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GROWTH AND YIELD RESPONSES OF SOYBEAN VARIETIES TO DIFFERENT SOIL FERTILITY MANAGEMENT PRACTICES IN ABAKALIKI, SOUTHEASTERN NIGERIA

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ABSTRACT*:* *Evaluation of the growth and yield responses of three early maturing promiscuous soybean varieties (TGx 1876-4E, TGx 1485-ID, TGx 1903-7F) and three medium maturing varieties (TGx 1908-8F, TGx 1904-6F, TGx 1844-4E) to eight soil fertility management practices were carried out in Abakaliki, Southeastern Nigeria, in a two-year field trials. TGx1485-1D responded better in the years combined, on the number of nodules/plant (12.70) and number of pods/plant (119.2) than others, but TGx 1903-7F had the highest number of seeds/plant (160.5) and weight of pods (31.28 g/plant). TGx 1904-6F had the least number of nodules (9.39) but was second to the highest in number of seeds (145.4). TGx 1876-4E had the highest number of nodules (12.72 in 2009). TGx 1908-8F had the highest % germination (64.1) in 2008, while TGx 1876-4E was highest (53.05) in 2009 and in combined years (57.2). No one variety showed consistent superior response on all the parameters across the years.*

KEYWORDS*:* Promiscuous Soybean; Soil Fertility; Management Practices

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill), is a versatile species of the grain food legume (Gibson and Benson, 2005), family, Fabaceae, (Wikipedia, 2011) with chromosome number 2n=40 (Singh *et al*., 1987, Hymowitz and Newell, 1981), notable for its rich source of valuable and quality protein, oils and an excellent source of food for man and animals. It is ideal for infant foods because it has minimal oligosaccharides which cause flatulence in other grain legumes and its oil content belongs to the linolenic unsaturated fatty acid group without cholesterol (Rehm and Espig, 1991), a native of East Asia. It is perhaps the oldest cultivated temperate legume (3000 BC) in China where it is a long established cultivated plant (Onwueme and Sinha, 1991; Rehm and Espig, 1991).

Over the years, several species of legumes were screened and adopted for inclusion into the farming systems for soil fertility improvement and restoration, but none has received the expected acceptance and inclusion like soybean by the smallholder farmers as it meets the food, fodder and fertilizer needs of the farmers (Misiko, 2007). It is found to be a benchmark nitrogen fixing legume, able to fix up to 180kg N/ha symbiotically, 80% of which is harvested as beans (Williams *et al*., 1980) and is second only to *Sesbania rostrata* which can fix more than 250kg N/ha in 50 days in both roots and stems (Ludwig, 1989, Rinaudo *et al*., 1983). Cultivars are broadly grouped into three according to the number of days to maturity (early maturing (125-130 days), medium

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maturing (140-150 days) and late maturing (150-160 days) cultivars, which increase with increase in latitude, day light and cool conditions. It is considered suitable for integration into the traditional intercropping systems (Lampang, 1981) and in crop rotation due to its outstanding features, such as short growth duration (100 ± 20 days), adaptability to short spells of moisture deficiency, high yield potentials, soil fertility restoration through nitrogen fixation and easy ploughing as it leaves the soil friable. If grown in rotation with maize, cotton, sorghum or winter wheat, is capable of increasing grain yield of succeeding maize or wheat by 1.3 t/ha (Smith, 2006), and maize yields by a factor of 2-4, according to Sanchez (Spore, 2003), almost attaining the levels achievable by applying recommended rates of N fertilizer or as much as 3000-4000kg /ha. Brazil with 59.9 million tons is second to USA (80.5) in the world and she saves over US$ 2.5 billion yr^{-1} in terms of N-fertilizer from biological nitrogen fixation technology (Alves *et al*., 2003), thus soybean could satisfy other crops nitrogen needs of smallholder farmers (Sanchez *et al*., 1990) while the fragile ecological system is conserved economically (Sanchez, 1987, Muller-Samann and Kotschi, 1997, Kotschi and Adelhelm, 1986). However, studies show that plant vigour (healthy plant growth) determines the rate of nitrogen fixation which in turn depends on the efficiency of the native *rhizobium* population and prevailing environmental conditions (Leinonen, 1996).
Soybean is described variously as a “golden bean”, a “miracle bean”, “crop of the planet”, “God´s sent golden bean”, “greater bean,” etc., has become the dominant crop in world commerce and the most important supplier of high quality edible vegetable oil (20%) and superior protein (40%), with Carbohydrate/soluble sugars (35%) and ash (5%) as human food and feed for animal (Singh *et al*., 1987, Thompson, 1981). Soybean seed comprises approximately 8% seed coat or hull, 90% cotyledons and 2% hypocotyls axis or germ. From USDA Nutrient Database, the nutritional value per 100g of mature seeds are: energy -1866 kJ (446 kcal), carbohydrates -30.16g, (sugars -7.33g, dietary fibre -9.3g), fat -19.94g, (saturated -2.884g, monounsaturated -4.404g, polyunsaturated -11.255g), protein -36.49g, (tryptophan -0.591g, threonine -1.766g, isoleucine -1.971g, leucine -3.309g, lysine -2.706g, methionine -0.547g, cystine -0.655g, phenylalanine -2.122g, tyrosine -1.539g, valine -2.029g, arginine 3.153g, histidine -1.097g, alanine -1.915g, aspartic acid -5.112g, glutamic acid -7.874g, glycine -1.880g, proline 2.379g, serine -2.357g), water -8.54g, vitamin A equiv -1µg (0%), vitamin B_6 -0.377mg (29%), vitamin B_{12} 0µg, choline -115.9mg (24%), vitamin C -6.0mg (7%), vitamin K -47µg (45%), calcium -277mg (28%), iron -15.70mg (121%), magnesium -280mg (79%), phosphorus -704mg (101%), potassium -1797mg (38%), sodium -2mg (0%), and zinc -4.89mg (51%). It balances the amino acid deficiencies of grains like corn and wheat which are low in important amino acids, lysine and tryptophan and is used weight-loss drinks, sport drinks, as low-fat substitute in hamburger, in commercial bakery industry to aid in dough conditioning and bleaching, as it possesses excellent moisture-holding qualities that helps to retard staling in bakery products. A 60-pound bushel (27.24kg) of soybeans yields about 11pounds (5kg) of oil and about 48pounds (21.79kg) of meal (Gibson and Benson, 2005).

The United Soybean Board (USB) of America pronounced it a versatile crop with many applications such as adhesives, coatings and printing inks, lubricants, plastics, biodiesel and specialty products. New soy-based products are quickly gaining popularity as many benefits of soybeans are updated and alternative industrial products have seen heightened demand as manufacturers are replacing petrochemicals with the renewable product (soy plastics and foams,

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soy methyl esters and soy ink). Approximately 85% of the world's soybean seeds are processed into soybean meal and vegetable oil (Gibson and Benson, 2005). Early uses in Asia was the processing of seeds into variety of fresh, fermented and dried food products while the U.S. used it as forage. Presently, the oil extracted from the seeds is made into shortening, margarine, cooking oil, and salad dressings. Soy oil is also used in industrial paints, vanishes, caulking compounds, linoleum, printing inks, and other products. Recently development efforts have resulted in several soy oil-based lubricant and fuel products that replace non-renewable petroleum products. Lecithin from soy oil is a natural emulsifier and lubricant used in many foods, commercial, and industrial applications. As an emulsifier, it can make fats and water compatible with each other, e.g. it helps keep the chocolate and cocoa butter in a candy bar from separating. It is also used in pharmaceuticals and protective coatings.

