# EVALUATION OF SOILS OF ASABA AREA FOR THE PRODUCTION OF *AMARANTHUS CRUENTUS* L.

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## ABSTRACT

There is paucity of information on soils of Asaba area of rain forest of the Northern Agro-ecological zone of Delta State of Nigeria. The study was conducted in 2009 and in 2010 at the Teaching and Research farm of Delta State University, Asaba campus, Asaba to assess the various soils types of Asaba for *Amaranthus cruentus* production, with three treatments and ten replicates in a completely randomized experimental design. The soils of Anwai, Fadama and Mile 5 which formed the treatments were each weighed into polythene bags and manured with 62.5g of poultry droppings, and sown with *Amaranthus cruentus* seeds. Prior to and after harvest of *Amaranthus cruentus* the soils and poultry droppings were analyzed for physico-chemical properties. The fresh leaf and total plant were weighed at harvest. The post soil analysis and leaf and total fresh weight were analyzed. The soil structure and texture were more suitable for *Amaranthus cruentus* production in Anwai soil than in Fadama and Mile 5 soils. Liberal application of poultry droppings ($P < 0.05$) improved the Ca, Mg and CEC of the soils in the order of Anwai > Fadama > Mile 5 at harvest of *Amaranthus cruentus*. This ($P < 0.05$) enhanced the fresh leaf and total fresh weights in Anwai soil than in Fadama and Mile 5 soils. For *Amaranthus cruentus* production in Asaba area of North Agro-ecological zone of Delta State, Anwai soil is hereby recommended.

**Key words:** Anwai, Fadama, Mile 5, Soil characteristics, leaf weight, total biomass

## INTRODUCTION

*Amaranthus cruentus* L. belongs to the family *Amaranthaceae*, which is an important leafy and highly nutritious vegetable in human diet. It is rich in carbohydrate, fibre, minerals (calcium, folic acid, iron, phosphorous), protein (lysine that is lacking in cereals and tuber based diets and anthocyanin), sugar, vitamins (A and C) and water needed for healthy body growth and sustenance (Bailey, 1992; Schippers, 2001; Rai and Yadav, 2005). The leaves and tender stem can be cut, cooked as green leaf or fried with cucurbits seed, fish and meat (NRC, 1984; Grubben and Denton, 2004), and consumed or as an ingredient in sauces. It has potentials of reducing malnutrition in Nigeria, which is rampant among the low income group (Taylor, 1996). Vegetable amaranth posses medicinal properties and is good for lactating mothers, young children, and for patients with anaemia, constipation, fever, haemorrhage and kidney complaints (Grubben and Denton, 2004).

The bulk of *Amaranthus cruentus* consumed in Delta State and especially Asaba and its environs are grown and supplied by subsistence farmers. Most of the growers' have little or no knowledge of soil characteristics as it affects crop performance. Crop performance in any soil depends on the physical and chemical properties of the soil (Law-Ogbomo and Nwachokor, 2010). Important physical properties that affect soil fertility are structure and texture (Lyn, 2010), while the soil chemical fertility includes organic matter, nutrients, CEC and minerals (Pur, 2003; Ir, 2003). Of these chemical and physical properties of the soil, soil fertility and soil texture plays a significant role in the quality and quantity of the eventual crop output (Johnson *et al.*, 2005).

The fertility requirement of Amaranth appears to be intermediate between small

grains and corn, and the P and K requirements is in the medium to high range, that is, 15 – 50ppm and 0.3 – 1.2cmol/kg respectively (Faccicola, 1990). Similarly, Olufolaji (1980) reported 70kgN, 34kg P and 26kgK/ha for optimum plant height, highest leaf yield and dry matter while FMNAR (1990) reported 75kg N, 20kgP and 40kgK/ha for optimum production. However, there is a dearth of information about the characteristics of various soils used for the production of the highly nutritious *Amaranthus cruentus* L. in Asaba area of the North Agro-ecological zone of Delta State.
Hence the objective of this study was to assess the various soil types around the University Farm, Asaba for their suitability for the cultivation of Amaranthus.

