Swift Journals

Swift Journal of Agricultural Research
Vol 2(2) pp. 012-020 June, 2016
http://www.swiftjournals.org/sjar
ISSN: 2986-982X


*Original Research Article*

# Productivity Assessment of Groundnut (Arachis Hypogaea L.)/Maize (Zea Mays, L.) Intercrop Grown on a Marginal Acid Sandstones Soil

**[1]Akpan, I. I., [2]Eteng, E. U. and [1]Willie, E. S.**

[1]Department of Agronomy, College of Crop and Soil Sciences Michael Okpara University of Agriculture, Umudike, Nigeria.
[2]Department of Soil Science and Meteorology, Michael Okpara University of Agriculture, Umudike, Nigeria.

Accepted 24th June, 2015.

**ABSTRACT**

**A field experiment was carried out in 2010 and 2011 at the Research and Training Farm of Abia State University, Umuahia Campus. The aim of the study was to evaluate the productivity of groundnut/maize intercropping at varying maize planting densities. The experiment was a randomized complete block design replicated 4 times. The result shows that intercropping groundnut with maize at varying densities decreased grain yields of groundnut in both years. Productivity indices indicated that groundnut/maize intercropping was productive, and maize was the dominant component. The productivity of the cropping system was determined using the land equivalent ratio (LER) and gross monetary returns (GMR) for the two years and produce prices of N120/kg and N60/kg for groundnut and maize respectively. The result also showed that intercropping improved resistant red bulk (RRB) groundnut variety at 80,000 with maize at either 40,000 or 48,000 plants/ha and these gave significantly higher gross monetary returns (N4,840.00) than intercropping the local variety. Moreover, intercropping RRB and 48,000 maize plants/ha stand to give the farmer over 10% gross returns above the local, suggesting profitability of the intercropping systems.**

**Keywords** *groundnut, maize, intercrop, LER, GMR, Ultisol, planting density, acid sandstone.*

## INTRODUCTION

In the past few decades, maize production has increased tremendously in the tropical rainforest (FAO, 2012). Maize (Zea mays L) is rated as the third most important cereal crop for both human and animal consumption in the world (FAO, 2015) and has contributed greatly to the economic growth of many developing countries. It is an important source of carbohydrate in the human diet and as animal feed worldwide (Onasanya et al., 2009). Maize is commonly intercropped with various crops in the farming systems of southeastern Nigeria and has versatile uses as food, feed and industrial raw material (Ologunde and Ogunlela, 1984; Ogunlela et al; 1988). It is grown under climatic conditions ranging from temperate to tropical when mean daily temperatures are above 15°C and frost – free. Early season maize is planted in mixture with other crops and is harvested first for subsistence or sold as fresh maize to urban dwellers. The large gap between demand and supply has necessitated expansion of cultivation into the late cropping season. Expansion in the cultivation of the early season maize crop in the humid Tropical Rainforest agroecology of South Southern Nigeria is limited by lack of appropriate technologies for preservation of the fresh harvest.
Groundnut (Arachis hypogea L.) is a leguminous oil crop in the family Fabaceae (or Leguminosae). It is an important source of protein for man and non-drying oil and cake which are an important ingredient in animal feed (Undie et al, 2013). It can be cultivated within Lat. 40° N and S of the Equator under a temperature range of 27 - 35° C (Sigmund and Gustav, 1991; Onwueme and Sinha, 1992) on a well-drained sandy loam soil with pH 5.5-7.5 (Purseglove, 1988). Groundnut is intercropped with maize, okra, and yam in the south-eastern zone of

*Corresponding Author:* Eteng, E. U. Department of Soil Science and Meteorology, Michael Okpara University of Agriculture, Umudike, Nigeria.
*Email:* idaresitidung@yahoo.com; eteng_em@yahoo.com

Nigeria. It has the potential of improving soil fertility because of its ability to produce root nodules which fix atmospheric nitrogen. Farmers practice groundnut/maize intercropping because of the advantages it has over sole cropping such as increased total output per area of land, increased yield under stress condition, greater gross monetary advantages at zero nitrogen (N), availability of more mineral N at the topsoil of plot formerly grown with groundnut compared to that of cotton, sorghum or cowpea and land equivalent ratios (LERs) always larger than unity (Marshall and Willey, 1983; Kumaga et al. 2003).

