amendments has improved the quality of arid and non-farming soils to cultivable land, soil structure of soils are improved through organic fertilizers used as soil amendment which increase the activities of micro and macro organisms in soil types, thus improves soil formation through increasing organic matter content in soils, structure and aeration. Many long-term studies in the United States have documented trends of organic matter losses on agricultural land (NRCS Soil Quality Institute, 2001). Land degradation and declining soil fertility are increasingly being viewed as critical problems affecting agricultural productivity and human welfare in tropical Africa. It is estimated that an average of 660 kg of nitrogen (N) ha^{-1}, 75 kg of phosphorus (P) ha^{-1} and 450 kg of potassium (K) ha^{-1} have been lost during the last 30 years from around 200 million ha of cultivated land in 37 countries in sub-Saharan Africa (SSA) (Stroorvogel et al., 1993). Past long-term experimental studies have shown that soil organic C (SOC) is highly sensitive to changes in land use, with changes from native ecosystems such as forest to agricultural systems almost always resulting in a loss of SOC (Jenkinson, 1977; Paul et al., 1997). Likewise, the way in which land is managed following land use change has also been shown to affect SOC stocks. We therefore have the opportunity in the future to change to land use and land management strategies that lead to C storage in the soil, thereby mitigating GHGs effects and improving soil fertility. The critical issue for improving agricultural productivity in southern Africa is how to build up and maintain soil fertility despite low incomes, increasing labour and land constraints faced by smallholder farmers (Kumwenda et al., 1997).

Smallholder farmers in Nigeria have adopted high yielding plantain varieties and other crops such as maize, cassava and grain legumes with some success. However, increase in crop growth and yields have been disappointing. This is largely as a result of declining soil fertility among many other factors. This problem is widespread and is becoming worse with market liberalization in Nigeria. Most nutrient budgets show a negative balance due to soil nutrients deficiencies, which are used up by other crops initially grown on the land or by leaching and little use of inorganic fertilizer and organic inputs. The question to be posed is how to build up and maintain soil fertility under the poverty faced by many farmers. The need for added external nutrients is imperative. However, inorganic fertilizers are expensive; their use is sometimes unprofitable especially because of blanket recommendations. As a result, farmers need to be enhanced to produce a basic stable crop like plantain more efficiently putting into cognizance soil quality improvement and also improve on the constraints and possible areas of conservation towards a greater plantain output. Therefore, comparative effects of organic and inorganic soil amendments was carried out on growth performance of plantain and the variation in the treatments used was determined in order to recommend best soil amendments that could be used to boost plantain production and conserve soil nutrients for further crop production.

MATERIALS AND METHODS

Experimental design

The following experiments was laid out in a randomized complete block design and replicated thrice. Nine plantain suckers (corms) were planted at a spacing of 3 x 3 m per plot, ultimately a total plant population of eighty-one was established in 729 m^2 land area.

Treatments

The nine treatments used were derived from both organic and inorganic sources. The organic fertilizer used included sunshine organo– mineral (fortified) and other organic manures derived from Jatropha husk, palm kernel cake residue. Meanwhile, the inorganic fertilizer used was NPK fertilizer (15:15:15). Weeding was done manually four times at four, eight, twelve and fifteenth week after planting. The treatments were arranged as follows:

(1) NPK 15:15:15 sole
(2) Sunshine organo – mineral sole
(3) Palm kernel cake sole (residue)
(4) Jatropha husk sole (Decaying)
(5) Jatropha husk + sunshine organo- mineral (50:50)
(6) Jatropha husk + NPK (50:50)
(7) Palm kernel cake (PKC) (residue) + sunshine organo- mineral (50:50)
(8) Palm kernel cake (residue) + NPK (50:50)
(9) Control

Figure 1. A selected plant with inorganic soil amendment (NPK15:15:15, sole).

Fertilizer application

Placement method of fertilizer application adopted in this study involves placing fertilizers at a safe distance from where the root system of the crops is able to make use of it (Figure 1). Nine varied treatment combinations and quantity of fertilizer and manure were applied (Table 1).

Criteria used in the selection of crop experimental variety

(1) Early maturing
(2) Moisture stress resistance
(3) High yielding
(4) Pests and diseases free
(5) Average weight of corms (250 g)

Data collection and analysis

Primary data were collected starting at sixth week after planting which is equivalent to 4 weeks of growth before fertilizer application and 2 weeks for mineralization after its application. The growth parameters measured included, stem girth, number of leaves, leaf area and plant height. Data was collected from each experimental plot two weeks after treatment application and at intervals of two weeks up to the 16th week. Treatment effect were determined by analysis of variance (ANOVA) and significant mean differences were separated using Tukey at P≤0.05.

