Renewable Agriculture and Food Systems: 24(4); 245–250 doi:10.1017/S1742170509990184

Effects of organic nitrogen fortifiers on some growth parameters of green amaranths (*Amaranthus caudatus* L.)

O.O. AdeOluwa*, G.O. Adeoye and S.A. Yusuff

Department of Agronomy, University of Ibadan, Ibadan, Nigeria.
*Corresponding author: adeoluwaoo@yahoo.com

Accepted 29 September 2009; First published online 18 September 2009 **Preliminary Report**

Abstract

Chemical fertilizers for boosting crop production are becoming more expensive and scarce. Green amaranth (*Amaranthus caudatus* L.) is a fast growing and highly nutritious crop, but its common use in the diet of Nigerians is constrained by its high demand for nitrogen fertilizer. Thus, there is a need to find local fertilizer materials that are readily available to peasant farmers. A preliminary field study was conducted to evaluate urine and neem (*Azadirachta indica* L. juss) as alternative sources for mineral fertilizers in fortifying organic fertilizer (OF) made from cow dung and market waste compost, and OF fortified with urea and bone meal [organo-mineral fertilizer (OMF)], for yield and growth of green amaranth. Fifteen treatments, based on the percentages of N supplied, were NPK15-15-15, OMF, OF, urine, neem and ten treatments of 50, 60, 70, 80 or 90% OF supplemented with a total of 50, 40, 30, 20 and 10% urine or neem, respectively, to provide a total application rate of 100 kg N ha^{-1}, with no fertilizer treatment as a control. Planting was done in two successions (main with fertilizer treatments and residual without further application). The fertilizer sources and levels had significant effects on plant height, number of leaves, stem girth, fresh weight and dry weight. The residual effects were also significant for plant height, number of leaves, total fresh and dry weights. Forty percent N urine amendment of the OF produced the highest total fresh amaranth biomass (269.3 g $plot^{-1}$ main effect and 110.8 g $plot^{-1}$ residual effect), which was significantly better than the values of (140 and 35.3 g $plot^{-1}$, respectively) obtained with respect to OMF during main planting and NPK during residual planting. Results of our study reveal that 40% N urine fortification of OF was a viable substitute for synthetic fertilizers in production of amaranth, and that urine and neem cake can be alternatives to mineral fertilizer for crop production.

Key words: urine, neem, amaranth, fertilizer fortification, soil fertility

Introduction

Each year, the finite capacity of tropical soils grow food and fiber has progressively decreased, largely because of the decline in soil fertility[1–4]. Therefore, management of the soil in order to prevent further degradation and declining soil productivity is imperative[5].

Conventionally, farmers use mineral fertilizers that are usually not readily available in most developing countries. Currently, some commercial organic fertilizers (OFs) and organo-mineral fertilizers (OMFs) are being developed. The mineral fertilizer (mostly NKP) is currently at least four times more expensive than the most expensive organic sources. This necessitates the search for local materials that can be readily available (as fertilizers) to peasant farmers; even if they are not as effective as the conventional ones. In this case, OFs readily come to mind. One of the major problems with OF sources is their low nutrient status, a situation that could be corrected by fortification with higher nutrient sources.

Benefits of OFs include the slow-release pattern of N and S, supply of most of the essential cations and micronutrients, contribution to the soil pore system (macroporosity, microporosity, pore space and size distribution and type of soil structure), aggregate stability, soil crusting, water retention, water movement, soil strength, penetration resistance, soil compaction and bearing capacity[6,7]. Application of OFs improves soil physical properties by improving porosity and aggregate stability, thereby reducing formation of a surface crust[6,7]. These benefits often lead to increase productivity of crops. Thus, sustainable production of crops on tropical soils greatly requires input of OF sources.

Among organic materials of high nutrient value that can be used as alternative sources of nutrient amendment are

Table 1. Total N analysis of OFs used.