Soybean production is deterred in the tropics primarily because of biological constraints on the crop and the lack of markets - cultivation and utilization practices were not adequately known (Singh *et al*., 1987). In North America yields were poor until soil containing compatible Rhizobia was introduced from Japan (Allen and Allen, 1981). The largest world producers in 2008 were, the USA 80.5 million metric tonnes, Brazil 59:9, Argentina 46.2, China 15.5, and India 9.0, representing more than 90% of global soybean production, others include Paraguay 6.8, Canada 3.3, Bolivia 1.6, and European Union 0.6, to arrive at a world total of 230.9 million tonnes (Wikipedia, 2011). In the 2010-2011 production year the U.S. figure was expected to be over 90 million tonnes. Nigeria is the largest producer in Africa mainly in the southern Guinea savanna zone which comprises Benue, Kaduna, Oyo, Ondo, Adamawa, Taraba and Plateau with Benue as the highest (Smith *et al*., 1995, Olufajo and Adu, 1992, Roots *et al*., 1987). Abakaliki has no history of soybean cultivation (Okonkwo and Nnoke, 1993), as there are no suitable varieties bred and adapted to the humid climate of the southeast agro-ecological zone.

Inoculation of seeds with suitable micro-symbionts is one of the most successful agronomic practices in legume husbandry which is relatively inexpensive (Hardarson and Atkins, 2003), but the formulation, production, and delivery of viable inoculants for a particular crop at the time of sowing is exacting (Stephens and Rask, 2000). It is reported that if "promiscuous nodulating" soybeans are inoculated, yields are sometimes increased, at least in the first season, indicating that the initial inoculation with indigenous bacteria was poor in comparison to the plant's capacity for nodulation (Ranga Rao *et al.*, 1985). It is possible that over a few seasons the population of compatible bacteria may increase in response to the presence of the host, at least where soil conditions are favourable. Obviously, it should be recognized that soybean is far more selective than other legumes such as cowpea in its requirements for Rhizobia such that success in soybean inoculation can only be possible when inoculants of selected strains are freely available. Singleton and Tavares (1986) found that a substantial rate of nodule occupancy by an inoculant strain could only be predicted if the indigenous population was less than 100 cells per gramme of soil. Weaver and Fredrick (1974) likewise concluded that a 1000-fold excess of inoculant cells over indigenous Rhizobia was needed for successful inoculum establishment. Wollum and Cassel (1984) reported that Rhizobia population could range from 10^2 to 10^7 cells g^{-1} soil within a single field but can be as low as $<10^2$ to 10^7 cells g^{-1} soil (Bottomley, 1992). But given the lack of inputs commonly

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experienced by smallholder farmers in the tropical African agriculture, even inputs as inexpensive as rhizobial inoculums may not be easily affordable, therefore the legume species which fix N_2 and grow well without the need for inoculation are the best solution for the immediate future (Giller and Wilson, 1991).

Inoculation reduces soybean nitrogen requirement, which is one kilogram of nitrogen for every eleven kilogram of seed produced (Dobereiner, 1977), and one ton of soybean seed removes 60kg of N by the plant, or about 270kg N for a three-ton seed crop, but where inoculation is poor N fertilizers should be applied at the same rate as maize (Smith, 2006). Nitrogen deficiency results in reduced chlorophyll development (leaf colour becomes pale-green), the growth and the yield of the plants. It was found that to produce a ton of soybean grains, the following elements will be required: 65kg N, 11kg P_20_5, 20kg K_20, 4kg Mg0, 4kg Ca0, 2kg S, 110kg Fe, 33kg Mn, 43kg Zn, 16kg Cu; 16kg B, 6kg Mo (Bataglia and Mascarenhas, 1978).

There is a growing concern now all over the continent of Africa over the decline in the productive capacity of its soil resources due to dwindling soil fertility with continuous cultivation and with the withdrawal of subsidies on chemical fertilizers and its consequent high cost. Indeed, agricultural productivity has actually declined over the past 45 years in many African countries which has been blamed on persistent soil degradation (Bluffstone and Köhlin, 2011) and soil fertility depletion which Sanchez observed is the fundamental cause of low per capita food production among smallholder farmers in Africa who remove huge amounts of nutrients from the soil with harvests without returning any at the rate of 22 kg N, 2.5 kg P and 15 kg K per hectare over the past 30 years in 37 African countries (Anon, 2003). An average of 23 kg ha^{-1} is consumed in Nigeria (Mustapha, 1992) which is below the 1992 world average of 86kg ha^{-1}. In global agriculture, soil fertility is maintained through inorganic fertilizer application, but it costs two to six times more in Africa than anywhere else in the world at the farm gate (Sanchez, 2001, Spore, 2010). Incidentally, the tropical soils in Africa do not respond well to some of the temperate farming practices like heavy use of fertilizers, herbicides and pesticides (Houngnandan *et al.*, 2000). Against these backdrops, the objective of this experiment was therefore, to determine the growth and yield responses of six soybean varieties to some soil fertility management practices in Abakaliki, Southeastern Nigeria, reported to have no history of soybean cultivation.

METHODS

Site description

The experiment was carried out on the research farm of Faculty of Agriculture and Natural Resources Management, Ebonyi State University, Abakaliki, Southeastern Nigeria, lying on latitude 06^0 19´ 407´´ N and longitude 08^o 7´ 831´´ E at an altitude of about 447 m above sea level with a mean annual rainfall of about 1700 mm to 2060 mm spread between April and October. The maximum mean daily temperature is between 27^o C to 31^o C with abundant sunshine and a high humidity all through the year. The soil is shallow with unconsolidated parent materials (shale residuum) within 1m of the soil surface, described as *Eutric Leptosol* (Anikwe *et al.*, 1999). Soil

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samples from the experimental plot were collected and analyzed before planting and after harvesting in 2008 and 2009 planting years.

Land preparation and plot maintenance

Clearing and raised-bed making were manually carried out. Clearing was essentially slashing of new weed flushes resulting from the usual annual uncontrolled bush fire to which the research plots were often subjected to. Lime, wood ash and poultry manure were applied to the designated plots resulting from numbered paper card randomization technique, at the time beds were made. Two weeks were allowed for poultry manure, lime and wood ash to react with the soil after one or two rains have fallen before seeds were sown. Two seeds were sown after mild loosening of the soil surface with a hand fork for seeds to germinate and emerge without obstruction at plant spacing of 30 cm x 15 cm (inter- and intra- rows respectively) sown at a depth of about 2-3cm. Weeds were manually removed as the need arose in each year, 2-3 times and earthen of the plants to prevent lodging and the pods from touching the ground were carried out on the plots.