RESULTS

There was a significant effect on the growth parameter in the soil amendments used at P≤0.05 (Tables 2 to 5). The mean difference among the parameters showed significant effect at P≤0.05.

Comparison of means of number of leaves (NL)

NPK 15:15:15 as a treatment showed the highest number of leaves among other treatments selected (Table 2). There was significant difference between the ‘numbers of leaves’ as a growth parameter considered on plants and the source of fertilizers used. This result was taken from number of leaves (fresh and dry) produced by plantain plant during the experiment.

Comparison of means on the stem girth of plantain plants

NPK 15:15:15 and sunshine organo-mineral soil treatments showed a better response in stem girth from 2 to 14 weeks of application. But sunshine organo-mineral showed a higher response (52.13 cm) than NPK at 16th week of application (Table 3).

Comparison of means on leaf area (cm²) of the sampled plantain plants

The wide and vigorous growth of leaves observed in Sunshine organo-mineral sole and NPK 15:15:15 sole produced by plants, exposed the plants to more area of photosynthesis and as a result helps in the vigorous growth of other parts of plant (Table 4).

Table 1. Treatments combination and quantity of fertilizer and manure applied.

Treatments	Quantity applied/stand	Quantity applied/ha
	grammes	kilogramme
NPK 15:15:15 sole	180	200
Sunshine organo-mineral sole	226	250
PKC sole (residue)	361	400
Jatropha husk sole	361	400
Jatropha husk + Sunshine organo-mineral (50:50)	294	325
PKC residue + sunshine organo-mineral (50:50)	294	325
Jatropha husk + NPK (50:50)	271	300
PKC residue + NPK (50:50)	271	300
Control (no fertilizer application)	0	0

Table 2. Effects of organic and inorganic soil amendments on number of leaves.

Treatments	2	4	6	8	10	12	14	16
	Weeks after treatments application							
Control	6.00^{cd}	7.00^{de}	7.33^{de}	8.33^{de}	9.33^{de}	9.67^{d}	10.67^{cd}	11.33^{de}
PKC residue + NPK (50:50)	4.67^{d}	5.67^{e}	6.67^{e}	7.67^{e}	8.67^{e}	9.33^{d}	10.00^{d}	10.67^{e}
Jatropha husk sole	7.33^{bc}	8.00^{cde}	8.67^{cde}	9.33^{cde}	10.33^{cde}	11.00^{cd}	11.67^{cd}	12.67^{cde}
PKC residue sole	8.00^{abc}	9.67^{bc}	10.67^{bc}	11.33^{bc}	12.33^{bc}	13.00^{bc}	13.33^{bc}	14.33^{bc}
Jatropha husk + Sunshine Organo-mineral (50:50)	8.00^{abc}	8.67^{bcd}	9.67^{bcd}	10.67^{bc}	11.67^{bcd}	11.67^{cd}	12.67^{bcd}	13.67^{bcd}
PKC residue + Sunshine organo-mineral (50:50)	7.67^{abc}	8.67^{bcd}	9.67^{bcd}	10.33^{cd}	11.33^{bcd}	11.67^{cd}	12.67^{bcd}	13.67^{bcd}
Jatropha husk + NPK (50:50)	7.67^{abc}	8.67^{bcd}	9.33^{bcd}	10.33^{cd}	11.33^{bcd}	12.33^{bc}	13.00^{bc}	14.00^{bcd}
Sunshine organo-mineral sole	9.33^{ab}	10.67^{ab}	11.67^{ab}	12.67^{ab}	12.33^{ab}	14.33^{ab}	15.00^{ab}	15.67^{ab}
NPK sole	10.00^{a}	12.33^{a}	13.33^{a}	14.33^{a}	15.67^{a}	16.33^{a}	17.00^{a}	17.33^{a}

Means followed by the same column are not significantly different from each other by Tukey at 5% level of probability.

