EFFECTS OF INTERCROPPED LEGUMES WITH MAIZE (*Zea mays L.*) ON CHEMICAL PROPERTIES OF SOIL AND GRAIN YIELD OF MAIZE IN ABAKALIKI, NIGERIA

Nwite, J.N., Njoku, C. and Alu, M.O

Department of Soil Science and Environmental Management, Faculty of Agriculture and Natural Resources Management, Ebonyi State University, PMB 053 Abakaliki
Email:nwitejamesn@yahoo.com

Abstract
An experiment was carried out to study effects of intercropped legumes with maize (*Zea mays L.)* on chemical properties of soil and grain yield of maize in Abakaliki. The field was laid out in a Randomized Complete Block Design with four treatments of soybean (*Glycine max*) and maize, groundnut (*Arachis hypogea*) and maize, bambaranut (*Vigna subterranean)* and maize and sole maize which is the control and were replicated five times. Data obtained from the study were subjected to Statistical Analysis System for Agricultural Science (SAS). Results showed significantly ($P<0.05$) higher effect of legumes intercropped with maize on soil pH, total N, organic carbon, calcium, magnesium, cation exchange capacity (CEC) and base saturation when respectively compared to values obtained in sole maize monoculture except in soybean intercropped with maize for organic carbon, CEC and base saturation. Soil pH, total N and organic carbon in plot treated with bambaranut and maize intercrop were higher by 9, 35 and 57% compared to their respective values in plot receiving sole maize. Groundnut and maize intercrop had 39, 34, 29 and 10% higher Ca, k, CEC and base saturation than values obtained in sole maize. Legumes intercropped with maize further showed significantly ($P<0.05$) higher effect on grain yield of maize than in sole maize. Groundnut and maize intercrop had 33, 4 and 44% higher grain yield of maize compared to values recorded in plots receiving soybean and maize as well as bambaranut and maize intercrop and sole maize. Legumes intercrop with maize is recommended as management technology for higher and sustainable soil productivity in Abakaliki agro ecology, but with more emphasis on groundnut and maize intercrop for its phenomenal superior performance and easy accessibility.

Keywords: Chemical properties, fertility, grain yield, Intercropped and legumes

Introduction
Natural forces in form of erosion, compaction, sealing or crusting and inappropriate farming practices such as bush burning (Nwite and Alu, 2017), overgrazing, indiscriminate felling of trees, continuous cropping and soil mining have resulted in serious degradation of soils in Abakaliki agricultural ecology. The consequence is reduced soil fertility and productivity. Incidentally, inorganic fertilizer sources are becoming increasingly unavailable due to their scarcity and high cost to small scale farmers for intensive agriculture and sustainable production. For instance, Ayoola and Makinde (2007) reported that continuous use of inorganic fertilizers alone is not helpful under intensive agriculture as they often aggravate the problem of soil degradation. Consequently, there must be concerted efforts in exploring and evolving other viable alternatives for sustainable soil fertility and productivity in our farming system. One of such alternatives is the legume- cereal intercrop. Legumes fix atmospheric nitrogen or one excereted from their nodules into the soil and this is used by plants growing nearby (Andrew, 2000). Alternatively, legumes could transfer fixed N which is important mineral nutrient to intercropped cereals during their joint growing period (Shen and Chu, 2004). Apart from improving soil fertility status through their ability to fix N and thereby produce N rich resides in soil, legumes intercropped with cereal play important role in subsistence

food production under traditional or developed and developing countries (Tsubo *et al.*, 2005) especially in situations of limited soil resource and for appropriate soil management technology. Other host of benefits accruing from legume-cereal intercrop include ability of legumes to combat erosion and thereby conserve soil resources, suppression of weeds and increase in yield of benefiting crops (Ijoyah, 2012). Essentially, cultivating two or more crops in the same piece of land had been a common practice among small holder or peasant farmers (Dahmardeh, 2013). This combination commonly referred to as "intercropping" mostly involves legumes and cereals (Ijoyah, 2012) and in most cases maize, cowpea, groundnut or soybean are involved. Studies indicate positive contributions of legumes-cereal intercropping system in farming systems (Dahmardeh, 2013) compared to monocrop culture. However, exploit of farmers in legume-cereal intercrop appears to be location specific with particular reference to agro climatic circumstances for improved production. Generally, in Abakaliki agro ecological environment, legume-cereal intercrop is practiced under traditional farming system with no scientific approach to document results. This to a large extent has given rise to paucity of information in this area. This study was therefore to bridge this gap as well as to create awareness to farmers and land users on effects of the system on immediate soil environment and host crops. The main objective of the research was to study effects of intercropped legumes with maize on chemical properties of soil and grain yield of maize in Abakaliki, Nigeria.