Design and treatment application

The experiment was a 6 x 8 factorial arranged in a randomized complete block design (RCBD) in four replications. Factor A was six soybean varieties (three early maturing varieties- TGx 1876-4E, TGx 1485-ID, TGx 1903-7F) and three medium maturing varieties- TGx 1908-8F, TGx 1904-6F, TGx 1844-4E), while factor B was eight soil fertility management options (lime ($CaCO_3$) at 10 tons ha^{-1}, wood ash at 10 tons ha^{-1}, poultry manure at 20 tons ha^{-1}, single super phosphate (SSP) at 40 kg ha^{-1}, urea (N) at 20 kg ha^{-1}, NPK (15:15:15) at 40 kg ha^{-1}, muriate of potash (MOP) at 30 kg ha^{-1} and a control**)**. The fertilizers and the lime were sourced from Ebonyi State fertilizer blending plant, Onuebonyi, Izzi Local Government Area. Wood ash was collected from a bread bakery, Nora Foods Industries (Enugu-Ngwo) Enugu State. Poultry manure was obtained from the Department of Animal Science, Ebonyi State University, Abakaliki, Ebonyi State. Soybean varieties from the promiscuous series (form nodules naturally without inoculation) bred by the International Institute of Tropical Agriculture (IITA), Ibadan. 48 treatment combinations were planted out in 192 plots of 1m x 1m size separated from one another by 0.5m, while each block (replicate) was separated by 1m pathways. Each plot contains three rows of six plant stands or 18 plant stands per plot out of which four innermost plants from the innermost row of the plots consisted the observational unit from which the following growth and yield parameters were measured: percentage emergence at 6 days after planting (DAP), number of branches per plant at harvest, number of leaves per plant at flowering, leaf area (cm^2) per plant at flowering, plant height (cm) at harvest from ground level to the apex, girth size (cm) measured with a caliper, number of nodules per plant, number of pods per plant at harvest, weight of pods (g) per plant and per hectare (tons/ha), number of seeds per plant after shelling, weight of seeds (g) per plant, 1000 seed weight (g).

Statistical analysis

All data collected in each year were subjected to analysis of variance (ANOVA) separately and thereafter combined using a statistical tool, the GenStat Release 7.22 DE (Copyright 2008).

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Treatment means were separated using Fisher's least significant difference (F-LSD = LSD) as described by Obi (1986) to identify significant treatment effects in the experiment.

RESULTS AND DISCUSSION

Soil physical and chemical properties of the experimental area

The pH values (Table 1) before planting was 5.50 (2008), while it rose to 5.55 and 5.85 in 2008 and 2009 respectively after harvesting, confirming the description of this area as acidic by Enwezor *et al*. (1989). High available phosphorus (P) was observed in the area before planting (20.00 mg Kg^{-1} in 2008 and after harvesting (22.11 mg Kg^{-1} in 2008 and 24.57 mg Kg^{-1} in 2009) which showed that the application of limes and phosphorus improved their availability (Lickacz, 2002, Sarrantonio, 1991, Duong and Diep, 1986). This level of available P before planting may have led to the non significant response of soybean varieties to P. Elliot *et al.* (2009) reported that P tends to move down hill across the field and is less likely to leach vertically into the ground water. The percentage total N and the exchangeable K were low which led to the significant result obtained in the treatments.

Summarized pattern of varietal growth and yield responses

Table 2 indicates there were significant differences ($p<0.05$) in the growth and yield responses of the six varieties of soybean in 2008, 2009 and in years combined, but the varieties performed better in 2009 and in the years combined than in 2008. In other growth and yield parameters, the varieties varied significantly ($p=0.05$) in their responses across the years and showed no significance in number of pods/plant, weight of pods/plant and number of seeds/plant in 2008/2009 combined. Varieties TGx 1904-6F (119.2) and TGx 1876-4E (100.0) responded better in number of seeds in 2008, TGx 1903-7F (238.7), TGx 1844-4E (205.1) and TGx 1485-1D (198.8) did better in 2009, while TGx 1903-7F (160.5), TGx 1485-1D (145.8) and TGx 1904-6F (145.4) did better in years combined. TGx 1876-4E had the largest girth size (0.92 cm) in 2008, whereas in 2009, TGx 1876-4E, TGx 1903-7F, TGx 1904-6F and TGx 1908-8F had the largest girth sizes (1.03, 1.00, 1.02 and 1.33 cm), but only TGx 1908-8F attained the girth size of 1.05 cm in the mean of the two years as influenced by the management options. The soybean varieties in this experiment can be termed short plants in comparison with the varieties used by Ndaeyo *et al.* (2000) who reported a plant height of up to 72.4cm in the first year of his experiment 30 days after sowing. The three medium maturing varieties were not as tall as the early maturing ones in both years with a few exceptions where up to 30cm or more were obtained. The short plants observed in the experiment caused loss of majority of the pods and seeds which were lying on the ground when the pod-bearing stalks became heavy with pods. Taller plants may be preferred in areas that have water collection on the soil surface for any length of time after it rains to avoid seed decay by prolonged moisture collection. The differences in the percentage emergence among the varieties were insignificant yet, TGx 1908-8F, TGx 1876-4E and TGx 1485-1D stood out among others. However, seedling emergence can be affected by a number of factors such as physical obstruction by gravels and hard soil clods, inadequate moisture in the soil and depth of sowing, 2-3cm have been suggested by

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other researchers (Smith, 2006) but experience can guide better in the choice of depths and types of cultural attention to be given where the rule of thumb may not avail.

The varieties varied in their pod number, weight of pods, number of seeds and weight of seeds per plant. TGx 1903-7F had the highest pod weight (47.5g in 2009 and 31.28g in 2008/2009 combined), number of seeds (238.7 in 2009 and 160.5 in 2008/2009 combined) and seed weight (26.81g in 2009 and 18.10 g in 2008/2009 combined) whereas TGx 1485-1D had the highest number of pods (119.2 in 2008/2009 combined) but failed to be the highest in the first and second years. The significant improvement on yield response of soybean [number of pods, weight of pods (g), number of seeds and weight of seeds (g) to these treatments, makes soybean the crop for the future to bail man from malnutrition, hunger and starvation. Although, legumes are known for their ability to fix nitrogen from the air, yet experience has shown that in a degraded soil (inhospitable soil for plants to grow), applying a 'starter dose' of nitrogen can kick-start the legume´s establishment and growth before the benefits from nitrogen fixation can be realized (Giller, 2003). There were marked differences in the performances of the varieties on the number of seeds in the two years, 2008 and 2009 plantings, showing that second year was better than the first. This may not be unconnected with the prevalent weather conditions, although there were no weather records in Ebonyi State University to justify this option. Else, a more plausible reason may be the residual effect of soybean from the previous planting as expected (Leinonen, 1996). Giller (2003) stated that legumes are capable of improving soil fertility through their ability to fix nitrogen from the air making use of Rhizobia bacteria in their root nodules as the area is unknown as a soybean growing zone.Soybean is more acceptable to most smallholder farmers not only because of its agronomic usefulness in fixing atmospheric nitrogen in its root nodules, but for its superb quality as a rich source of high quality food protein (Giller, 2003), and as demographic factors cause dwindling of labour force and shrinking farm size, the resource-constrained smallholder farmers are forced to prefer legumes that would attract the highest economic returns: relevant as food, fibre, fodder and fertilizer to justify their labour, lean resources and time input beyond simply improving soil fertility (Misiko, 2007). This is obvious and agrees with the observation of Giller (2003) when he reported that using legumes to rehabilitate degraded soils as an 'off-the-shelf' method with universal acceptability does not work. He maintained that despite more than a century of research on green manures in the tropics, examples of smallholder farmers using such methods to regenerate their soils are remarkably rare, but extensive reviews of past experiences indicate that rapid uptake by farmers occurs only when green manures have other advantages, beyond simply improving soil fertility.