## MATERIALS AND METHODS

The experiment was conducted between 2009 and 2010 at the Teaching and Research Farm, Delta State University, Asaba campus, Asaba. The location lies on $06^0$ 14 $^1$N and $06^0$ $49^1$E, 97.5m above the sea level with annual rainfall of 1560 – 1874mm (NIMET, 2008). Asaba is in the Northern Agro-ecological zone of Delta State of Nigeria. Surface soils were collected from 0 – 20cm depth. Soils from each location were bulked, mixed and air dried under room temperature for two weeks and pulverized to pass through the 2mm sieve. The soils were subjected to physico-chemical analysis. Soil particle size distribution was determined by the hydrometer method (Bouyoucous, 1951) using sodium hexametaphosphate as a dispersing agent. Bulk density, particle density, total porosity and water retention at field capacity were determined according to the procedure for soil physical analysis of IITA (1979). The organic carbon content was determined by modified wet oxidation method of Walkey and Black (1945). The soil pH was measured with the glass pH electrode in 1:1 soil-water ratio suspension. The total nitrogen was determined by a semi-micro kjedahl digestion distillation method (Bermer and Mulvalcy, 1982) while available phosphorous was determined by L-ascobic method (Bray and Kurtz, 1945). The total exchangeable acidity was assessed by the method described by Maclean (1982), while the cation exchange capacity was determined by Ammonium Acetate technique. Similarly, Exchangeable Acidity ($H^+$ and $Al^+$) were determined using the KCl method and the percentage base saturation was calculated as the sum of exchangeable bases divided by the cation exchange capacity and multiplied by 100. A modified green house experiment was carried out using bulk soil samples collected from the various locations of Anwai, Fadama and Mile 5. Fadama is Hausa name for fertile irrigable low lying floodplains, underlined by shallow aquifer found along river system where water is easily accessible (The World Bank Group, 2011). The study was a completely randomized design with ten replicates. The soils where the *Amaranthus cruentus* vegetables were grown (Anwai, Fadama and Mile 5) constituted the treatments. *Amaranthus cruentus* L. sourced from the Department of Agronomy, Delta State University, Asaba Campus, Asaba was used as the test crop. Five kilograms of soils were weighed out into different polythene bags measuring 25cm X 20cm X 30cm and used for the trial. Five seeds of *Amaranthus cruentus* L. were sown per pot and later thinned to 3 at 2 weeks after sowing (WAS) and 62.5g of poultry droppings were applied to all pots as amendment. At harvest (7 WAS), data were collected on fresh leaf weight as well as seed dry weight in gramme per plot. The data collected were polled for two years and subjected to Analysis of variance (ANOVA), and means showing significant difference were separated using Duncan multiple range test (Duncan, 1955).

## RESULTS

### Pre physico-chemical properties of the soils

The initial soil properties of Anwai, Fadama and Mile 5 are presented in Table1. Anwai soil is sandy loam in texture with bulk density of 1.38g/cm$^3$, particle density of 2.56g/cm$^3$, field capacity of 28.22%. The soil was slightly acidic (pH of 6.8), low in organic carbon (1.72%) with total N of 0.102%, available P of 5.6ppm. The $Ca^{++}$, $Mg^{++}$ and $Na^+$ were low, with CEC and % base saturation of 4 cmolkg$^{-1}$ and 58.75 respectively (Table 1). The Mile 5 soil was sandy in texture with a bulk density of 1.52g/cm$^3$, particle density of

2.62g/cm$^3$, porosity of 45.5% and field capacity of 17.79%. The soil was very strongly acidic (pH of 4.8) with low organic carbon content of 1.49%. The total N is 0.112% while the available P was 4.60ppm and the exchangeable base contents were generally low. The CEC was low (8 cmolkg$^{-1}$) while the % base saturation was 50 (Table 1). The Fadama soil was clayey in texture with bulk density of 1.25g/cm$^3$, porosity of 55.5% and particle density of 2.86g/cm$^3$ and a field capacity of 29.63%. The total N was 0.154% and the available P was 7.46ppm. The basic cations were low with CEC of 9.2cmolkg-$^1$ and % base saturation of 34.46 (Table 1).