Materials and Methods

Study Area

This experiment was carried out at the Teaching and Research Farm of the Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki. It is located by Latitude 06^0 04 $^/$ N and Longitude 08^0 65 $^/$ E in the derived savannah of the southeastern agro-ecological zone of Nigeria. The area experiences a bimodal pattern of rainfall which is spread from (April-July and September-November) with a short dry spell in August. The mean annual rainfall ranges from 1700 mm to 2000 mm. The area has minimum and maximum temperatures of 27 ^{0}c and 31 ^{0}c respectively for dry and rainy seasons. The relative humidity in dry and rainy seasons ranges between 60% and 80%, respectively. The soil belongs to the Order ultisol and is classified as a Typic haplustult (FDALR, 1985).Abakaliki area falls within derived savannah zone of Nigeria. The vegetation of the place includes tall and short trees, shrubs, herbs and grasses. There is also growth of economic trees.

Field Design and layout

The site was cleared of existing vegetation with cutlass and debris removed without burning. A total land area of 418m^2, approximately (0.042 ha) was used for the experiment. The field was laid out in randomized complete block design (RCBD) with four treatments of legumes and maize intercrop and five replications. The plot size was 3 m x 3 m and separated from one another by 0.5 m spaces while replicates were set apart by 1m alley. Plots were prepared with native hand hoe. The treatments were soybean and maize, groundnut and maize, Bambaranut and maize and control which was sole maize. The treatments were replicated five times to give a total of twenty experimental plots. The planting distances for the legumes were 60 cm x 60 cm, 60 cm x 60 cm, 60 cm x 60 cm and 25x75 cm respectively for soybean, bambaranut, groundnut and maize. Seed rates of two per hole and at 5cm depth were sown in all plots receiving treatments. Two weeks after germination of both legume crops and maize, thinning was carried out while those which failed to germinate were replaced to ensure optimum plant population. Weeds were removed with hands at three weekly intervals till harvest. Cobs of maize were harvested when husks had dried. The cobs were dehusked, shelled, and further dried while grain yield was determined at 14% moisture content. The legume crops were uprooted at flowering stage and deposited on their plots.

Soil Sampling

Soil samples were collected with soil auger at 0-20 cm depth. These samples were composited for pre-planting analysis. Auger samples were further collected from each plot after planting for soil chemical properties determinations. The samples were collected at 0-20 cm plough layer. Samples were air dried ground and passed through 2mm sieve for laboratory analysis.

Laboratory Methods

Soil pH was determined in soil/water solution ratio of 1:2.5. The values were read off with glass electrode pH meter as described by Mclean (1982). Organic carbon determination was done using modified Walkely and Black method of Nelson and Sommers (1982). Total Nitrogen was determined by use of micro kjeldahl method (Bremner and Mulvaney, 1982). Available phosphorus determination was carried out as outlined in Page *et al.* (1982). Organic matter was evaluated using Bemeler factor of 1.724. Exchangeable bases were extracted by the process described by Tel and Hagarty (1984). Exchangeable acidity was determined using titration method as described by Juo (1979). Cation exchange capacity was obtained using ammonium acetate (NH_40AC) displacement (Jackson, 1958) method whereas base saturation was evaluated by diving total exchangeable bases (TEB) with cation exchange capacity value and product multiplied by 100. The expression is:

$$\% BS = \frac{TEB}{CEC} \times \frac{100}{1} \quad \text{--} \quad 1$$

where

TEB= total exchangeable bases ($cmolkg^{-1}$)

CEC= Cation exchange capacity ($cmolkg^{-1}$)

Data Analysis

Data which were collected from the field during the experiment and laboratory were subjected to Statistical Analysis System for Agricultural Science. Significant difference (F-LSD) was accepted at 5% probability level (Obi, 2012) for means that were significant.

Results and Discussion

The result in Table 1 shows the properties of soil prior to amendment. Even though the particle sizes varied but sand was dominated among the fractions. Textural class was sandy loam. The pH (5.10) of the soil was strongly acidic. Total nitrogen was very low (6.00gkg^{-1}) while available phosphorus was moderate with value of 21.50 mg kg^{-1} but organic matter and organic carbon values were low. calcium and magnesium dominated the exchange complex of soil. Cation exchange capacity recorded very low value (3.57 cmol kg^{-1}) but there was high base saturation (84%).