The cropping system is defined as the combination of crops grown in a given area within a year (Okpara et al., 2005; Seran and Brintha, 2010). In small farms, the farmers raise crops as a risk minimizing measures against total crop failures and to get different produce to take for his family's food, income, etc (Ullah et al., 2007). Subsistence farmers in the tropics rely on mixed cropping as their crop production system (Seran and Brintha, 2010). Recent research findings have shown that mixed cropping shall continue to be more beneficial to these small-scale farmers for obvious reasons. Mixed cropping provides security in food output which is considered more important than food maximization (Undie et al, 2013). It also suppresses weeds, increases cash returns to the farmers and provides higher yield advantages over sole cropping (Seran and Brintha, 2010). The commonest food crops grown in this region are yams, cassava, maize, plantain, and cocoyam. Three or more of these food crops in combination are common on farmers' plots with rarely any legume in the combinations. In the tropics, maize-cowpea intercropping is often practiced (Seran and Brintha, 2010) as it's found beneficial in legume-cereal intercrop which increases the fixation of nitrogen by legumes. Cereal-legume mixtures have been adjudged the most productive form of intercropping since the legume does not compete with the cereal for available nitrogen but fixes and use its own nitrogen (Adu-Gyamfi et al., 2007). The cereal may also benefit from the nitrogen fixed in the root nodules of the legumes either in the current year or subsequent years (Chiezey et al., 2005).

High plant density of 53,000-67,000 maize plants/ha has been recommended for the Savannah zone of Nigeria and 55,000 maize plants/ha for the tropical rainforest of the Southern parts of Nigeria under sole cropping while increased plant density above 500,000 plants/ha has been recommended for the Northern zone and 250,000 – 350,000 plants/ha for the South-eastern ecological zone of Nigeria in terms of groundnut and other legumes (Imo, 1998). Apart from certain factors which affect intercropping such as type of agricultural system, variety or genome, environment and the purpose for which the crop is grown, optimum plant density is usually arrived at through field experimentation because at above or below optimum plant density, crop growth and development are negatively affected with consequent reduction in yield per unit area through inter-plant and intra-plant competition for growth factors which would manifest itself on source/sink relationships during the growth cycle of the crops.

Huxley and Miangu (1978) and Okpara et al. (2004) reported that maximum productivity in intercropping could be achieved when inter- and intra- competitions are minimal for growth limiting factors and density of each crop adjusted to minimize competition between them. Maximization of yields in crop mixtures will always be on the basis of high species compatibility, optimum plant population (Baker, 1974) and minimization of below- and aboveground competition for growth (Trenbath, 1976). Schmidt and Frey (1985) conducted an experiment in which a 1:1 and 1:2 (24,000 to 24,000 and 48,000 to 96,000, respectively) plants per hectare maize/groundnut intercrop was tested and obtained a higher LER in the 1:2 ratio.

Sandstones derived soils of southeastern Nigeria are generally dominated, alfisols and ultisols soil types, where a bulk of maize grain second to the northern guinea savanna of Nigeria, is produced. These soil types are well-drained and coarse textured. But, they are inherently very low in organic matter, ECEC, clay and are very strongly acidic (Chude et al., 2004). Our objective was to evaluate the productivity of groundnut/maize intercrop grown in soils of south-eastern Nigeria.

## MATERIALS AND METHODS

### *Description of the Experimental Site*

The field experiment was carried out for two years during the cropping seasons of 2010 and 2011 on an ultisol at the Research and Training Farm of Abia State University, Umuahia campus (5°25'N and 7°35'E) in the tropical rainforest of Southeastern Nigeria on an elevation of 122 m above sea level. The soil was classified as Typic Paleudult (USDA). The experiment was conducted in the same location in each year. The mean annual rainfall was 2455 mm. The highest average rainfall was 434.07 mm and was recorded in September while the lowest was 9.21 mm in December. The highest average temperature was 30 °C recorded November. The highest average sunshine duration was 5.97 (hrs/day) which occurred in December while the lowest 2.27 (hrs/day) was recorded in August. Relative humidity was generally high, especially between April and October.

### *Soil Sampling and Analysis*

Ten core samples of soil were collected from different parts of the experimental field from a depth of 0 to 30 cm and bulked into a composite sample and used for the determination of the physical and chemical properties of the soil (Table 2) before planting (2010) and (2011). The composite soil samples were sent to the National Root Crop Research Institute (NRCRI) Umudike, Soil Science Laboratory for analysis according to standard methods.