Fertilizer material	Total N ($g\,kg^{-1}$)
OMF	44.20
OF	16.80
Neem cake powder	35
Human urine	10

Analytical results indicated OMF having greater total N content than other treatments used, while the lowest was recorded in human urine.

urine, neem cake, palm kernel cake, castor oil seed cake and compost from drumstick (Moringa) tree, *Gliricidia sepium* and sunflower. Human urine is an excellent high nitrogenous liquid fertilizer. Studies indicate that each person's waste fluid can provide enough nitrogen, phosphorus and potassium to grow a year supply of wheat and maize for that person[8]. Neem cake is a good OF because of its high a zadirachtin content with high NPK value[9].

The nutrients in urine are in forms which are readily available to plants. The nitrogen is in the form of urea, which readily degrades to ammonium and nitrate, both of which are available to plants. The phosphorus is mainly in the form of phosphate ions, the potassium in the form of potassium ions and the sulfate in the form of sulfate ions. This means that they are all in forms that are taken up readily by plants. This makes urine a unique biologic fertilizer[10]. In many other parts of the world it is also a tradition to keep the urine and feces apart. The old Japanese practice of night soil recovery from urban areas separated urine and feces, since urine was regarded as a valuable fertilizer[11]. In Yemen, the urine is drained away and evaporated on the outer surface of multi-storey buildings to obtain the feces as a dry fraction without smell for later use as fuel, a system that has been in use for hundreds of years[12].

Of crucial importance also is the acceptance of urine as a fertilizer by the market. At present the EU does not include human urine on the list for approved fertilizers in organic farming, whereas the International Federation of Organic Agriculture Movements (IFOAM) allows urine (and feces) if sanitary requirements are met[13]. In a healthy individual, the urine is sterile in the bladder. The urine can be collected in ordinary *jerry cans* or, if this is more suitable, in large tanks. The fate of the enteric pathogens entering the urine tank is of vital importance for the hygiene risks related to the handling and reuse of the urine. Survival studies of bacteria in urine have been performed at 4 and 20°C. Their persistence was also investigated at different dilutions of the urine and at different pH values. Bacteria were added or originally present in the urine mixture. At different time intervals, the bacteria were enumerated and T90-values (time for 90% inactivation) for the different organisms were then estimated[10].

Green amaranth (*Amaranthus caudatus* L.), a fast growing and highly nutritious crop common in the diet of Nigerians, was used as a test crop in this experiment.

Table 2. Effects of organic nitrogen fortifiers on height (cm) of amaranth.

	Planting mode	
Treatments	Main[1]	Residual[2]
Control	25.43c	14.73ab
NPK	37.66ab	12.79b
OMF	35.29c	16.98ab
OF	23.72c	21.13ab
Urine	30.01abc	13.09ab
90% OF + 10% urine	32.48abc	18.88ab
80% OF + 20% urine	29.96abc	13.11b
70% OF + 30% urine	32.25abc	6.71ab
60% OF + 40% urine	39.55a	21.21ab
50% OF + 50% urine	32.26abc	15.50ab
100% neem cake	29.93abc	22.49a
90% OF + 10% neem cake	30.34abc	18.63ab
80% OF + 20% neem cake	28.29abc	15.46ab
70% OF + 30% neem cake	29.23abc	19.96ab
60% OF + 40% neem cake	28.53bc	21.00ab
50% OF + 50% neem cake	32.70abc	18.85ab

Means followed by the same letters in a column are not significantly different by Duncan's multiple range test at the 5% level.
[1] Harvested at 4 weeks after planting.
[2] Harvested at 5 weeks after planting.

However, one major constraint to growing this crop is the high cost of mostly available fertilizer sources[4].

A. caudatus was used in the present investigation because it is a good indicator plant for N, P and K nutrients[14]. Fortification of compost with 50% *G. sepium* as a N source has been found to encourage better productivity of *A. caudatus*[15]. Plant growth parameters such as height, girth, number of leaves and fresh weight are often consumers' preference, while dry weight seems to more scientific. Thus, the objective of this report was to evaluate growth responses of green amaranths to application of urine, neem cake and their various fortifications of compost from market wastes. This investigation, although preliminary, could lead to further investigations in utilizing urine and neem cake in crop production and sustainable agricultural resources management for food security.