Table 3. Effects of organic and inorganic soil amendments on stem girth development

Treatments	2	4	6	8	10	12	14	16
	Weeks after treatments application							
Control	10.33^{c}	17.37^{c}	20.07^{e}	23.03^{e}	26.07^{d}	29.00^{d}	31.37^{d}	34.10^{e}
PKC residue + NPK (50:50)	12.00^{bc}	18.07^{bc}	21.00^{de}	25.03^{de}	28.67^{cd}	33.00^{cd}	37.43^{c}	41.67^{cd}
Jatropha husk sole	14.67^{abc}	20.07^{bc}	23.37^{cde}	29.03^{cd}	33.67^{bc}	38.00^{bc}	42.37^{bc}	45.67^{cd}
PKC residue sole	15.00^{abc}	19.00^{bc}	22.73^{cde}	28.00^{cde}	32.10^{bc}	35.00^{bc}	40.33^{bc}	45.33^{cd}
Jatropha husk + Sunshine organo-mineral (50:50)	15.00^{abc}	21.07^{abc}	25.37^{bcd}	29.33^{cd}	33.07^{bc}	37.67^{bc}	41.00^{bc}	43.33^{cd}
PKC residue + Sunshine organo-mineral (50:50)	17.33^{ab}	23.67^{ab}	26.67^{abc}	31.40^{abc}	35.67^{b}	39.67^{ab}	43.33^{b}	46.67^{bcd}
Jatropha husk + NPK (50:50)	17.40^{ab}	22.73^{abc}	26.07^{abcd}	31.00^{bc}	35.33^{b}	40.37^{ab}	44.10^{ab}	47.70^{abc}
Sunshine organo-mineral sole	18.03^{ab}	26.13^{a}	30.00^{ab}	35.00^{ab}	41.43^{a}	44.43^{a}	48.67^{a}	52.13^{a}
NPK Sole	18.47^{a}	26.67^{a}	31.10^{a}	36.40^{a}	41.43^{a}	44.77^{a}	48.67^{a}	51.87^{ab}

Means followed by the same column are not significantly different from each other by Tukey at 5% level of probability.

Comparison of means on Plant height (cm) of the sampled plantain plants

Jatropha husk + NPK 15:15:15 (50:50) and NPK 15:15:15 sole, produced a better response in terms of plantain plant height at (160 and 172 at 16 weeks respectively). Higher levels of phosphorus derived from both organic and inorganic sources in Jatropha and NPK was noted to be responsible for higher response in the height of plants as realized in the study (Table 5 and Figure 2).

Table 4. Effects of organic and inorganic soil amendments on Leaf area of plants

Treatments	2	4	6	8	10	12	14	16
	Weeks after treatment application							
Control	772.7^{b}	1343.0^{c}	2098.3^{b}	2757.7^{cd}	2681.3^{d}	4269.3^{c}	5110.3^{b}	6024.0^{cd}
PKC residue + NPK (50:50)	828.7^{b}	1198.0^{c}	2082.3^{b}	2706.7^{d}	3265.7^{cd}	3946.0^{c}	4689.7^{b}	5347.7^{d}
Jatropha husk sole	1285.3^{ab}	1928.7^{bc}	2813.3^{b}	3666.7^{bcd}	4393.0^{bcd}	5277.0^{bc}	6302.3^{b}	6968.7^{bcd}
PKC residue sole	1789.0^{ab}	2542.0^{abc}	3147.0^{b}	4420.3^{bc}	6335.7^{ab}	6814.0^{b}	8191.0^{ab}	9191.7^{b}
Jatropha husk + Sunshine Organo-mineral (50:50)	1719.0^{ab}	2282.0^{abc}	3310.0^{b}	4120.3^{bcd}	4769.3^{bcd}	5737.0^{bc}	6622.0^{b}	7244.7^{bcd}
PKC residue + Sunshine organo-mineral (50:50)	1894.7^{ab}	2378.0^{abc}	3520.7^{b}	4642.3^{b}	5427.0^{bc}	6096.0^{bc}	5236.0^{b}	8377.3^{bc}
Jatropha husk + NPK (50:50)	1894.7^{ab}	2554.7^{abc}	3561.3^{b}	4741.7^{b}	6025.3^{b}	7115.3^{b}	8140.7^{ab}	9371.0^{b}
Sunshine organo-mineral sole	2423.3^{a}	3621.7^{ab}	5506.7^{a}	6754.7^{a}	8368.7^{a}	10233.7^{a}	11413.0^{a}	12494.0^{a}
NPK Sole	2567.3^{a}	3945.3^{a}	5815.0^{a}	6687.7^{a}	8557.0^{a}	10360.7^{a}	11586.0^{a}	12406.7^{a}

Means followed by the same column are not significantly different from each other by Tukey at 5% level of probability.

Table 5. Effects of organic and inorganic soil amendments on plant height.