Growth and yield varietal responses to soil fertility management practices

The number of pods per plant of the soybean varieties was not improved significantly ($P<0.05$) by the interaction effect of variety x soil fertility management options in 2008 and in the mean of 2008 and 2009, but was highly improved in 2009 especially under poultry manure (149.3) with the highest from TGx1903-7F (190.2), TGx 1904-6F (159.3), TGx 1844-4E (153.0), TGx 1876-4E (137.8), TGx 1485-1D (134.2) and TGx 1908-8F (121.5) followed by wood ash (121.3) and urea fertilizer (106.1) (Table 5). This better performance in the second year than in the first may be attributed to the residual effect of the previous planting of the legume as previously observed

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in this report, that after a previous legume planting the soil could be made beneficial for subsequent crops especially a non legume crop (ICRISAT/MAI, 2000, Williams *et al*., 1980). Nitrogen level in the soil was found to increase by about 500kg in 2.5 years under *Centrosema pubescens* cover in association with star grass in Nigeria (Williams *et al*., 1980) while Ludwig (1989) found soybean as a benchmark legume for nitrogen fixation second only to stem-forming nodule legumes and as such can boost soil fertility for good pod yield in the second year. The building up of a solid fertilizing scheme for soybean, not only improves its growth and yield, but also means building a solid soil fertility system for other non-legume crops like maize, which would benefit from crop rotation that includes atmospheric nitrogen fixing legume. Abundant, sustainable quality cheap food protein production system which results from soybean cultivation will guarantee food security and rural transformation in Africa. By this the rural environment can be revitalized and life made better for the inhabitants as green environment is guaranteed. Managing soybean growth and yield significantly in this zone through the application of soil fertility treatments in this research, we recommend that the use of poultry manure and wood ash be intensified as effective and veritable tools for producing soybean to adequately deal with soil degradation, fertility loss and low crop yield.

Table1: Some Soil Physical and Chemical properties of the experimental area before planting and after harvesting

	2008		2009	
Chemical analysis	Before	After	Before	After
pH (H_2O)	5.50	5.55	5.50	5.85
% Total N	0.14	0.18	0.15	0.20
Available P $mgKg^{-1}$	20.00	22.11	19.00	24.57
% Organic carbon	1.64	1.01	1.29	1.12
% Organic matter	2.83	1.74	2.22	1.93
Exchangeable cations ($cmol\text{-}kg^{-1}$)				
Calcium (Ca)	3.00	2.75	2.60	2.36
Magnesium (Mg)	1.60	1.65	1.70	1.72
Potassium (K)	0.13	0.15	0.16	0.18
Sodium (Na)	0.21	0.20	0.20	0.20
Soil particle analysis (%)				
Sand	64.50	63.50	65.00	64.60
Clay	25.00	25.00	26.00	25.50
Silt	11.00	11.02	11.01	11.04
Texture	Sandy loam	sandy loam	sandy loam	sandy loam

Analytical laboratory of the National Root Crops Research Institute (NRCRI), Umudike with soil samples collected at 15cm and 30cm depths (bulked) and air dried before the analysis.

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Table 2: The mean varietal growth and yield response of six promiscuous soybean varieties in Abakaliki

Variety	No. of branches	% emergence	Girth size cm	plant Ht(cm)	no of nodules	no of pods	wt of pods	wt of seeds	no of seed/plt
2008									
TGx1876-4E	1.88	45.4	0.92	32.66	12.22	48.2	17.71	11.38	100.0
TGx1903-7F	2.28	36.5	0.76	26.41	9.72	41.0	15.10	9.39	82.3
TGx1485-1D	2.47	44.1	0.69	25.44	12.59	44.0	16.52	10.08	88.3
TGx1844-4E	1.63	37.1	0.66	23.03	9.75	40.4	14.89	10.31	82.1
TGx1904-6F	2.03	36.7	0.86	27.38	12.03	59.0	20.61	13.50	119.2
TGx1908-8F	1.19	64.1	0.77	24.38	12.91	47.8	21.46	11.05	94.2
F-LSD(P=0.05)	0.27	13.7	0.07	1.91	2.02	18.13	4.95	4.40	16.14
2009									
TGx1876-4E	2.47	53.05	1.03	41.39	12.72	101.6	29.0	23.04	183.9
TGx1903-7F	2.34	46.42	1.00	37.23	12.25	122.7	47.5	26.81	238.7
TGx1485-1D	2.38	48.75	0.98	36.33	12.81	107.8	31.9	23.18	198.8
TGx1844-4E	2.16	44.87	0.95	33.41	9.91	101.1	37.7	23.01	205.1
TGx1904-6F	1.75	29.52	1.02	28.73	7.22	87.1	26.6	19.36	163.2
TGx1908-8F	2.03	47.87	1.33	33.58	9.97	94.6	32.4	21.07	179.3
F-LSD(P=0.05)	0.21	4.12	0.46	1.53	1.30	10.97	9.54	2.55	24.2
2008 and 2009 Combined									
TGx1876-4E	2.17	57.2	0.97	37.02	12.47	74.9	23.37	17.21	144.9
TGx1903-7F	2.31	49.5	0.88	31.82	10.98	81.9	31.28	18.10	160.5
TGx1485-1D	2.42	46.4	0.84	30.88	12.70	119.2	24.23	16.64	145.8
TGx1844-4E	1.89	41.0	0.81	28.22	9.72	70.7	26.30	16.66	143.6
TGx1904-6F	1.89	33.1	0.94	28.05	9.39	73.1	23.60	16.43	145.4
TGx1908-8F	2.11	56.0	1.05	28.98	11.31	71.2	26.94	16.06	136.8
F-LSD(P=0.05)	0.23	15.2	0.22	1.48	1.43	ns	ns	1.93	ns

Key: Ht = height, Plt = plant, wt = weight, ns = non significance

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Table 3: Variety x soil fertility management options interaction on the girth size (cm) of soybean varieties.