Materials and Methods

The experimental site is situated at the experimental plot of the Department of Agronomy, University of Ibadan, located in the northern limit of the lowland rainforest zone of western Nigeria (latitude 7.43°N and 3.9°E) having an annual rainfall of 1289.2 mm with bimodal distribution. Experimental soil was low in N, P and K. The choice of this soil with marginal plant essential nutrient was to ensure a response to applied treatments. The amaranth seeds and mineral fertilizer (NPK 15:15:15) were obtained from the Department of Agronomy seed store and urine used was collected from Nnamdi Azikwe Hall of the University of

https://doi.org/10.1017/S1742170509990184 Published online by Cambridge University Press

Table 3. Effects of organic nitrogen fortifiers on number of leaves of amaranth.

Treatments	Planting mode	
	Main[1]	Residual[2]*
Control	10.63c	0.88
NPK	13.75bc	10.22
OMF	13.50bc	11.13
OF	11.75bc	11.75
Urine	12.75bc	11.13
90% OF + 10% urine	13.38bc	10.75
80% OF + 20% urine	13.13bc	10.35
70% OF + 30% urine	12.88bc	11.38
60% OF + 40% urine	14.63ab	12.00
50% OF + 50% urine	12.75bc	1.22
100% neem cake	12.75bc	11.75
90% OF + 10% neem cake	12.88a	11.13
80% OF + 20% neem cake	13.25bc	11.13
70% OF + 30% neem cake	13.50bc	11.13
60% OF + 40% neem cake	13.38bc	12.50
50% OF + 50% neem cake	13.88bc	11.65

Means followed by the same letters in a column are not significantly different by Duncan Multiple Range Test at the 5% level.
[1] Harvested at 4 weeks after planting.
[2] Harvested at 5 weeks after planting.
* Not significant ($P>0.05$).

Table 4. Effects of organic nitrogen fortifiers on stem girth (cm) of amaranth.

Treatments	Planting mode	
	Main[1]	Residual[2]*
Control	1.38c	1.43
NPK	2.45a	1.19
OMF	1.85abc	1.44
OF	1.61bc	1.56
Urine	1.83abc	1.35
90% OF + 10% urine	2.03abc	1.41
80% OF + 20% urine	1.91abc	1.14
70% OF + 30% urine	2.29ab	1.53
60% OF + 40% urine	2.58a	1.56
50% OF + 50% urine	1.96abc	1.40
100% neem cake	1.90abc	1.63
90% OF + 10% neem cake	2.51a	1.53
80% OF + 20% neem cake	1.98abc	1.34
70% OF + 30% neem cake	1.94abc	1.48
60% OF + 40% neem cake	1.96abc	1.69
50% OF + 50% neem cake	1.91abc	1.36

Means followed by the same letters in a column are not significantly different from Duncan's multiple range test at the 5% level.
[1] Harvested at 4 weeks after planting.
[2] Harvested at 5 weeks after planting.
* Not significant ($P>0.05$).

Ibadan and stored for a month before use[10]. Neem cake was made from crushed neem seeds obtained from Cocoa Research Institute of Nigeria (CRIN), Ibadan, Nigeria. The OF and OMF were obtained from Pacesetters' fertilizer plant, Bodija, Ibadan, Oyo State, Nigeria. The OF comprises cow dung and market waste compost in the ratio 1 : 3. The OMF is OF fortified (for N and P) with urea and bone meal, respectively. The investigation was a field trial laid out in a randomized complete block design with four replicates.

The experimental soil was a loamy sand, slightly acidic with pH of 6.5 and the total nitrogen of 1 g kg^{-1} was lower than the critical level of 1.5 g kg^{-1} soil. The P content of the soil was 7 mg kg^{-1} which was also very low. Exchangeable Ca, K and Mg levels (0.2, 0.1 and 0.1, respectively), were also on the low side. Thus, the soil was suitable for the fertilizer trial experiment.

The investigation was carried out in two successions (main with fertilizer treatments and residual without further application) between November 2005 and February 2006. Seedbed preparation was done manually. Each experimental unit (bed) was 0.65 × 0.50 m in size (0.325 m^2) and there were a total of 64 experimental beds, bringing the total land area for the vegetable production to 63 m^2 (18 × 3.5 m) with 0.5 m spacing between beds. The fertilizer treatments were applied a week before planting and watered adequately to aid nutrient mineralization for plant growth. Fertilizers were applied by drilling. The amaranths plants were thinned to a planting density of 1.8 million plants hectare^{-1} 2 weeks after planting. The experiment was carried out during the dry season, so watering to field capacity was done daily (usually in the morning). Weeding was done manually as the situation demanded.