Table 1: Initial Properties of soil before planting

Soil Properties	Values
Sand (gkg^{-1})	468
Silt (gkg^{-1})	344
Clay (gkg^{-1})	198
Textural Class	Sandy loam
pH (H_20)	5.10
Available phosphorus ($mgkg^{-1}$)	21.50
Nitrogen (gkg^{-1})	6.00
Organic carbon (gkg^{-1})	10.90
Organic matter (gkg^{-1})	18.80
Calcium ($cmolkg^{-1}$)	2.00
Magnesium ($cmolkg^{-1}$)	0.80
Potassium ($cmolkg^{-1}$)	0.05
Sodium ($cmolkg^{-1}$)	0.16
Exchangeable acidity ($cmolkg^{-1}$)	0.56
Cation exchange capacity ($cmolkg^{-1}$)	3.37
Base Saturation (%)	84

Table 2 showed that different legumes intercropped with maize had significantly ($p<0.05$) higher respective effect on soil pH, total N, organic carbon, calcium, magnesium, cation exchange capacity (CEC) and base saturation when compared to sole maize cropping except in soybean intercropped with maize for organic carbon, CEC and base saturation. Significantly ($p<0.05$) higher effect of bambaranut and maize intercrop was obtained in N and organic carbon compared to other legumes intercropped with maize. There were also significant ($p<0.05$) differences in calcium among different legumes intercropped with maize. The result further indicated that groundnut legume intercropped with maize significantly ($p<0.05$) differed in magnesium and CEC from those of soybean and maize as well as bambaranut and maize intercrop, respectively. However, groundnut legume intercropped with maize only significantly differed in base saturation when compared to value recorded in soybean legume intercropped with maize. Soil pH, total N and organic carbon of bambaranut plot intercropped with maize were respectively higher by 9, 35 and 57% compared to value obtained in plot receiving sole maize treatment. Plot receiving groundnut and maize intercrop had 39, 34, 29 and 10% higher Ca, K, CEC and BS when compared to respective values obtained in plot treated with sole maize crop. Conversely, available phosphorus of maize sole crop was significantly ($p<0.05$) higher than their respective values in plots receiving soybean and maize as well as groundnut and maize intercrop. These represent 12 and 25% increments in available phosphorus of maize sole crop compared to their counterparts in soybean and maize and groundnut and maize intercrop. Similarly, sodium and exchangeable acidity were significantly ($p<0.05$) higher in maize sole crop compared to values recorded in legumes and maize intercrop except in plot treated with soybean and maize intercrop for exchangeable acidity. Exchangeable acidity was higher by 8, 65 and 49% in plot receiving maize sole crop than in plots treated with soybean and maize, groundnut and maize and bambaranut and maize intercrop, respectively, Legume intercropped with maize did not show any significant effect on potassium. The general trend in improvements of chemical properties of soil due to legumes and maize intercrop is bambaranut and maize intercrop > soybean and maize intercrop>groundnut and maize intercrop>maize sole crop.

Table 2: Effect of intercropped legumes with maize on chemical properties of soil

			gkg^{-1}		cmolkg^{-1}						
Treatments	**pH(H_20)**	**P(mgkg^{-1})**	**OC**	**N**	**Ca**	**Mg**	**K**	**Na**	**EA**	**CEC**	**BS%**
Sole maize	5.8	23.59	1.10	8.20	2.71	1.90	0.07	0.13	0.66	5.47	87
Soybean and maize	6.2	20.82	1.40	9.40	3.27	2.30	0.07	0.07	0.61	6.32	90
Groundnut and maize	6.3	17.74	1.30	10.10	4.45	2.89	0.07	0.09	0.23	7.73	97
Bambaranut and maize	6.4	23.59	1.70	19.00	4.10	2.30	0.09	0.07	0.34	6.90	95
FLSD (P<0.05)	0.5	4.11	0.2	0.28	0.77	0.48	NS	0.04	1.17	1.12	5.0

Results (Table 3) show that legumes intercropped with maize had significantly ($p<0.05$) higher effect on grain of maize when respectively compared to sole maize cropping. Furthermore, groundnut and maize intercrop significantly ($p<0.05$) differed in grain yield of maize from that of plot receiving soybean and maize intercrop. Generally, the groundnut intercropped with maize had 33, 4 and 44% higher grain yield of maize than plots receiving soybean and maize, bambaranut and maize intercrop and maize sole crop. The trend in grain yield of maize as influenced by legumes and maize intercrop and sole maize is groundnut and maize intercrop > bambaranut and maize intercrop > soybean and maize intercrop> sole maize crop.