	Treatment								
Variety	Wood ash	Control	Lime	MOP	NPK	PM	SSP	Urea	Mean
2008									
TGx1876-4E	1.08	0.70	1.03	0.75	0.95	1.38	0.70	0.80	0.92
TGx1903-7F	1.00	0.35	0.78	0.48	0.70	1.43	0.50	0.88	0.76
TGx1485-1D	0.93	0.68	0.85	0.33	0.50	1.28	0.48	0.48	0.69
TGx1844-4E	0.55	0.33	0.70	0.58	0.70	1.23	0.50	0.70	0.66
TGx1904-6F	0.98	0.60	0.95	0.45	0.80	1.23	0.70	0.70	0.86
TGx1908-8F	0.75	0.43	0.70	0.70	0.73	1.55	0.45	0.83	0.77
Mean	0.88	0.51	0.83	0.63	0.73	1.35	0.55	0.73	
2009									
TGx1876-4E	1.15	1.08	0.95	0.95	0.95	1.13	0.98	1.03	1.03
TGx1903-7F	1.13	0.78	0.95	0.88	0.90	1.28	1.13	0.95	1.00
TGx1485-1D	1.13	1.03	0.90	0.83	0.95	1.10	0.95	1.00	0.98
TGx1844-4E	0.85	0.88	0.83	1.00	1.13	1.13	0.83	1.00	0.95
TGx1904-6F	0.68	0.55	0.50	2.60	1.10	1.20	0.60	0.90	1.02
TGx1908-8F	3.83	1.08	0.93	0.95	0.88	1.33	0.78	0.90	1.33
Mean	1.46	0.90	0.84	1.20	0.98	1.19	0.88	0.96	
2008 and 2009 Combined									
TGx1876-4E	1.11	0.89	0.99	0.85	0.95	1.25	0.84	0.91	0.97
TGx1903-7F	1.06	0.56	0.86	0.68	0.80	1.35	0.81	0.91	0.88
TGx1485-1D	1.03	0.87	0.88	0.58	0.73	1.19	0.71	0.74	0.84
TGx1844-4E	0.70	0.60	0.76	0.79	0.91	1.18	0.66	0.85	0.81
TGx1904-6F	0.83	0.58	0.73	1.78	0.95	1.21	0.65	0.80	0.94
TGx1908-8F	2.29	0.75	0.81	0.83	0.80	1.44	0.61	0.86	0.05
Mean	1.17	0.71	0.84	0.92	0.86	1.27	0.72	0.85	

2008: F-LSD (P=0.05) =0.7 for comparing two varietal means
=0.8 for comparing two treatment means
=0.19 for comparing variety x treatment interaction means

2009: F-LSD (P=0.05) =0.46 for comparing two varietal means
=0.53 for comparing two treatment means
=1.29 for comparing variety x treatment interaction means

2008 and 2009 Combined: F-LSD (P=0.05) =0.22 for comparing two varietal means
=0.27 for comparing two treatment means
=0.65 for comparing variety x treatment interaction means

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Table 4: Variety x soil fertility management options interaction on the plant height (cm) of soybean varieties

Variety	Wood ash	Control	Lime	MOP	NPK(15:15:15)	Poultry manure	SSP	Urea	Mean
2008									
TGx1876-4E	38.50	26.75	35.50	27.50	32.25	46.25	25.25	29.25	32.66
TGx1903-7F	38.25	17.00	30.00	18.00	21.00	41.00	16.50	29.50	26.41
TGx1485-1D	32.75	22.50	27.25	16.00	20.25	46.00	17.25	21.50	25.44
TGx1844-4E	25.50	16.00	30.50	22.25	18.50	33.25	14.75	23.50	23.03
TGx1904-6F	31.50	21.00	28.00	29.00	28.00	32.00	20.75	28.75	27.38
TGx1908-8F	33.50	18.00	31.75	18.00	18.25	34.00	18.25	23.75	24.38
Mean	33.33	20.21	30.50	21.79	23.04	38.75	18.79	25.96	

F-LSD (P=0.05) =1.91 for comparing two variety means
=2.21 for comparing two fertilizer means
=5.40 for comparing variety x treatment interaction means

Variety	Wood ash	Control	Lime	MOP	NPK(15:15:15)	Poultry manure	SSP	Urea	Mean
2009									
TGx1876-4E	38.00	36.25	42.10	41.25	43.50	53.50	42.00	34.50	41.39
TGx1903-7F	36.88	32.38	37.25	41.00	35.00	41.88	36.25	37.25	37.23
TGx1485-1D	38.12	33.00	33.00	36.25	35.00	45.25	32.75	37.25	36.33
TGx1844-4E	31.75	31.25	31.50	35.25	34.12	35.25	31.75	36.38	30.41
TGx1904-6F	26.00	28.00	27.25	24.12	35.25	32.50	22.25	34.50	28.73
TGx1908-8F	37.00	36.25	37.75	29.50	31.88	34.25	30.25	31.75	33.58
Mean	34.62	32.85	34.81	34.56	35.79	40.44	32.54	35.27	

F-LSD (P=0.05) =1.53 for comparing two varietal means
=1.77 for comparing two treatment means
=4.33 for comparing variety x treatment interaction means

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2008 and 2009 Combined									
TGx1876-4E	38.25	31.50	38.80	34.38	37.88	49.88	33.62	31.88	37.02
TGx1903-7F	37.56	24.69	33.62	29.50	28.00	41.44	26.38	3.88	31.82
TGx1485-1D	35.44	27.75	30.13	26.12	27.62	45.62	25.00	29.38	30.88
TGx1844-4E	28.62	23.62	31.00	28.75	26.31	34.25	23.25	29.94	28.22
TGx1904-6F	28.75	24.50	27.62	26.56	31.62	32.25	21.50	31.62	28.05
TGx1908-8F	35.25	27.12	34.75	23.75	25.06	34.12	24.25	27.50	28.98
Mean	33.98	26.53	32.65	2818	29.42	39.59	25.67	30.61	

F-LSD (P=0.05) =1.48 for comparing two varietal means
=1.38 for comparing two treatment means
=4.90 for comparing variety x treatment interaction means

Table 5: Variety x soil fertility management options interaction on the weight of seed/ plant (g) of soybean variety.