The fertilizers were applied at a rate of 100 kg N ha^{-1}. Treatments used were: control (no fertilizer), NPK 15:15:15, OMF (grade A), OF (grade B), urine, 90% OF + 10% urine, 80% OF + 20% urine, 70% OF + 30% urine, 60% OF + 40% urine, 50% OF + 50% urine, neem cake, 90% OF + 10% neem cake, 80% OF + 20% neem cake, 70% OF + 30% neem cake, 60% OF + 40% neem cake and 50% OF + 50% neem cake. Details of N content of the applied OF treatments are shown in Table 1. OMF had the highest concentration of N.

Data were collected on plant height, number of leaves, stem girth, total fresh and dry weights. Soil samples were analyzed for routine physical and chemical analysis. The data on plant responses were subjected to analysis of variance and the means separated using Duncan's multiple range test.

Results and Discussion

The responses of the crops to the applied fertilizers are hereby presented.

Plant height

At the end of main planting (4 weeks after planting), the tallest plants (mean of 39.55 cm) were those treated with 40% urine N amended OF (Table 2), though not significantly ($P>0.05$) different from effects of other treatments

https://doi.org/10.1017/S1742170509990184 Published online by Cambridge University Press

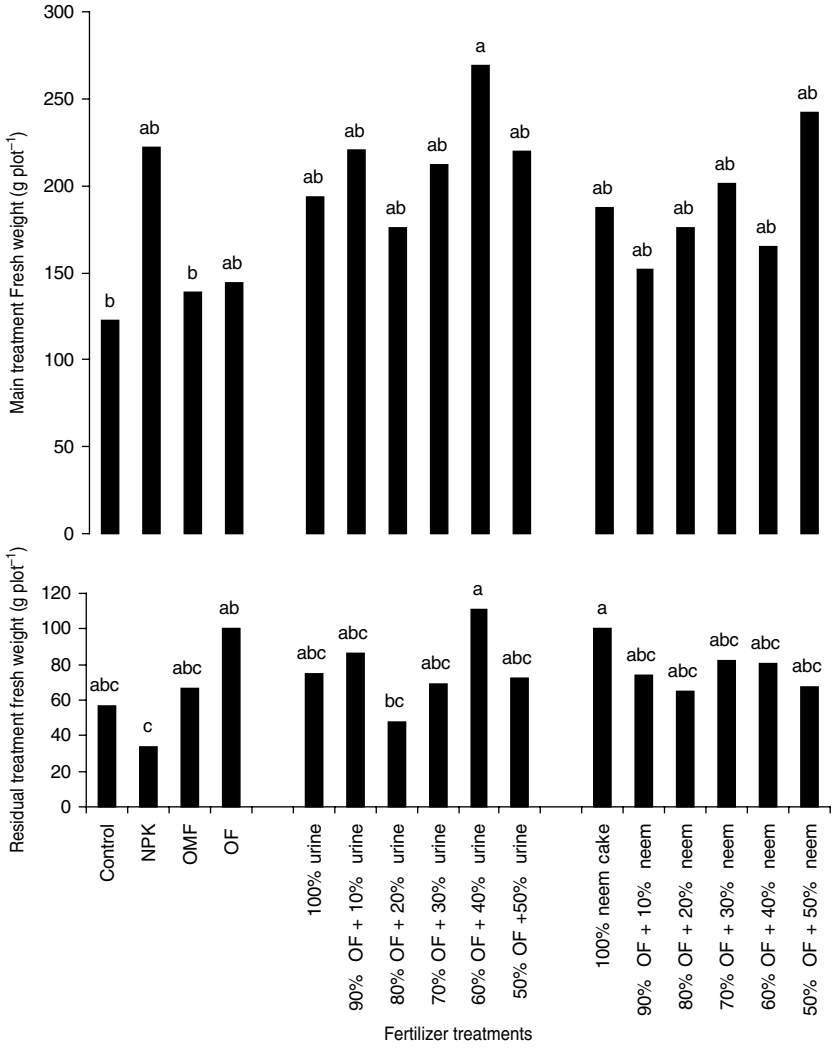

Figure 1. Effects of fertilizer treatments on total fresh weight of *A. caudatus*.