Table 3: Effect of intercropped legumes with maize on grain yield of maize

Treatments	Maize grain yield (t ha^{-1})
Sole maize	0.25
Soybean and maize	0.30
Groundnut and maize	0.45
Bambara and maize	0.43
FLSD (P<0.05)	0.04

The net effect of legumes and maize intercrop is evidenced in the higher N value obtained in all plots treated with legumes and maize when compared to values obtained in maize sole crop and pre-planting values. This finding was corroborated by Crews and People (2004) who noted that legumes trapped and fixed N in the soil through their nodules and in that way increased N content of soil. Significant N level recorded in all plots receiving legumes and maize intercrop also agrees with the report of Nweke (2016) that significant N levels were obtained in plots treated with groundnut and maize as well as bambaranut and maize intercrop. Dahmardeh *et al.* (2010) had reported that legume and maize intercrop was beneficial to nitrogen poor soil as it increased its content. The positive effects of increased N content in plots receiving legumes and maize intercrop are the corresponding increments in organic carbon, calcium, Mg, CEC, BS, pH and reductions in exchangeable acidity. Furthermore, Esekhade and Idoko (2010) reported higher soil pH in legume and cereal intercropping treatments compared to their counterpart under mono cropping culture. Soil pH moved away from strongly acidic to slightly acidic conditions in all plots which received legumes and maize intercrop (Schoenerberge *et al.,* 2002). Similarly, exchangeable calcium and magnesium increased from low values to moderate values respectively for groundnut and maize and bambaranut and maize intercrop compared to soybean and maize intercrop, maize sole crop as well as pre-planting values. Increase in soil pH and organic carbon was instrumental to reduction of exchangeable acidity (Esekhade *et al.,* 2003). The decrease in value of available phosphorus in all plots treated with legumes and maize intercrop relative to value obtained in maize sole crop could be attributable to excessive demand and use of phosphorus by legumes for N fixation and other physiological processes. This finding is supported by Nweke and Emeh (2013) report that legumes required abundant P in the soil for nitrogen fixation and growth. The non-significant effect of legumes and maize intercrop on K could be attributed to exploitation of the nutrient element by maize host crop for fruit formation and ripening. Similarly, the beneficial effect of legumes intercrop with maize is the observed higher grain yields of maize in the plots treated with legumes and maize intercrop in contrast to plot with sole maize crop. This positive higher grain yield of maize in these plots could be adduced to be higher N contents of the plots due to N-fixation by the respective legumes compared to sole maize (Table 3) as well as generally improved soil condition. On the other hand, higher grain yields of maize obtained in plots which had legumes and maize intercrop relative to sole maize monoculture could be due to higher organic carbon content, calcium, magnesium, CEC, base saturation, soil pH and decreased exchangeable acidity in the plots (Table 2). These findings are supported by the report of Thyamini and Brintha (2010) that legumes and maize intercropping system significantly increased grain yield of maize compared to maize monoculture. This was facilitated by positive impact of nitrogen fixation by the legumes that created ideal environment (Jekison, 1990) for the maize grain yields. Higher grain yield of maize in plot with groundnut and maize intercrop could be due to more efficient N fixation by the legume crop and its maximization by maize crop for higher yield. Reddy and Reddi (2007) in their studies reported increased grain yield of maize after intercropping with groundnut.

Conclusion

The results of this study have shown that intercropped legumes with maize improved soil chemical properties and therefore productivity of the soil. Legumes intercropped with maize played restorative role on a poor fertility degraded soil. Soil N was significantly increased after intercropping activity. Organic carbon, calcium and magnesium moved away from critical to moderate levels. Soil pH was improved from strongly acidic to slightly acidic condition which acted as panacea for proliferation of other nutrient elements. The consequence was increased grain yields of maize in all plots with legumes and maize treatments. The performance of the legumes and maize intercrop in terms of improving soil chemical properties and grain yields of maize could be in the order of groundnut and maize intercrop > bambaranut and maize intercrop >soybean and maize intercrop >sole maize culture. Legumes-cereal intercrop is recommended as a low technology base for soil restoration and sustainable productivity.

References

Andrew, R.W. (2005). *Intercropping: Its importance and Research need. Competition and yield advantages. Field crops. 32:1-10.*

Ayoola, O.T. and Makinde, E.A. (2007). Complementary organic and Inorganic Fertilizer Application: Influence on Growth and yield of Cassava/maize/melon Intercrop with a Relayed cowpea. Aust. J. of Basic and App. 1(3): 187-192.