2008									
Treatment									
Variety	Wood ash	Control	Lime	MOP	NPK(15:15:15)	Poultry manure	SSP	Urea	Mean
TGx1876-4E	10.62	9.75	15.06	9.44	11.25	15.56	7.69	11.69	11.38
TGx1903-7F	13.44	5.50	11.12	6.12	8.69	12.06	6.50	11.69	9.39
TGx1485-1D	15.12	7.19	13.62	5.00	10.00	12.62	8.50	8.56	10.08
TGx1844-4E	9.94	4.87	14.62	8.00	18.62	9.39	6.56	10.50	10.31
TGx1904-6F	13.04	7.81	12.75	13.31	16.94	18.94	9.31	15.87	13.50
TGx1908-8F	12.56	5.56	11.87	8.31	11.25	17.94	7.18	13.75	11.25
Mean	12.45	6.78	13.18	8.36	12.79	14.42	7.62	12.01	

F-LSD (P=0.05) =2.40 for comparing two variety means
=2.77 for comparing two fertilizer means
=6.80 for comparing variety x treatment interaction means

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2009									
TGx1876-4E	24.25	18.62	27.72	19.65	24.28	28.48	18.98	21.31	23.04
TGx1903-7F	33.80	20.02	18.95	27.07	22.62	43.25	21.98	26.77	26.81
TGx1485-1D	23.86	18.43	22.12	22.20	22.63	30.38	18.98	26.82	23.18
TGx1844-4E	19.07	18.62	18.88	21.25	24.93	35.25	22.95	23.10	23.01
TGx1904-6F	26.25	9.58	20.00	11.48	17.13	33.50	12.25	24.73	19.36
TGx1908-8F	27.40	19.72	26.57	11.47	21.20	26.75	12.25	23.20	21.07
Mean	25.77	17.67	22.38	18.85	22.13	32.93	17.90	24.32	
F-LSD (P=0.05) =2.55 for comparing two varietal means =2.94 for comparing two treatment means =7.20 for comparing variety x treatment interaction means									
2008 and 2009 Combined									
TGx1876-4E	17.44	14.69	21.39	14.54	17.76	22.02	13.33	16.50	17.21
TGx1903-7F	23.62	12.76	15.04	16.60	15.66	27.66	14.24	19.23	18.10
TGx1485-1D	19.58	12.81	17.88	13.60	16.31	21.50	13.34	17.69	16.64
TGx1844-4E	14.51	11.75	16.75	14.63	21.78	22.32	14.76	16.80	16.66
TGx1904-6F	19.64	8.69	16.38	12.39	17.03	26.22	10.78	20.30	16.43
TGx1908-8F	19.98	12.64	19.23	9.89	16.23	22.34	9.72	18.48	16.06
Mean	19.13	12.22	17.78	13.61	17.46	23.68	12.76	18.17	

F-LSD (P=0.05) =1.93 for comparing two varietal means
=2.00 for comparing two treatment means
=4.94 for comparing variety x treatment interaction means

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Table 6: Variety x fertility management options interaction on the number of seeds/plant of soybean variety

2008

Treatment

Variety	Wood ash	Control	Lime	MOP	NPK(15:15:15)	Poultry manure	SSP	Urea	Mean
TGx1876-4E	92.0	86.2	133.1	83.4	99.4	136.0	67.4	102.8	100.0
TGx1903-7F	118.4	47.5	97.8	53.7	76.4	105.9	56.2	102.4	82.3
TGx1485-1D	131.8	62.6	119.9	43.6	86.9	110.6	74.0	76.9	88.3
TGx1844-4E	86.9	42.8	132.1	70.1	67.1	108.5	57.6	91.9	82.1
TGx1904-6F	117.6	68.8	112.2	117.7	147.9	168.0	82.7	138.8	119.2
TGx1908-8F	109.8	48.3	185.5	72.9	89.2	156.2	63.1	119.9	94.2
Mean	109.4	59.3	113.4	73.6	96.0	130.9	66.8	105.4	

F-LSD (P=0.05) =16.14 for comparing two variety means
=18.64 for comparing two fertilizer means
=45.66 for comparing variety x treatment interaction means

2009

Variety	Wood ash	Control	Lime	MOP	NPK(15:15:15)	Poultry manure	SSP	Urea	Mean
TGx1876-4E	202.3	131	236.7	158.5	102.1	246.0	153.9	159.8	183.9
TGx1903-7F	307.8	176.2	1167.0	240.9	204.6	179.8	195.5	238.1	238.7
TGx1485-1D	207.2	135.7	192.9	196.4	204.6	261.4	153.9	238.1	198.8
TGx1844-4E	170.8	150.1	165.8	189.8	250.6	309.0	202.0	202.8	205.1
TGx1904-6F	227.5	84.0	179.2	89.3	138.0	291.2	95.4	200.7	163.2
TGx1908-8F	201.4	178.6	233.6	89.3	186.8	245.0	95.9	203.7	179.3
Mean	219.5	142.7	195.8	160.7	194.5	288.7	149.4	207.2	

F-LSD (P=0.05) =24.29 for comparing two varietal means
=28.04 for comparing two treatment means
=68.69 for comparing variety x treatment interaction means

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2008 and 2009 Combined

TGx1876-4E	147.1	108.9	184.9	120.9	140.7	191.0	110.6	131.3	141.9
TGx1903-7F	213.1	111.9	132.3	147.3	140.5	242.8	125.9	170.2	160.5
TGx1485-1D	169.5	99.1	156.4	120.0	145.7	204.2	114.0	157.5	145.8
TGx1844-4E	128.8	96.4	148.9	129.9	158.9	208.7	129.8	147.3	143.6
TGx1904-6F	172.6	78.2	127.6	103.5	142.9	229.6	139.0	169.7	145.4
TGx1908-8F	155.6	113.5	159.5	81.1	142.5	200.6	79.5	161.8	136.8
Mean	164.5	101.3	151.6	117.1	145.2	212.8	116.5	156.3	

F-LSD (P=0.05) =17.09 for comparing two varietal means
=18.49 for comparing two treatment means
=45.44 for comparing variety x treatment interaction means

Table 7: Variety x fertility management options interaction on the number of pods/plant of soybean varieties.

2008

Treatment

Variety	Wood ash	Control	Lime	MOP	NPK(15:15:15)	Poultry manure	SSP	Urea	Mean
TGx1876-4E	45.7	42.8	66.1	41.3	49.4	56.1	33.4	51.1	48.2
TGx1903-7F	59.5	23.8	48.6	26.4	37.7	52.8	27.9	51.1	41.0
TGx1485-1D	65.8	30.9	59.4	21.8	43.2	55.3	37.2	38.2	44.0
TGx1844-4E	43.1	21.1	63.1	34.6	33.2	53.7	28.5	45.4	40.4
TGx1904-6F	57.9	24.0	55.6	58.7	73.2	83.1	40.9	68.7	59.0
TGx1908-8F	54.6	24.3	52.1	33.6	48.9	77.8	31.2	59.9	47.8
Mean	54.4	29.5	57.5	36.1	47.6	63.1	33.2	52.4	

F-LSD (P=0.05) =8.13 for comparing two variety means
=9.39 for comparing two fertilizer means
=23.01 for comparing variety x treatment interaction means

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2009									
TGx1876-4E	115.5	93.5	121.0	89.5	93.8	137.8	79.3	82.3	101.6
TGx1903-7F	161.0	97.6	83.2	126.0	107.0	190.2	102.3	124.5	122.7
TGx1485-1D	117.5	93.8	101.5	104.3	107.8	134.2	79.3	124.5	107.8
TGx1844-4E	84.9	77.3	82.8	94.3	115.5	153.0	100.5	100.9	101.1
TGx1904-6F	118.0	44.7	98.3	49.6	71.0	159.3	53.0	103.3	87.7
TGx1908-8F	130.8	93.8	113.3	49.8	93.0	121.5	53.0	101.5	94.6
Mean	121.3	81.8	100.0	85.6	98.0	149.3	77.9	106.1	