apart from those of control, OMF and OF. The residual effects of the treatments (at 5 weeks after planting), however, took different dimension; the highest crops were those treated with 100% neem cake N (mean of 22.49 cm) with least resulting from those treated with mineral fertilizer NPK, urine and 20% urine fortified OF.

Number of leaves

At the end of main planting (4 weeks after planting), plants (mean of 39.55 cm) treated with 10% neem N amended OF resulted in the highest significantly ($P < 0.05$) different mean number of leaves of 12.88, though not significantly different from effects of 40% urine N amended OF. None of the treatments resulted in a significantly different ($P < 0.05$) number of leaves at 5 weeks after planting (Table 3).

Stem girth

Crops treated with 40% urine N amended OF had the highest stem girth (mean of 2.58 cm) at the end of main planting (4 weeks after planting), though not significantly different from effects of other treatments except those of control and OF. None of the treatments resulted in a significantly different ($P < 0.05$) number of leaves (Table 4).

Fresh plant weight

Crops treated with 40% urine N amended OF had the highest fresh biomass weight (mean of 269 g/plot) at the end of main planting (4 weeks after planting), which was not significantly different from effects of other treatments except those of control and OMF.

At the residual level, the 40% urine N amended OF had the highest fresh biomass weight (mean of 110.8 g plot^{-1}) but this was not significantly different ($P > 0.05$) from the effects of other treatments apart from NPK and 20% urine N amended (Fig. 1).

Dry plant weight

Crops treated with 40% urine N amended OF had the highest dry biomass weight at the end of main planting (4 weeks after planting), which was not significantly

https://doi.org/10.1017/S1742170509990184 Published online by Cambridge University Press