Bremner, J.M. and Mulvaney, C.S. (1982). Total nitrogen. *In*: Page, A.L., Miller, R.H. and Keeny, D.R. (eds). Methods of soil Analysis. Amer. Soc. Agron. 1: 320-328.

Crews, T.E. and People, M.B. (2004). Legumes versus fertilizer sources of Nitrogen. Ecological tradeoffs and human needs. Agric. Ecossyst. Environ. 102:279-297

Dahmardeh, M. (2013). Intercropping two varieties of Maize (*Zea mays L.*) and Peanut (*Arachis hypogea L.)*: Biomass yield and intercropping advantage. Int. J. Agric. And forestry. 3(1): 7-11.

Esekhade, T.U. and Idoko, S.O. (2010). Effect of Intercropping on the Development of rubber saplings in acid sand in southern Nigeria. J. Sustain. Trop. Agric. Res. 9:12-23.

Federal Department of Agricultural Land Resources (FDARL). (1985). Reconnaissance Soil Survey of Anambra State Nigeria Soil Report, FDALR Kaduna.

Iyoyah, M.O. (2012). Review of intercropping research on cereal-vegetable based cropping system. J. of crop Sci. 1 (3): 55-62

Jackson, M.I. (1958). *The Soil Chemical Analysis, London, Constable.*

Jekinson, D.S (1990). An Introduction to the Global Nitrogen Cycle. Soil Use and Land Management. 6:56-61.

Juo, A.S.R. (1979). Selected methods of soils and plants analysis: Farming systems program. Manual Series no. 1. Ibadan, IITA.

Mclean, E.O. (1982). Soil pH and Lime Requirements. *In*: Page, A.L. (eds). Methods of Soil Analysis. Part 2.Chemical and Microbialogical properties. Agronomy Series No.9 ASA, SSSA Madison, W.I. USA. pp. 539-579.

Nelson, D.W. and Sommers, L.E. (1982). Total carbon, organic carbon and organic matter. *In:* Page, A.L., Miller, R.H. and Keeny, D.R. (eds). Methods of Soil Analysis. Chemical and Microbiological properties. Amer. Soc. Agron. 2: 539-579.

Nweke, I. A. and Emeh, H.O. (2013). The response of Bambara (*Phaseolus spp*) and ground nut (*Arachis hypogea)* to phosphate fertilizer levels in Igbariam SouthEast Nigeria. IOSR J. of Agric and Vet. Sci. 2(1): 28:34.

Nweke, I.A. (2016). Influence of different leguminous crop on the ultisol that had been continuously cropped to cassava/maize intercrop for over six years of Soil Sci. and Environ. Mgt. 14:205-212

Nwite, J.N. and Alu, M.O. (2017). Carbon Sequestration and assessment of fertility status of Soil under different land uses for Agronomic potentials in Abakaliki, south Eastern Nigeria. Afr. J. of Agr. Res. 12 (11): 871-880.

Obi, I.U. (2012). *Statistical Methods for detecting differences between treatment means and Research Methodology issues in laboratory and field experiment.* Pp. 11-13.

Reddy, T.Y. and Reddi, G.H.S. (2007). *Principles of Agronomy.* PP. 468-489.

Schoenerberger, P.J., Wysocki, D.A., Benham, E.C. and Broderson, W.D. (2002). *Field book for describing and Sampling Soils (Ver1.1). Natural Resources Conservation service, USDA. Natural Soil Survey Center, Lincoly NE.*

Shen, Q.R. and Chu, G.X. (2004). Bi-directional nitrogen transfer in an intercropping system of peanut with rice cultivated in aerobic soil. Boil. Fertile Soils. 40:81-87.

Statistical Analysis System (SAS)(1985). *User's Guide, 1985 (ed) Statistical Analysis Systems Institute Inc. cary, Nc.*

Tel, D.A. and Hagarty, M. (1984). *Soil and Plant Analyses. Study guide for agricultural laboratory Directors and Technologists working in tropical regions. Printed by IITA, Ibadan, Nigeria in conjunction with the University of Guelph, Guelph, Canada.* PP. 3510-664.

Thyamini, H.S. and Brintha, I. (2010). Review on maize based intercropping. J. of Agron. 9 (3): 135-145.

Tsubo, M., Walker, S. and Ogindo H.O. (2005*). A simulation model of cereal legume intercropping systems for semi-arid regions. Department of Soil, Crop and Climate Sciences, University of the Free Crops Res.* 93(1): 73-85.