Treatments	2	4	6	8	10	12	14	16
	Weeks after treatments application							
Control	51.33^{b}	59.67^{a}	76.67^{a}	89.00^{c}	99.00^{b}	107.67^{b}	117.67^{c}	126.00^{c}
PKC residue + NPK (50:50)	51.00^{b}	66.00^{ab}	88.00^{ab}	96.33^{bc}	96.33^{bc}	117.00^{ab}	127.67^{bc}	136.00^{bc}
Jatropha husk sole	56.00^{ab}	72.67^{ab}	89.33^{ab}	102.33^{abc}	111.67^{ab}	122.33^{ab}	133.33^{abc}	144.33^{abc}
PKC residue sole	50.67^{b}	68.33^{ab}	89.00^{ab}	05.33^{abc}	133.33^{ab}	121.67^{ab}	133.00^{abc}	143.67^{abc}
Jatropha husk + Sunshine Organo-mineral (50:50)	54.67^{ab}	70.33^{ab}	89.67^{ab}	104.33^{abc}	115.67^{ab}	124.67^{ab}	132.33^{abc}	140.67^{bc}
PKC residue + Sunshine organo-mineral (50:50)	77.67^{ab}	88.67^{ab}	102.33^{ab}	117.00^{abc}	127.67^{ab}	136.67^{ab}	147.67^{abc}	157.00^{ab}
Jatropha husk + NPK (50:50)	87.67^{a}	101.67^{a}	117.67^{a}	126.00^{ab}	134.33^{ab}	142.00^{a}	150.00^{ab}	160.67^{ab}
Sunshine organo-mineral sole	59.33^{ab}	83.33^{ab}	107.00^{ab}	15.00^{abc}	125.00^{ab}	133.33^{ab}	142.00^{abc}	154.00^{abc}
NPK Sole	76.67^{ab}	101.67^{a}	121.33^{a}	134.33^{a}	142.67^{a}	149.00^{a}	158.33^{a}	172.33^{a}

Means followed by the same column are not significantly different from each other by Turkey at 5% level of probability.

DISCUSSION

There was a significant comparative effect of organic and inorganic soil amendments on the growth performance of plantain in this study. NPK 15:15:15(treatment) showed a better response in stem girth, number of leaves and leaf area. NPK + Jatropha gave more significant effect on plant height; this confirmed the observation made by Swift et al. (1994) that combination of organic matter and fertilizer improved growth performance of crop when maintained without degrading soil fertility status. This observation was also made by Obiefuna (1984) that plantain vigorous growth could be attributed to mulching and nutrient uptake. Also faster rate of mineralization of the NPK treatment in the soil before others aided the fast uptake by plants taking the nutrients added, in

Figure 2. A selected plant with organic soil amendment (sunshine organo-mineral plus decaying Jatrofa husk 50:50).

a bottom-up manner for growth and development. This support the observation of Metcalfe and Elkins (1984), that nitrogen fertilization enhanced water use efficiency of a crop. This resulted in higher yield at harvest season. The applied nitrogen might have enhanced water uptake by the suckers which was utilized for growth efficiency. Downton (1983) also observed that availability of nitrogen source to plants roots facilitates and encourages osmo-regulation in the leaves such that the leaves did not suffer photosynthetic inhibition.

The fortified 'sunshine organo-mineral' which was made up of decayed organic matter has higher moisture absorbing character, thus water is absorbed from the environment to the root zone of plants which correlated with the observation of Crafts (1968), that the supply of nutrients to a plant is directly related to water movement into roots. Also Ndubuzi and Okafor (1976) earlier reiterated the importance of moisture availability on leaf production in plantain. This character established a more competitive association between NPK and 'sunshine organo-mineral'. It was deduced from this study that soil amendments using both organic and inorganic sources aided the growth performance of plantain especially after 4 to 8 weeks of application.

Conclusion

It could be deduced from this study that the application of nutrients supplements as soil amendments enhanced the growth of plantain resulting in rapid leaf production and plant vigour. However, NPK 15:15:15 fertilizer sole, showed the highest level of response to agronomic growth performance of plantain while 'sunshine organo-mineral' and combination of decayed Jatropha husk + NPK fertilizer also had a significant contribution. In addition, the soil amendments might have improved the soil quality through the increase in available soil nutrients to plants. The solution to soil fertility problems will not depend on use of inorganic fertilizers alone. More attention should be directed to the use of organic and inorganic sources and the combination of both for better soil quality improvement. Therefore it is highly suggestive that the usage of soil amendments such as NPK 15:15:15 fertilizer, 'sunshine organo-mineral' and combination of decayed Jatropha husk + NPK fertilizer will boost plantain production tremendously and soil fertility level to further plantain production. The paradigm of research and development on soil fertility options must change. The approaches need to move from rigid and prescriptive approach to flexible, problem solving format with a lot of farmer participation. There is need for social science research to deal with issues of adoption and scaling up of the available options. Potential synergies to address soil fertility problems can be gained by combining technical options with farmer's knowledge as well as new approaches to farmer training and policy dialogue. Policy issues touching on the soil resource base, as well as product markets need to be addressed to ensure use of agricultural technological innovations.