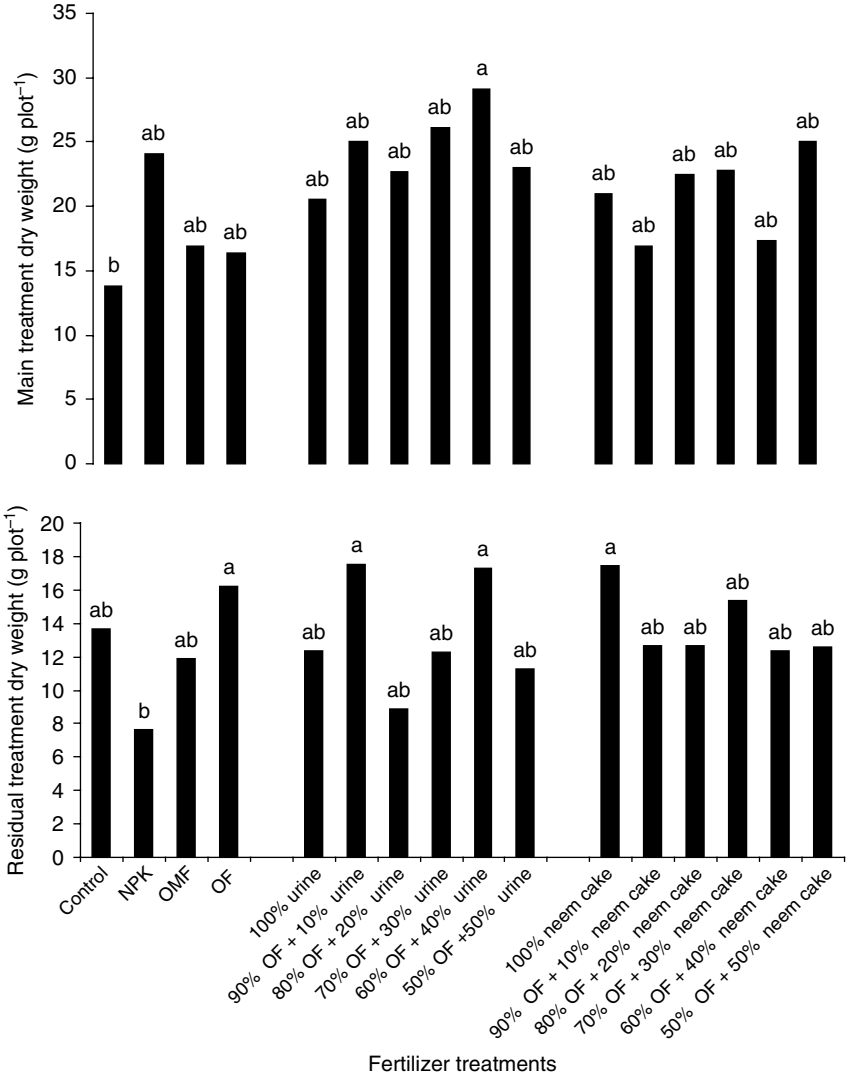

Figure 2. Effects of fertilizer treatments on total dry weight of *A. caudatus*.

different from effects of other treatments apart from the control. During the residual effects observation, the 40% urine N amended OF had the highest dry biomass weight but was not significantly different ($P>0.05$) from other treatments apart from NPK (Fig. 2).

Plant growth parameters are of interest to either the consumers or the researchers in different ways. To the consumer, his/her choice of selection of vegetable crops could be determined merely by height, stem girth or how leafy (number of leaves) such leafy vegetables. In this study, the responses of growth parameters of *A. caudatus* to the applied treatments vary. Depending on the interest of the consumer regarding growth parameters, choice of the best performing treatments could be made.

Most of the urine- and neem-treated plants had better growth in terms of mean height than those treated with urea-amended compost. Fertilizer NPK gave the least residual effect on plant height. This means that urine and neem used as fortifiers interacted with the OF to produce better residual effect in relation to plant height. Normally, organic manure does not release the total nutrient value in the life span of most arable crops since mineralization is slow[11]. NPK applied during the main planting might have been leached down the soil by irrigation water and the remaining exhausted by the plants. This could have been the reason why urine and neem resulted in greater value during plant growth.

Plants treated with 10% N neem, 40% N neem and 40% N urine-amended OFs producing the highest number of leaves is an indication that these treatments enhanced leaf production. The residual effects of the treatments on number of leaves was similar to that observed with respect to plant height in that 40% N urine fortification performed much like 40% N neem amendment (Table 3). The reason suggested for the result on plant height is also applicable here. Mineral fertilizer (NPK 15 : 15 : 15) produced the least number of leaves.

In the same vein, 40% N urine and 10% N neem treatments resulted in better stem girth than OMF and

https://doi.org/10.1017/S1742170509990184 Published online by Cambridge University Press

unamended OF (Table 4). This could have been a result of positive complementary effects of the urine and neem on the OF.

The best mean 269 g plot^{-1} fresh yield (34 t ha^{-1}) of amaranths produced from 40% N urine (Fig. 1) is greater than the 20 t ha^{-1} obtained by AdeOluwa[16] and 30 t ha^{-1} reported by Grubben and Van Slotten[17]. This 40% N still had the highest residual effect on mean dry yield of amaranth (Fig. 2).

The results of this preliminary experiment reveal that 40% nitrogen urine amendment of the commercial compost from market wastes (OF) seems to have greater potential to enhance plant production than Pacesetter's OF grade A (fortified with urea) (OMF) and mineral fertilizer (NPK) in terms of total fresh weight (the marketable weight). This result is in consonance with the reports of Grubben and Van Slotten[17], Cooke[18] and Perverly and Gates[19], which stated that sole OFs perform better on some crops than mineral fertilizers.

Conclusion

From the results, it can be recommended that 40% N urine be used to compost with OF. Similarly, the neem amendment showed a tendency to perform better than urea and NPK. Depending on the parameter of interest (whether from the perspective of consumers or the scientist) the use of both urine and neem cake in agriculture is a way of putting organic wastes into productive use. This could lead to sustainable utilization of environmental resources. However, other useful impacts of the OF sources on soil health and crop quality would have to be investigated.