The two-year field experiments were conducted using randomized complete block design replicated 4 times. The treatments consisted of a complete factorial of 2 groundnuts (Arachis hypogea L.) cultivars at 80,000 plants/ha and 2 maize (Zea mays L.) variety DMR.1. (Y), population densities of 40,000 and 48,000 maize plants/ha. The groundnut varieties were the improved resistant red bulk (RRB) and a local cultivar (Local). Groundnut was sown on the crest of 1.0 m ridges at 25 cm spacing. Maize was sown at 1.0 m spacing on both sides of the ridge to achieve a density of 40,000 plants/ha and alternately at 0.75 m spacing along both sides of the ridge to give a density of 48,000 plants/ha. Two seeds of each crop were sown per hole. Plot size was 4 m x 4 m.

The crops were harvested 12 WAP and yields evaluated by oven-drying the samples at 65°C for 48 hours and measuring according to Undie et al. (2013) to obtain the dry weight. The productivity of the cropping system was determined using the land equivalent ratio (LER) and gross monetary returns (GMR) for the two years and produce prices of N120/kg and N60/kg for groundnut and maize respectively.

## STATISTICAL ANALYSIS

Data generated were analyzed using Genstat 13th Edition. Means were separated by the use of the least significant difference (LSD) test at 5% probability level. A T-test was also used where necessary for paired comparisons at 5% level of probability.

## RESULTS AND DISCUSSIONS

The weather conditions received within the experimental period were considered adequate for crop growth and development (Table 1).

### *Soil properties of the experimental site*

The results of laboratory analyses of soil sample of the study area for 2010 and 2011 cropping seasons are shown in Table 2. The soil is coarse in texture with a high content of sand in the surface layer (0-15cm) which varied from 70.9 to 68.6 %, giving a textural class of sandy loam. Similar results were obtained for the coastal plain sands derived soils (Akpan-Idiok, 2012; Eteng et al., 2014). Such soils lack adsorption capacity for basic plant nutrients and water. The pH (4.71) indicated that the soil is strongly acidic. Organic matter content is rated low according to previous studies conducted in similar soils (Enwenzor et al., 1989; Akpan-Idiok and Ofem, 2014). Total nitrogen is also rated low when compared with the range 2 - 5 % for productive soils (Enwenzor et al., 1989; Chude et al., 2004). Available P was also low having values less than 15 mgkg−1 considered for productive soils (Enwezor,et al.,1990; Akpan-Idiok, 2012). Exchangeable bases (Ca, Mg, Na and K) were low when compared to the acceptable limits of individual basic cations for crop production in the ecological zone. Effective cation exchange capacity (ECEC) value was low as established by (Enwezor et al., 1990; Chude et al., 2004) for productive soils. A percentage base saturation varied from 65.2 to 63.04% suggests that basic nutrients must have occurred in marginally available forms in the soil solution for plant uptake. Bulk density varied from 1.52 to 1.37g/cm3 indicates that the top soil can enhance deep permeable easily penetrable of crop roots (Ogban et al., 2011; Essoka et al., 2009). Generally, soil available micronutrients (Fe, Mn, Zn and Cu) were extremely low in the soil type, compared to the critical values of 4.5mgkg-1 (Eteng et al., 2014).

### *The effects of groundnut/maize intercrop on crop yield*

The effects of groundnut/maize intercrop on crop yield are presented in Table 3. In all cropping seasons, cropping sequences significantly influenced groundnut and maize yields respectively. Sole RRB groundnut gave the highest grain yield (7.3 kg/plot) in 2011 while sole maize (M2) gave the highest grain yield (75.7) in 2010. However, Sole maize gave higher grain than intercropped treatments (Table 4). The result showed that maize yields in 2010 were significantly ($p<0.05$) higher in 2011 than the yields in 2011 cropping season. There was no significant difference in the average yields of groundnut in 2010 cropping season (Table 3). However, intercropping significantly lowered grain yields of groundnuts. This trend of behavior was recorded in 2010 and 2011 cropping seasons, which agree with the better performance of sole crops than in mixtures in separate works of Emuh and Agboola (2000) and Egbe and Idoko (2009).