**Chemical properties of poultry manure used for the experiment**

**Table 1:** Pre physico-chemical properties of soils used for *Amaranthus cruentus* Production

| Soil characteristics | Anwai | Fadama | Mile 5 |
|---|---|---|---|
| Sand (%) | 74 | 47 | 94 |
| Silt (%) | 15 | 9 | 1 |
| Clay (%) | 11 | 44 | 5 |
| Bulk density (g/cm$^3$) | 1.38 | 1.25 | 1.52 |
| Particle density (g/cm$^3$) | 2.56 | 2.68 | 2.62 |
| Porosity (%) | 49.50 | 55.50 | 5.50 |
| Field capacity (%) | 28.22 | 29.63 | 7.79 |
| Soil pH ($H_20$) | 6.80 | 4.80 | 4.80 |
| Organic carbon (%) | 1.72 | 1.84 | 1.49 |
| Total N (%) | 0.102 | 0.154 | 0.112 |
| Available P (ppm) | 5.60 | 7.46 | 4.60 |
| $Ca^{++}$ (cmolkg-$^1$) | 1.00 | 2.40 | 2.40 |
| $Mg^{++}$ (cmolkg-$^1$) | 0.40 | 0.60 | 1.40 |
| $K^+$ (cmolkg-$^1$) | 0.02 | 0.06 | 0.05 |
| $Na^+$ (cmolkg-$^1$) | 0.13 | 0.11 | 0.15 |
| $H^+$ (cmolkg-$^1$) | 0.80 | 2.00 | 4.80 |
| $Al^{3+}$ (cmolkg-$^1$) | 0.00 | 0.00 | 2.20 |
| CEC (cmolkg-$^1$) | 4 | 9.2 | 8 |
| % B.S | 58.75 | 34.46 | 50.00 |

The chemical properties of poultry manure used are presented in Table 2. The pH was slightly alkaline (7.3) with high organic carbon content. The total N was high while the total P content was low. The basic cation contents were low (Table 2).

**Physico-chemical properties of the cropped soils**

The post harvest physico-chemical properties of the soils cropped to Amaranthus after application of poultry manure are presented in Table 3. The particle size distributions (textural class) were sandy loam for Anwai, clayey for Fadama and sandy loam for Mile 5 soil. The pH of the soil were in the order of Mile 5 (7.2) > Anwai (5.8) > Fadama soil (5.3). The value of organic carbon contents of the soil was significantly low for Mile 5 while they were not significantly different ($P < 0.05$) for Anwai and Fadama respectively (Table 3). The total N content of the soils were in the order of Fadama > Anwai > Mile 5, while the values of available P in the soils were in the order of Mile 5 (50.67) > Fadama (52.22) > Anwai (36.36). The $Ca^{++}$ contents of the soils was ($P > 0.05$) higher in Fadama soil than in Anwai and Mile 5 soils while there was no difference ($P < 0.05$) in the values of $Mg^{++}$ and $Na^+$ obtained from the soils of Anwai, Fadama and Mile 5 (Table 3). The CEC and % B.S were not significantly different for the three soils (Table 3).