F-LSD (P=0.05) =10.97 for comparing two varietal means
=12.67 for comparing two treatment means
=31.03 for comparing variety x treatment interaction means

2008 and 2009 Combined									
TGx1876-4E	80.6	68.2	93.6	65.4	71.6	96.9	56.3	66.7	74.9
TGx1903-7F	110.2	55.7	65.9	76.2	72.3	121.5	65.1	87.8	81.9
TGx1485-1D	91.7	62.3	80.4	63.0	75.5	94.8	58.2	77.9	75.5
TGx1844-4E	64.0	49.2	72.9	64.4	74.4	103.3	64.5	73.2	70.7
TGx1904-6F	88.0	39.3	76.9	54.2	72.1	121.2	47.0	86.0	73.1
TGx1908-8F	92.7	59.0	82.7	41.7	70.9	99.7	42.1	80.7	71.2
Mean	87.9	55.6	78.7	60.8	72.8	106.2	55.5	78.7	

F-LSD (P=0.05) =51.25 for comparing two varietal means
=57.61 for comparing two treatment means
=140.88 for comparing variety x treatment interaction means

ISSN: ISSN 2054-6319 (Print), ISSN 2054-6327(online)

REFERENCES

Adamu, H., 1992. An address In: Proceedings of 2nd National Fertilizer Workshop held at Abuja, 1992, 1-2pp.

Alves, J.R., Boddey, R.M., Urquiaga, S., 2003. The success of BNF in soybean in Brazil, Plant and Soil 249:237-245.

Alhassan, W.S., 1993. Chairman's address In: Ahenkorah, Y., Owusu-Bennoah, E., Dowuona, G.N.N. (eds.), Sustaining soil productivity in intensive African agriculture, being seminar proceedings held at Accra, Ghana, 15-19 November 1993.

Anikwe, M.A.N., Okonkwo, C.I., Aniekwe, N.L., 1999. The effects of changing land use on selected soil propertices in the Abakaliki agro ecological Zone, Southeastern Nigerian, Environmental Education and Information 18, 79-84.

Anonymous, 2003. Soil Fertility: Are you still beating your Mother Earth? Spore Magazine, CTA, Netherlands. No. 105; pp4-5

Anonymous, 2004. Farmers in the Frontline. Spore, no. 113, CTA, Netherlands, pp1-2

Anonymous, 1989. Alternative Agriculture. National academy Press, Washington D.C.

Bluffstone, A. R. and Köhlin, G. (eds), 2011. Agricultural Investment and Productivity building Sustainability in East Africa. Earthscan, DunstanHoues, London, UK, 192pp

Broughton, W.J. (ed.) 1981. Nitrogen Fixation. Clarendon Press, Oxford

Cleveland, C.C., Townsend, A.R., Schimel, D.S., Fisher, H., Howarth, R.W., Hedein, L.O., Perakis, S.S., Latly, E.F., Von Fischer, J.C., Elserond, A., and Watson, M.F.1999. Global patterns of terrestrial biological nitrogen (N_2) fixation in natural ecosystems, Global Biogeochem. Cycles 13:623-645.

Dresrusse, G. 1996. Meeting world food demand in the 21st century: challenges and new focuses. Special paper, CTA Annual Report 10 pp

Duong, T.P. and Diep, C.N.1986.An inexpensive cultural system using ash for cultivation of soybean (*Glycine max* (L) Merrill) on acid clay soils, Plant and Soil, 96:225-237

Elliott, A. L., J. G. Davis, R. M. Waskom, J. R. Self and D. K. Christenson 2009. Phosphorus Fertilizers for Organic Farming Systems, www.ext.colostate.edu/pubs/crops/00569.html

ENDA, 1977. Is chemical fertilizer the only answer? African Environment. Vol. II, 4 and III, 1, November, pp 281-285.

Enwezor, W. O., Udo, E. J., Usoroh, N. J., Ayotade, K. A., Adepetu, J., Chude, V. O., and Udegbe, C.I., 1989. Fertilizer use and management practices for crops in Nigeria series no. 2 by FPDD, FMA, Bobma Publishers, Ibadan, Nigeria

FIAN, 2010. "Land Grabbing in Kenya and Mozambique" FIAN International Secretariat, Germany http://tinyurl.com/2w3phct. Accessed on 17/09/2010

Giller, K.E. 2003. Kick- starting legumes LEISA magazine Vol. 19, no. 4, pp19-20

Glen, J. J. and Tipper, R, 2001. A mathematical programming model for improvement planning in a semi-subsistence farm agricultural system, 70 (1): 295-317

Houngnandan , P., Manyong, V.M., Sanginga N., Diels, J., Vanlauwe, B. and Van Cleemput, O. 2000a. Farm-level use of soil amendments and definition of typologies: Implication for the

ISSN: ISSN 2054-6319 (Print), ISSN 2054-6327(online)

design of balance nutrient, Management systems in the derived savanna zone, Benin IITA, Annual Report, 2000.

Hymowitz, T. and Newell, C.A., 1981. Taxonomy of the genus *Glycine* domestication and uses of soybeans, Economic botany, 35, 272-288

ICRISAT/MAI, 2000. Cost-effective soil fertility management options for smallholder farmers in Malawi, ICRISAT and Ministry of Agriculture and Irrigation (MAI), Lilongwe, Malawi, 24

IFA, 2006. Fertilizers vital for protecting fragile soil soils from erosion and desertification. Farming outlook. March issue. Vol.5, no.1 pp30-31

IFPRI, 1995. A 2020 Vision for Food, Agriculture and Environment, International Food Policy Research Institute, Washington, D.C. 50pp

Jiggins, J. 2008. Sustainable Agriculture in the news: International study stresses role of farmers. LEISA Magazine vol. 24 no.2 June issue p36

Kang, B.T., Wilson, G.F. and Lawson, T.L. 1984. Alley cropping: A sustainable alternative to shfting cultivation. IITA. Ibadan, Nigeria 22pp.

Kang, B.T. and Reynolds, L. 1986. Alley farming in the humid and sub-humid tropics-IITA/ ILCA, Ibadan, Nigeria, 41 pp

Khaliq, T., Mahmood, T., Kamal, J. and Masood, A., 2004. Effectiveness of farmyard manure, poultry manure and nitrogen for corn (*Zea mays* L) productivity, International Journal of Agriculture and Biology, vol. 6, no. 2, pp 260-263

Knapp, B.J. 1979. Soil Processes. George Allen & Unwin Ltd, London, 72pp.

Kotschi, .J. and Adelhelm, R. 1986. Development and introduction of self- sustaining Agricultural practice in tropical smallholder farms In: Vogtmano, H.j Boehcke, E.and Fricke, I (eds). The importance of Biological Agriculture in a world of Diminishing Resources. Proceedings of the 15th IFOAM international scientific conference, University of Kssel. Pp 211-221.

Krantz, B.A., Kampen, J. and Russell, M.B. 1978, Soil Management differences of Alfisols and Vertisols in the Semi-arid Tropics In: Nicholaides, J.J. and Swindale, L.D. (eds.) Diversity of soils in the tropics, American society of Agronomy special publication no. 34 pp77-95.