These workers observed better performance in yield of sole crop than in their intercrops. It was realized that when the yield of maize was high, that of groundnut was low and vice versa, indicating a high competition for growth factors in the environment and as the population of maize was raised from 40,000 to 48,000 plants/ha the competition became more intense. This goes on to explain an intercropping phenomenon that maximization of yields in crop mixtures will always be on the basis of high species compatibility, optimum plant population (Baker, 1974) and minimization of below- and above-ground competition for growth (Trenbath, 1976).

### *Effect of groundnut/maize intercrop on land equivalent ratio and gross monetary returns*

It was, however, observed in all the intercrop treatments (Table 4), that LER was above unity with Local x 48,000 maize plants/ha giving the highest productivity in 2010 (LER = 1.91) while the RRB x 48,000 maize plants/ha gave the highest productivity in 2011 (LER = 2.31 ). The comparatively higher LER from RRB is as a result of its capability to develop sprouts as it trails on, whereas the Local has the habit of growing erect and with no branches. When the yields were expressed in monetary terms, the result showed a significant difference only when RRB was intercropped with maize at 48,000 plants/ha [Gross monetary return (GMR) N4, 840.00 and N3, 918.00 in 2010 and 2011, respectively].

The result also showed that intercropping improved resistant red bulk (RRB) groundnut variety at 80,000 with maize at either 40,000 or 48,000 plants/ha and these gave significantly higher gross monetary returns (N4,840.00) than intercropping the local variety. Moreover, intercropping RRB and 48,000 maize plants/ha stands to give the farmer over 10% gross returns above the local, suggesting profitability of the intercropping systems. This result is in agreement with results reported by Karikari (2003) in Bambara groundnut intercropping with sorghum in Botswana. The LER (>1) values obtained in this study proved that intercropping was advantageous this was equally reported by Chiezey et al. (2005); Egbe and Idoko (2009). Emuh and Agboola (2000); Imoh, (1998) reported a contrasting view. However, the intercrop advantage was due mainly to the greater grain yield of the maize component. Similar observations had been reported by previous researchers (Alhassan et al., 2013; Ullah et al., 2007).

## CONCLUSION

The study has shown that cropping systems strongly affected the net benefits derived from these intercrop combinations of groundnuts and maize. Since optimum plant population for any crop plant is always derived through field operation, this experiment shows that intercropping improved variety of groundnut with maize at 48,000 maize plants per hectare will give the farmer the highest gross monetary returns of about N4000 per hectare which is about 10% above the Local. The differences in yields, net benefits and monetary returns of the groundnuts under intercropping with varying maize densities further emphasize the importance of evaluating crop varieties before making recommendations of crop varieties for intercropping.

**Table 1:** Average monthly meteorological data of the experimental site (2010 and 2011)

| Month | Rainfall (mm) | Temperature (°C) | Relative humidity (%) | Sunshine duration (hrs/day) | Wind speed (km/hr) | ETo mm/Day |
|---|---|---|---|---|---|---|
| January | 16.65 | 26.20 | 49.34 | 4.82 | 9.50 | 3.71 |
| February | 47.41 | 28.20 | 66.86 | 5.19 | 10.20 | 3.76 |
| March | 92.86 | 29.05 | 68.43 | 4.29 | 10.20 | 4.03 |
| April | 172.37 | 28.00 | 72.43 | 5.23 | 8.80 | 4.04 |
| May | 311.05 | 27.60 | 75.93 | 4.63 | 8.80 | 4.00 |
| June | 374.02 | 26.75 | 79.86 | 4.53 | 8.80 | 3.48 |
| July | 304.30 | 26.20 | 83.07 | 3.48 | 9.50 | 3.26 |
| August | 264.99 | 25.95 | 81.43 | 2.27 | 7.30 | 2.24 |
| September | 434.07 | 26.15 | 85.00 | 2.70 | 8.80 | 3.14 |
| October | 362.77 | 27.10 | 78.07 | 3.75 | 8.90 | 3.44 |
| November | 56.25 | 30.50 | 62.00 | 5.08 | 8.80 | 3.72 |
| December | 9.21 | 27.75 | 41.79 | 5.97 | 9.50 | 3.63 |
| **Total** | **2445.95** | **329.45** | **844.21** | **51.94** | **109.1** | **42.45** |
| **Mean** | **204.66** | **27.45** | **70.35** | **4.33** | **9.09** | **3.54** |

Key: ETo=reference crop evapotranspiration.