**Yield**

The influence of soil type on fresh weight (total biomass) in gramme per plant

**Table 2**: Poultry manure analysis

| Treatments | Values |
|---|---|
| pH ($H_2o$) | 7.30 |
| Organic carbon (%) | 23.46 |
| Total N (%) | 0.266 |
| Total P (mg/kg) | 0.54 |
| Basic cations (%) | |
| $Ca^{++}$ | 2.20 |
| $Mg^{++}$ | 0.66 |
| $K^+$ | 0.17 |
| $Na^+$ | 0.08 |

**Table 3:** Physico-chemical properties of the soils cropped to *Amaranthus cruentus* (after application of poultry manure)

| Soil characteristics | Anwai | Fadama | Mile 5 |
|---|---|---|---|
| Sand (%) | 71$^b$ | 47$^c$ | 94$^a$ |
| Silt (%) | 18$^a$ | 17$^a$ | 1$^b$ |
| Clay (%) | 11$^b$ | 36$^a$ | 5$^b$ |
| Soil pH ($H_20$) | 5.8$^b$ | 5.3$^b$ | 6.2$^a$ |
| Organic carbon (%) | 2.36$^a$ | 2.54$^a$ | 1.64$^b$ |
| Total N (%) | 0.17$^a$ | 0.24$^a$ | 0.05$^b$ |
| Available P (ppm) | 36.38$^b$ | 52.22$^a$ | 50.67$^a$ |
| Exch. Basic cations | | | |
| $Ca^{++}$ (cmolkg-$^1$) | 3.87$^a$ | 4.40$^a$ | 2.00$^b$ |
| $Mg^{++}$ (cmolkg-$^1$) | 3.47$^a$ | 3.13$^a$ | 1.27$^a$ |
| $K^+$ (cmolkg-$^1$) | 0.23$^b$ | 0.56$^a$ | 0.04$^c$ |
| $Na^+$ (cmolkg-$^1$) | 0.18$^a$ | 0.26$^a$ | 0.14$^a$ |
| Exch. Acidity | | | |
| $H^+$ (cmolkg-$^1$) | 0.93$^a$ | 1.93$^a$ | 0.93$^a$ |
| CEC (cmolkg-$^1$) | 15.33$^a$ | 16.93$^a$ | 7.00$^b$ |
| % B.S | 52.18$^a$ | 50.23$^a$ | 49.14$^a$ |

Means in the same row with similar letter superscript are not statistically different at 5% level of probability according to Duncan Multiple Range Test and leaf fresh weight (g/p) are presented in Table 4. The fresh weight (total biomass) and the leaves fresh weight were ($P > 0.05$) higher in Anwai soil (56.39g) than in Fadama and Mile 5 soils (Table 4).

Mile 5 soil was slightly alkaline (pH of 7.2). This could be as a result of the sandy nature of the soil, having low CEC, thereby very poorly buffered relative to the clayey soils. This should have probably caused the release of

**Table 4:** Effect of soils on leaf weight and total fresh weight (Total biomass) of *Amaranthus cruentus* in gramme

| Treatments | Fresh leaf weight (g)/pot | Total fresh biomass (g)pot |
|---|---|---|
| Anwai soil | $28.25^{a}$ | $78.42^{a}$ |
| Fadama soil | $17.40^{b}$ | $56.39^{b}$ |
| Mile 5 soil | $13.15^{b}$ | $45.45^{b}$ |

Means in the same row with similar letter superscript are not statistically different at 5% level of probability according to Duncan Multiple Range Test

**DISCUSSION**

The pre-planting soil analysis showed that soils of Anwai, Fadama and Mile 5 were low in nutrient status, hence poor in soil fertility. The poor fertility status of the soils may be due to the parent materials from which the soils were formed. Anwai soil, which was low in nutrient status, could be due to high and intensive rainfall experienced in Anwai. This is in agreement with the findings of Asadu and Bosah (2002) and Nnaji *et al* (2005), who reported that intensity and duration of rainfall in southern Nigeria increased soil acidity and depleted soil nutrients. The low plant nutrients observed in Fadama soil, could be due to the seasonal flooding, which may result in leaching of basic cations and soil nitrogen. This is in line with the findings of Aberger (2006), who reported large losses of basic cations in wet lands through leaching and erosion. For Mile 5 soil, sand size particles dominated other particle sizes which reflected in the coarse texture. Sandy soil is potentially not fertile (Brady and Weils, 2002).