References

1 Parr, J.F., Papendick, R.I., and Colacicco, D. 1989. Recycling of organic waste for suistainable agriculture. Biological Agriculture and Horticulture 3:115–130.
2 Ayoub, A.T. 1991. An assessment of human induced soil degradation in Africa. In Proceedings of the Second African Soil Science Conference, Cairo, Egypt. p. 17–23.
3 Agboola, A.A. 1978. Influence of soil organic matter on cowpea response to nitrogen fertilizer. Agronomy Journal 70:25–28.
4 Adeoye, G.O., Sridhar, M.K.C., AdeOluwa, O.O., and Akinsoji, N.A. 2005. Evaluation of naturally decomposed solid wastes from municipal dump site for their manurial value in south-west. Journal of Sustainable Agriculture 26(4):143–152.
5 Babalola, O. 2000. Soil management and conservation in Nigeria. In M.O. Akoroda (ed.). Agronomy in Nigeria. Agronomy Re-union Day: A Book on the Theory and Practice of Agronomy as it has been in the last 33 years from July 1967 to the Present in Support of the Department of Agronomy, University of Ibadan, Nigeria.
6 Greenland, D.J. and Dart, J.P. 1972. Biological and organic aspect of plant nitrification in relation to needed research in tropical soils. Tropical Soils Research Seminar IITA, Ibadan.
7 Agboola, A.A. 1975. Organic materials as fertilizers. Report of the FAO/SIDA Expert Consultation, Rome, 2–6 December 1974.
8 Williams, R. 2002. Free Urea Based Fertilizer. http://www.Ronwilliams2002.com.
9 Salako, E.A., Anjorin, S.T., Garba, C.D., and Omolohunnu, E.B. 2008. A review of neem biopesticide utilization and challenges in Central Northern Nigeria. African Journal of Biotechnology 7(25):4758–4764.
10 Höglund, C. 2001. Evaluation of microbial health risks associated with the reuse of source separated human urine. PhD thesis, Department of Biotechnology, Royal Institute of Technology, Stockholm, Sweden.
11 Matsui, S. 1997. Night soil collection and treatment, Japanese practice and suggestion for sanitation of other areas of the globe. Paper Presented at the Sida Sanitation Workshop, 6–9 August 1997 at Balingsholm, Stockholm. Sida Report No. 9.
12 Esrey, S.A., Gough, J., Rapaport, D., Sawyer, R., Simpson-Hébert, M., Vargas, J., and Winblad, U. 1998. Ecological Sanitation. Swedish International Development Cooperation Agency, Stockholm, Sweden.
13 International Federation of Organic Agriculture Movements—IFOAM. 2000. Basic Standards for Organic Production and Processing Decided by the IFOAM General Assembly in Basel, Switzerland, September 2000. International Federation of Organic Agriculture Movements.
14 Adeoye, G.O., Sridhar, M.K.C., AdeOluwa, O.O., and Akinsoji, N.O. 2005. Evaluation of naturally solid wastes from municipal dumpsites for their value in south west Nigeria. Journal of Sustainable Agriculture 26(4):143–152.
15 Sridhar, M.K.C., Adeoye, G.O., and AdeOluwa, O.O. 2001. Alternate to nitrogen amendments for organic fertilizers. Optimizing Nitrogen Management in Food and Energy Production and Environmental Protection. Scientific World Journal 19(12 Suppl 2):142–147.
16 AdeOluwa, O.O. 1999. Effects of *Gliricidia sepium* amendment of compost on *Amaranthus caudatus*. MSc Report, Department of Agronomy, University of Ibadan.
17 Grubben, G.J.H. and Van Slotten, D.H. 1978. Genetic resources of amaranths. IBPGR Secretariat, FAO, Rome.
18 Cooke, C.W. 1972. Fertilizing for Maximum Yield. The English Language Book Society and Granada, London.
19 Perverly, J.H. and Gates, P.B. 1993. Utilization of municipal solid waste and sludge composts in crop production systems in sewage sludge. Proceedings of a Conference on Land Utilization and the Environment. Bloomington, IN, USA, 11–12 August 1993. American Society of Agronomy, Madison, USA.