**Table 2: Physico-chemical characteristics of experimental soil (0-30 cm)**

| Soil parameter | Unit | Values | |
|---|---|---|---|
| | | 2010 | 2011 |
| pH (water) | | 4.71 | 4.54 |
| Organic carbon | (%) | 0.23 | 0.19 |
| Total nitrogen | (%) | 0.04 | 0.02 |
| Bray 2 Phosphorus | $mgkg^{-1}$ | 11.77 | 9.44 |
| Cation exchange capacity | $cmolkg^{-1}$ | 5.0 | 4.7 |
| Total acidity | $cmolkg^{-1}$ | 1.63 | 1.72 |
| Base saturation | (%) | 65.2 | 63.04 |
| C/N ratio | | 20.8 | 18.2 |
| **Exchangeable cations** | | | |
| $Ca^{+2}$ | $cmolkg^{-1}$ | 1.99 | 1.67 |
| $Mg^{+2}$ | $cmolkg^{-1}$ | 0.65 | 0.62 |
| $K^{+}$ | $cmolkg^{-1}$ | 0.07 | 0.11 |
| $Na^{+}$ | $cmolkg^{-1}$ | 0.03 | 0.02 |
| **Particle size distribution** | | | |
| Sand | % | 70.9 | 68.6 |
| Silt | % | 7.6 | 9.8 |
| Clay | % | 21.5 | 20.6 |
| Texture | | Sandy clay loam | Sandy clay loam |
| Bulk density | $g/cm^3$ | 1.52 | 1.37 |
| **Micronutrients' cations** | | | |
| $Cu^{+2}$ | $mgkg^{-1}$ | 2.03 | 1.89 |
| $Fe^{+3}$ | $mgkg^{-1}$ | 3.71 | 2.11 |
| $Mn^{+4}$ | $mgkg^{-1}$ | 3.65 | 2.73 |
| $Zn^{+2}$ | $mgkg^{-1}$ | 1.74 | 1.32 |

**Table 3:** Effects of groundnut/maize intercrop on yield at 12 WAP in 2010 and 2011 intercropping seasons

| Treatment | Crop yield: Groundnut (kg/plot) | | Maize (kg/ha) | |
|---|---|---|---|---|
| | **2010** | **2011** | **2010** | **2011** |
| Sole RRB | 5.2 | 7.3 | - | - |
| Sole Local | 4.9 | 5.8 | - | - |
| Sole $M_1$ | - | - | 70.3 | 69.2 |
| Sole $M_2$ | - | - | 75.7 | 58.5 |
| RRB x $M_1$ | 2.4 | 4.3 | 66.0 | 44.2 |
| RRB x $M_2$ | 3.2 | 2.7 | 65.0 | 45.9 |
| Local x $M_1$ | 3.1 | 3.0 | 68.3 | 33.6 |
| Local x $M_2$ | 2.7 | 2.0 | 58.3 | 41.8 |
| **$LSD_{(0.05)}$** | **NS** | **19.8** | **5.2** | **4.9** |

$M_1$ = Maize at 40,000 plants/ha; $M_2$ = Maize at 48,000 plants/ha RRB = Resistant red bulk

**Table 4:** Effect of groundnut/maize intercrop on land equivalent ratio (LER) and gross monetary returns (GMR) in 2010 and 2011 cropping seasons

| | Land Equivalent Ratio (LER) | | | | | | Gross Monetary Returns(N/kg) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Partial | | | | Total | | Partial | | | | Total | |
| | Groundnut | | Maize | | Groundnut | Maize | Groundnut | | Maize | | Groundnut | Maize |
| Treatment | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 | 2010 | 2011 |
| Sole RRB | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 384.00 | 852.00 | - | - | 384.00 | 852.00 |
| Sole Local | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 348.00 | 420.00 | - | - | 348.00 | 420.00 |
| Sole M1 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | - | - | 4002 | 2952.00 | 4002.00 | 2952.00 |
| Sole M2 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | 1.00 | - | - | 4002 | 2310.00 | 4002.00 | 2310.00 |
| RRB x $M_1$ | 0.75 | 0.60 | 1.04 | 0.89 | 1.35 | 1.93 | 288.00 | 516.00 | 4488.00 | 2652.00 | 4488.00 | 3168.00 |
| RRB x $M_2$ | 1.10 | 0.77 | 1.12 | 1.19 | 1.87 | 2.31 | 384.00 | 324.00 | 4840.00 | 3594.00 | 4840.00 | 3918.00 |
| Local x $M_1$ | 0.97 | 0.54 | 1.02 | 0.68 | 1.51 | 1.70 | 372.00 | 468.00 | 4470.00 | 2016.00 | 4470.00 | 2484.00 |
| Local x $M_2$ | 0.93 | 0.98 | 0.89 | 1.08 | 1.91 | 1.95 | 324.00 | 840.00 | 3822.00 | 2508.00 | 3822.00 | 3848.00 |