The liberal application of poultry droppings at the rate of 62.5g per pot did not affect the soil texture. This is in consonance with the findings of Landan (1991), who reported that texture of soil hardly change but could be improved by either application of manure or inorganic fertilizer.

The post harvest chemical analysis of basic cations by poultry manure into soil solution, thereby increasing the soil pH. This supports the findings of Kingery *et al* (1994). The amelioration of pH in Anwai soil after the application of soil amendment could be due to amaranth plant having a good soil condition to grow, thereby absorbing the basic cations. Hautin *et al* (1995) reported that soil amendments ameliorated the acidity of soils grown with barley. The increase of organic carbon and nitrogen in Anwai and Fadama soils and decrease in Mile 5 soil after harvest of *Amaranthus cruentus* could be adduced to the types of soil. The increase in available P in soils of Anwai, Fadama and Mile 5, and increase in basic cations in Anwai and Fadama soils respectively could be adduced to the soil amendment. Animal manure improves soil nutrient (Kingery *et al.,* 1994). The decrease in exchangeable cations in Mile 5 soil could be adduced to the sandy nature of the soil. Sandy soil lack negative sites unlike clay soil and organic matter. The $H^{+}$ and $Al^{3+}$ of Anwai and Fadama soils increased slightly could be as a result of plant uptake of cations. This could have caused soil acidity. The CEC and % B.S in the soil increased in the order of Anwai soil > Fadama soil > Mile 5 soil.

The three soils differed in fresh leaf weight and total fresh biomass. These observed differences may be due to native soil nutrients as in Table 1. Fadama soil have a very low field capacity and is sandy in nature which allows rapid movement of air and water while Mile 5 soil is clayey in nature which though hinders root penetration and drainage of water but has higher water retention capacity, thus can make more water available for plant to absorb. This might have relatively improved yield for Anwai soil. Onasanya and Ogunkunle (2002) and Fasina *et al* (2007) have observed that soil types and fertilizer application influences crop yield.

## CONCLUSION

The study revealed a remarkable difference in the sand, silt and available P contents of the soils of Asaba area of North Agro-ecological zone of Delta State and *Amaranthus cruentus* production is better in Anwai than in Fadama and Mile 5 soils.

## REFERENCES


**Aberger, A. (2006).** Soil fertility and plant nutrition in the Tropics and subtropics. http://www.fertilizer.org/ifacontent/down/

**Asadu, C.L.A. and Bosah, C.S.(2002).** A comparative study of soil of upper coal measure residual upper cropped grass-forestland continuum in Eastern Nigeria. *East Afriican Agricultural and Forestry Journal* **63:**141-155.

**Bailey, J.M.(1992).** *The leaves we eat. South pacific commission handbook,* New Caledonia, No 31, 48pp.

**Bermer, J.N and Mulvalcy, C.W.(1982).** Nitrogen total :Determination of total nitrogen by Micro-Kjeldahl method f soil analysis, chemical and micro biological properties part II. *American society of Agronomy* **48:**114-121

**Bouyoucous, G.J. (1951).** A recalibration of the hydrometer for making chemical analysis of soil. *Agronomy Journal* **43:** 434-438

**Brady, N.C. and Weil, R.R. (2002).** Nature and properties of soil. 13th edn., Pearson Educational Ltd., New Jersey.

**Bray, R.H. and Kurtz, L.T.(1945).** Determination of total and organic of phosphate in the soil. *Soil science Journal* **59:** 45-49.