Ledgard, S.J. and Giller, K.E. 1995. Atmospheric N_2 fixation as an alternative nitrogen source In: Bacon, P. (ed.) Nitrogen fertilization and the environment. Marcel Dekker, New York, pp443-486.

Leinonen, P. 1996. Influence of host plant cultivation and management on indigenous Rhizobium population in soil In: New research in organic agriculture, Kristensen, N. H. and Hogh-Jensen, H. (eds.) being 11th International Science IFOAM Conference 11-15 August 1996. Copenhagen. Proceedings Vol. 2, pp47-51

LEISA, 2006. Understanding Sustainable Agriculture, LEISA Magazine Special Issue, 4-5pp

Lickacz, J., 2002. Wood Ash: An Alternative Liming Material for Agricultural Soils, www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex3435

Ludwig, R. A. 1989. Synopsis In: *Sesbania rostrata*, ACTES-Proceedings International Congress Dakar, Senegal, pp13-15.

Magen, H. 2007. Use of Balanced Fertilizers: Highlights of International Symposium, Farming Outlook, vol. 6, no.1 March Issue 3-15pp.

Meelu, O.P.1989. Green Manuring *Sesbania* in different cropping systems In: *Sesbania rostrata* ACTES-proceedings, International Congress, Dakar, Senegal pp 161-163.

ISSN: ISSN 2054-6319 (Print), ISSN 2054-6327(online)

Miiko, M. 2007. The Use of Research Technologies and Concepts to Improve Soil Fertility, but their application is generally bolstered when they fulfill indirect benefits among the resources deprived small-holder farmers.

Muller-Samann , K.M. and Kotschi, J. 1997. Sustaining Growth: Soil fertility management in tropical small-holdings Margraf Verlag, Germany 486pp.

Munson, R.D. and Runge, C.F. 1990. Improving fertilizer and chemical efficiency through "high precision farming," Centre for International food and agricultural policy, University of Minnesota.

Mustapha, S. 1992. A keynote Address In: Proceedings of 2nd National Fertilizer Workshop held at Abuja, 1992, 3-5pp.

NAFCON, 1990. Field Notes, June 1990. National Fertilizer Company of Nigeria, Port Harcourt, p17

NAFCON, 1991. Field Notes, August 1991, National Fertilizer Company of Nigeria, Port Harcourt, p3

Ndaeyo, N., Oguzor, N.S., Utuk, E.S. and Dan, S.O. 2000. Growth and yield of soybean (*Glycine max* (L) Merr.) as influenced by combined application of cowdung and NPK fertilizer in Ogoja, Southeastern Nigeria, Tropicultura, 18, 2, 49-54

Obi, I. U. 1986. Statistical methods of detecting differences between treatment means, SNAAP Press, Enugu, Nigeria, VI + 45 pp

Okon, Y. 1982. *Azospirillum*: Physical properties, mode of association with roots and its application for the benefit of cereal and forage grass crops. Israel Journal of Botany 31:214-220.

Okonkwo, C.I. and Nnoke, F.N., 1993. Comparison of effects of various strains of locally isolated rhizobium spp. and N-fertilizer on nodulation, nitrogen accumulation and seed yield of soybean (*Glycine max*) Journal of Science and Technology, vol. 1 no. 1, 75-79

Place, F., Barrett, C.B., Freeman, H.A., Rannisch, J.J. and Vanlauwe, B. 2003. Prospects for integrated soil fertility management using organic and inorganic inputs: Evidence from smallholder African agricultural systems. Food Policy, 28:365-378

Rinaudo, G., B. Dreyfus and Y.R.Dommergues, 1983. *Sesbania rostrata* green manure and the nitrogen content of rice crop and soil. Soil Biology and Biochemistry 15:111-113

Sanchez, P.A.1987. Management of acid Soils in the humid tropics of Latin America In: Management of acid tropical soils for sustainable Agriculture (ed.) P.A. Sanchez, E. Stoner and E. Pushparajah, Proceedings of the Conference of the International Board for Soil Research and management held in Bangkok, Thailand 63-107pp

Sanchez, P.A., Palm, C.A. and Smyth, J.J., 1990. Approaches to mitigating tropical deforestation by sustainable soil management practices in soils on a warmer Earth, edited by H.W. Scharpenseel, M. Shomarker and A. Ayoub, Amsterdam, Elsevier, pp 211-220

Sanchez, P.A. 2001. Turning up the heat: How will agriculture weather global climate change? In: IFPRI, Sustainable food security for all by 2020, Proceedings of an International Conference,September 4-6, 2001, Bonn, Germany, pp116-117.

Sarrantonio, M., 1991. Methodologies for Screening soil-improving legumes. Rodale Institute Research Centre, Kutztown,USA. 310pp

ISSN: ISSN 2054-6319 (Print), ISSN 2054-6327(online)

Singleton, P., Somasegaran, P. Nakao, P. Keyser, H., Hobean, H., and Ferguson, P., 1990. Applied BNF Technology: A Practical Guide for Extension Specialists. Niftal, Paia, Hawaii.

Singh, S.R., Rachie, K.O. and Dashiell, K.E. (eds.) 1987. Soybeans for the tropics: research, production and utilization. John Wiley and Sons Ltd. Chichester, 230 pp

Sivakumar, M.V.K., Singh, P. and Williams, J.H. 1987. Agroclimatic aspects in planning for improved productivity of Alfisols In: Alfisols in the semi-arid tropics, ICRISAT, Patancheru, India pp15-30.

Smith, B., 2006. The farming Handbook. University of Kwazulu-Natal Press, South Africa and CTA, The Netherlands, 431pp.

Spore, 1994. Sustaining soil productivity in intensive African Agriculture. Spore no. 49, 1994, CTA, The Netherlands, Pp 1-4

Spore, 2009. Soil fertility: Feeding the Land, Spore no. 139, 2009, CTA, The Netherlands, pp 8-10.

Spore, 2010. Fertilizer: Bring down the price. Spore no.146, 2010. CTA, The Netherlands, pp 1-2

Spore, 2010. Population and Agriculture, Spore Special Issue, August 2010, CTA, The Netherlands

Thompson, W.N. 1981. Conference Summary In: Irrigated Soybean production in arid and semi-arid regions ed. Judy, W.H. and Jackobs, J.A., Proceedings of a conference held in Cairo, Egypt 31 August- 6 September 1979, pp193-194

Tittonell, P., Misiko, M. and Ekise, I. 2008. Talking Soil Science with farmers, LEISA magazine, Vol. 24 no.2, pp 9-11.

Willams, C.N., Chew, W.Y. and Rajaratnam, J.A. 1980. Tree and field Crops of the Wetter Regions of the tropics. Longman group Ltd. England 262pp.

WOCAT, 2007. Where the land is greener: case studies and analysis of soil and water conservation initiative worldwide. Editors: Hanspeter liniger and William Critchley, CTA, FAO, UNEP and CDE, Bern. 364pp.

ISSN: ISSN 2054-6319 (Print), ISSN 2054-6327(online)