Groundnut and maize were at prevailing market prices of N120/kg and N60/kg respectively in 2010 and 2011

## REFERENCES


Adu-Gyamfi,J.J., F.A. Myaka, W.D. Sakala, R. Odgaard, J.M. Vesterager & H. Hogh-Jensen, 2007. "Biological Nitrogen Fixation and Nitrogen and Phosphorus Budgets in Farmer-Managed Intercrops of Maize-Pigeonpea in Semi-Arid Southern and Eastern Africa". Plant and Soil 295, 127-136.

Akamigbo, F. O. R. (1999). Influence of land use on soil properties of the humid tropical agro-ecology of southeastern, Nigeria. Niger. Agric. J. 30: 59-76.

Akpan-Idiok, A. U. (2012). "Physicochemical Properties, Degradation Rate and Vulnerability Potential of Soils Formed on Coastal Plain Sands in Southeast, Nigeria," International Journal of Agricultural Research, Vol. 7, No. 7, 2012, pp. 358-366.

Akpan-Idiok, A. U. and K. I. Ofem (2014). Physicochemical Characteristics, Degradation Rate and Vulnerability Potential of Obudu Cattle Ranch Soils in Southeast Nigeria. Open Journal of Soil Science, 4: 57-63.

Alhassan, G. A, Kalu, B. A, Egbe, O. M. (2013). Influence of planting densities on the performance of intercropped Bambara groundnut with cowpea in Makurdi,Benue State,Nigeria. Int. J. Dev. Sustain. 1(3) (in press).

Baker, E.F. I. (1974). Research on mixed cropping with cereals in Nigerian farming system, a system for improvement. In: Proceedings of international workshop on farming systems, ICRISAT, Hyderabad, November 18-21, pp. 287-301.

Chiezey, U. F.; Haruna, I. M. & Odion, E. C. (2005)."Productivity of Sorghum/Soybean Mixture and Influence of N, P and Plant Arrangement in the Northern Guinea Savanna Zone of Nigeria". Crop Research 29:1-14.

Chude, V. O., Malgwi, W. B. Amapu, I.Y. and Ano, A.O. (2004). Manual on Soil fertility assessment. Federal fertilizer department/national special food programme for security, Abuja, Nigeria. Pp. 89.

Egbe, O. M. and Idoko, J. A. (2009). Agronomic assessment of some sweet potato varieties for intercropping with pigeonpea in Southern Guinea Savanna of Nigeria. ARPN J. Agric. Biol. Sci., 4: 22-32.

Emuh, F.N. and Agboola, A.A. (2000). Effect of intercropping sweet potato and pigeon pea on growth parameters and yield of maize. Nig. Agric. J., 31: 1-12.

Enwezor, W. O., Ohiri, S. C., Opuwaribu, E. E. and Udo, E. J. (1990). A Review of Fertilizer Use on Crops in Southeastern Zones of Nigeria (in five vols.) (FFDD). Boboma Publ. Ibadan, 47-70 pages.

Enwezor, W. O., Udo, E. J., Usoro, N.J., Ayotade, J.A. Chude, V.O. and Udegbe, C.C. (1989). Fertilizer use and management practices for crops in Nigeria. Series 2. Federal Ministry of Agriculture, Water Resources and Rural Development. Pp: 52-56.

Essoka, A., Ibanga, I. and Amalu, U. (2009). "Physical Properties of the Mountain Soils of Cross River State, Nigeria," Nigerian Journal of Soil Science, Vol. 19, No. 2, 2009, pp. 1597-4488.

Eteng, E. U., Asawalam, D. O. and Ano, A. O. (2014). Total and Available Micronutrients in Soils of Contrasting Parent Materials in Southeastern Nigeria. Journal of Agriculture, Biotechnology and Ecology, 7(2): 1-16.

FAO. 2012. Statistical Database. Food and Agriculture Organization (FAO). www. faostat. fao. org.