**Duncan, R.D. (1955).** Multiple Range and multiple F test. *Biometrics* **11:** 25-40.

**Faccicola, S.C. (1990).** A source book of Edible plants. Kampong publications http://www.crfg/./cornucopiall.htm/

**Fasina, A.S., Omotosho, S.O., Shittu, O.S. and Adenikinju, A.P.(2007).** Properties, classification and suitability evaluation of some cultivated Cocoa soils of South Western Nigeria. *American-Euroasian Journal of Agricultural & Environmental Science* **2(3):**311-317.

**FMNAR (1990).** Literature review on soil fertility investigations in Nigeria (in five volumes). Produced by the Federal Ministry of Agriculture and Natural Resources, Lagos, 281pp.

**Grubben, G.J.H. and Denton, O.A. (2004). Plant resource of South East Asia. Backhuys publishers, Leiden.**

**Hautin, J.A., Karem, L.E. and Adeoye, A. (1995).** Effect of moss-shrub waste composts on growth of Barley on loamy sandy soil. *Communications in soil science & Plant Annalysis* **126 (19 & 20):** 3275 - 3289

**IITA (1979).** *International institute of Tropical Agriculture. Selected methods of soil analysis.* Manual series No 1, reversed edition. IITA Ibadan, Nigeria.

**Ir, D.K.(2003).** Understanding the concept of fertility of land through method Simo (Microbial and oxygen injection system). *http://www.palmsugerestat.blogspot.com/*

**Kingery, W.L., Wood, C.W., Delanery, D.P., William, J.C. and Mullins, G.L. (1994)**. Impact of long term land application of broiler litter in environmentally related soil properties **23:**139-147

**Landon, J.R.(1991).** Booker tropical soil manual. A hand book for soil survey in the tropics and subtropics. Longman Group, London.

**Law-Ogbomo, K.E. and Nwachokor, M.A. (2010).** Soil physico-chemical properties of five soils formed on different parent materials in South Eastern Nigeria. http:www.insipub.com/rjabs.pdf/

**Lyn, A. (2010).** Soil health. http://www.soilhealth.com/

**Maclean, E.O. (1982).** Methods of soil analysis. Part II. *American Society of Agron-*

*omy* **9:** 978 – 998.

**NIMET (2008).** Nigeria Meteorological Agency, Asaba.

**Nnaji, G.U., Asadu, C.L.A. and Mbagwu, J.S.C. (2005).** *Changes in physical properties of soil under cassava monocropping and organic waste amendments.* Proceedings of the 19th Annual conference of Farm management Association of Nigeria Pp 374 – 375.

**NRC (National Research council) (1984).** *Amaranth. Modern prospects for an Ancient crop.* National Academy Press, Washington, D.C.

**Olufolaji, A.O. (1980).** *The effect of varieties, spacing and fertilizer on growth and development of Amaranthus sp and Celosia argentie.* M.Phil. Dissertation, University of Ibadan, Nigeria.

**Onasanya, S.O. and Ogunkunle, O.A. (2002).** Crop yield prediction from interaction of soil, Environment and management systems in South Western Nigeria. *Moor Journal of Agricultural Research* **3:** 1 - 10.

**Pur, C. ( 2003).** Development of organic fertilizer. .http://www.palsugarestate.blogstpt.com/

**Rai, N. and Yadav, D.S. (2005).** *Advances in vegetable production.* Researchco Book Centre, New Delhi.

**Schippers, R.R. (2001).** *African Indigenous vegetable. An overview of cultivated species.* National Research Institute. Pp 9 - 13.

**Taylor, O.A. (1996).** Potentials of grain Amaranth. Utilization as food training. Manual of National horticultural Research Institute (NIHORT). Grain amaranth production and utilization. Pp 17-28.

**The World Bank Group (2011).** Fadama 111 Agricultural project fast becoming a household name in Nigeria. http:// go:worldbank.org/WEBSITE/ EXTERNAL/ COUNTRIES AFRICAEXIT/

**Walkey, A. and Black, L.A. (1945).** An examination of the oxidation methods for determining soil organic matter and proposed modification of the chronic and titration method. *Soil science* **37:** 29 – 38.