Conflict of Interest

The authors have not declared any conflict of interest.

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REFERENCES

Crafts AS (1968). Water deficit and physiological process. In: Water Deficit and Plant Growth. Vol 11. Kozlowski TT (Ed.). Academic Press, N.Y. pp. 85-124.

Downton WJS (1983). Osmotic adjustment during water stress protects the photosynthetic apparatus against photo inhibition. Plant Sci. Lett. 30:137-143.

Food and Agriculture Organization of the United Nations FAO (1997). FAO production Statistics (FAO) and the Information Network on Post-harvest Operations (INPhO). P. 198 FAO Code: 86, AGRIS: SO1, ISBN 92-5-102862-1.

Jenkinson DS, Rayner JH (1977). The turnover of soil organic matter in some of the Rothamsted Classical Experiments. Soil Sci. 123:298-305.

Kumwenda JDT, Waddington S, Snapp SS, Jones JB, Blackie MJ (1997). Soil fertility management in the smallholder maize based cropping systems of eastern and southern Africa. In Eisher C (eds) The Emerging Maize Revolution. Michigan State University E. Lansing, MI, USA, pp. 153-172.

Metcalfe DS, Elkins DM (1984). Crop Production: Principles and Practices. 4th Edition. Macmillan Pub. Co., Inc. N.Y. P. 774.

Ndubuzi TOC, Okafor EI (1976). Growth and yield pattern of Nigeria

plantains. Fruit 31:672-677.
NRCS Soil Quality Institute (2001). Soil quality – agronomy technical note no. 12: Long-term agricultural management effects on soil carbon. United States Department of Agriculture, Natural Resources Conservation Service. Available online at http://soils.usda.gov/sqi (verified 9 Jun12).
Obiefuna JC (1984). Effects of delayed fertilizer application on the growth and yield of plantains in South Western Nigeria. Fertilizer Res. 5:309-313.
Owolabi O, Adeleye A, Oladejo BT, Ojeniyi SO (2003). Effect of wood ash on soil Fertility and crop yield in southwest Nigeria. Nig. J. Soil Sci. 13:55-60.
Paul EA, Paustian K, Elliott ET, Cole CV (1997). Soil Organic Matter in Temperate Agroecosystems. CRC Press, New York. P. 432.
Ramsey MD, Daniels JW, Anderson VJ (1990). Effects of *Sigatoka* leaf spot (*Mycophaerellamusicola* leach) on fruit yields, field ripening and green life of banana in North Queenland. Scientia Hortic. 41:305-313.
Stroorvogel JJ, Smaling EMA, Janssen BH (1993). Calculating soil nutrient balances in Africa. I. Supranational scale. Fertilizer Res.35:227-235.
United States Department of Agriculture, (USDA) Database (2009). Health benefits of Plantain, J. Educ. Res. pp. 31-34.
Rosati A, Day KR, DeJong TM (2000). Distribution of leaf massper unit area and leaf nitrogen concentration determine partitioning of leaf nitrogen within tree canopies. Tree Phys. 20:271-276.
Swennen R (1990). "Plantain Cultivation Under West Africa Conditions, A Reference Manual. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. P. 24.
Swift MJ, Seward PD, Frost PGH, Qureshi JN, Muchena FN (1994). Long term experiments in Africa: developing a database for sustainable land use under global change. In Leigh RA, Johnson AE (eds), Long term Experiments in Agricultural and Ecological Sciences, pp. 229-251.
Wilson GF (1983). Plantain Production: Prospects for improving the food situation on the Tropics". Fruits 38(4):229-239.
Wright DL, Marois JJ, Wiatrak PJ (2002). Perennial forage in rotation with row crops in the Southeast. In E. van Santen (ed.), Making conservation tillage conventional: Building a future on 25 years of research. Proceedings of 25th Annual Southern Conservation Tillage Conference for Sustainable Agriculture. Auburn, AL 24–26 June 2002. Special Report No.1. Alabama Agric. Expt. Stn. and Auburn University, AL. pp. 87-92. http://www.ag.auburn.edu/nsdl/sctcsa/sctcsa_2002/proceedings.html.