FAOSTAT (2015): Food and Agriculture Organization of the United Nations. Available at http://faostat.fao.org/site/567/default.aspx#ancor (accessed 29.6. 2015)

Huxley, P. A. and Maingu, Z. (1978). Use of a systematic spacing design as an aid to the study of intercropping: Some general considerations. A paper presented at the symposium on Intercropping in semi-arid areas, Morogoro, Tanzania.

Imoh, V. O. (1998). Influence of plant density on the performance of maize, soyabean and cassava, El-Elyon Press. Port Harcourt, Nigeria. pp. 1-66.

Karikari SK (2003). A decade of bambara groundnut agronomic research at the Botswana College of Agriculture. UNISWA J. Agric. 12:24-28.

Kumaga, F. K., S. G. K. Adiku and K. Ofori (2003). Effect of post-flowerring Water Stress on Dry Matter and Yield of Three Tropical Grain Legumes. Inter. J. of Agric. Biol. 5(4): 405-407.

Marshall, B. A and Willey, R. W. (1983). Radiation interception and growth in an intercrop of pearl millet/groundnut. Field Crops Research, 7: 141-160.

Ogban, P. I., Effiong, G. S., Obi, J. C. and Ibia, T.O. (2011).Characteristics, potentials, and constraints of wetland soils for Agricultural Development in Akwa Ibom State, South-eastern Nigeria. Niger. J. Agric., Food Environ. 7(2):80-87

Ogunlela, O. B., Omuruwa, G. M. and O. O. Ologunde (1988). Growth yield components and micronutrients nutrition of field grown maize (Zea mays L) as affected by nitrogen fertilization and plant density. Fertilizer Research 17:189-196.

Okpara, D. A. Awurum, A. N. and Okeke, A. I. (2004). Effect of planting schedule and density on cowpea/maize intercropping in south-eastern Nigeria. Journal of Sustainable Tropical Agricultural Research, 11: 59-67.

Okpara, D.A., T.O. Ojikpong and A.A. Udo, 2005. The effect of planting dates on seven varieties of soybean Umudike agroecosystems of South Eastern Nigeria. Nig. Agric. J., 36: 124-133.

Ologunde. O. and Ogunlela, O. B. (1984). Relationship of Plant Density and nitrogen Fertilization to maize Performance in the South Guinea Savannah of Nigeria. Samaru J. Agricultural Research 2 (1 and 2): 99-109.

Onasanya, R. O., Aiyelari, O. P., Onasanya, A., Oikeh, S., Nwilene, F. E. and Oyelakin, O. O. (2009). Growth and yield response of maize (Zea mays L) to different rates of nitrogen and phosphorus fertilizers in southern Nigeria. World J. Agric. Sci., 5(4): 400-407.

Onwueme, I. C. and Sinha, T. D. (1991). Food crop production in tropical Africa. The Technical Center for Agric. and Rural Cooperation (CTA). The Netherlands Pp. 337-343.

Purseglove, J. W. (1988). Tropical Crops. Longman Publication Ltd., London.

Schmidt, G. and Frey, E. (1985). Combined intercropping and crop rotation trial in 1985 with various crops. Nyankpala Agric. Exp. Station, CRI/GTZ Joint Project, Tamale/Ghana. 86: 44-45.

Seran, T. H. and Brintha, I. (2010). Review on Maize Based Intercropping. Journal of Agronomy, 9: 135-145.

Sigmund, R. and Gustav, E. (1991). The cultivated crops of Tropics and Sub-Tropics. IAT of Agronomy in the Tropics, University of Gohingen.

Trenbath, B. R. (1976) Plants interaction in mixed crop communities. In: Multiple cropping, Papendick, R.I: P.A. Sanchez and G.B Triplet (Eds), American Society of Agronomy. Wisconsin, U.S.A., 129 – 170.

Ullah, A., M.A. Bhatti, Z.A. Gurmani and M. Imran, (2007). Studies on planting patterns of maize (Zea mays L.) facilitating legumes intercropping. J. Agric. Res., 45: 113-118.

Undie, U. L., Uwah, D. F., Umoetuk, S. B. A., Attoe, E. E. and Effa, E. B. (2013). Response of Late Season Maize/Soybean Intercropping to Nitrogen in the Humid Environment of South Southern Nigeria. Journal of Biology, Agriculture and Healthcare Vol.3, No.10: 84-91.