PAT Dec, 2017; 13 (2): 91-101 ISSN: 0794-5213
Online copy available at *www.patnsukjournal.net/currentissue*
Publication of Nasarawa State University, Keffi

Nitrogen Uptake, Growth and Yield of Bambara nut in Response to Population Densities and Phosphorus Sources in an Ultisol

Ogundare S.K
Department of Agronomy, Kabba College of Agriculture, ABU, Zaria, Kabba
Ogundarekayode1970@gmail.com

Abstract
The experiment was carried at the Research Site of Kabba College of Agriculture. The study evaluates the effects of plant population density and phosphorus sources on nitrogen uptake, growth and yield of Bambara nut in an Ultisol. A split plot design experiment was laid out in a randomized complete block design (RCBD) with three replications to randomize the population density and phosphorus sources in the main and sub-plots, respectively. The experiment comprised of four population densities, i.e. 13,333 plants/ha, 26,666 plants/ha, 66,666 plants/ha and 100,000 plants/ha and three phosphorus sources i.e. poultry manure, cow dung, single superphosphate and no phosphorus source application (control). Results show that effect of phosphorus sources was not significant ($p>0.05$) on nitrogen content of the shoot and root while significant difference ($p<0.05$) was observed in nitrogen content of the seeds. Nitrogen content of shoot and root was highest in plots with poultry manure application, while the highest content on nitrogen in seed occurred in plots amended with single superphosphate fertilizer. The least nitrogen content of shoot, root and seed were observed in the control plots. The highest numbers of nodules, fresh and dry weight of nodules were recorded in plots with single superphosphate fertilizer, followed by plots with poultry manure application. Higher number and heavier nodules were recorded in plots with low population densities. These were significantly better than plots with higher population densities. Application of phosphorus through different sources out yielded significantly the control in cases of growth and yield of Bambara nut. Among organic manures, poultry manure increased the growth and yield significantly more than other manures. Grain yield per land area increases increased with increase in plant population density. In terms of yield per land area, Bambara groundnut planted at high density recorded higher yield compare to plots planted at low population density. Poultry manure plots recorded highest growth and yield among the amended plots. Individual plant growth parameters increased with decrease in plant population density but in terms of yield per land area, Bambara nut planted at high density recorded higher yield compare to plots planted at low population density. Population density of 66,666 plants per hectare recorded the highest yield and therefore recommended for farmers in the study area.
Keywords: *Nitrogen uptake, plant population density, Bambara nut, Poultry manure*

Introduction

In Nigeria, low protein intake predisposes the people to many diseases and malnutrition and the resultant effect is high death rate. The daily routine food consumption consisted of tubers and cereals. The consumption of animal protein remains low virtually in every home. Bambara nut (*Vigna subterranean*) is a pulse crop of immense potential in enhancing food security (Linnamann, 1988). The requirement of legumes for phosphorus is higher than cereals as this nutrient serve dual purpose in legumes including providing energy for the growth of host plant and its associated biological nitrogen fixing bacteria. After nitrogen, phosphorus (P) is another plant growth-limiting nutrient despite being abundant in soils in both inorganic and organic forms. However, many soils throughout the world are phosphorus -deficient because the free phosphorus concentration (the form available to plants) even in fertile soils is generally not sufficient (Gyaneshwar *et al*., 2002). Phosphorus is needed in relatively large amounts by legumes for growth and has been reported to promote leaf area, biomass, yield, nodule number and nodule mass in different legumes (Berg and Lynd, 1985: Pacovsky *et al*., 1986: Kasturikrishna and Ahlawat, 1999). Furthermore, phosphorus has important effects on photosynthesis, root development, fruiting and improvement of crop quality (Sara *et al*., 2013). The deficiency of phosphorus in legumes depressed the activity of nitrogen fixing bacteria (Rahman et al., 2008). Microbial community influences' soil fertility through soil processes such as decomposition, mineralization, storage and release of nutrients organic materials. Microorganisms enhance the phosphorus availability to plants by mineralizing organic phosphorus in soil and by solubilizing precipitated phosphates (Pradhan and Sukla, 2005).

In Bambara groundnut, plant densities vary considerably, depending on the environment, production system and cultivar. Previous studies have shown that plant density is an important factor affecting crop yield. Plant population density in crop governs the components of yield, and thus the yield of individual plants. A uniform distribution of plants per unit area is a prerequisite for yield stability (Diepenbrock, 2000). Al-Barzinjy *et al.* (1999) concluded that pods per plant, seed weights and dry matter per plant decreased as plant density increased. Leach *et al.* (1999) also reported that plants grown at high density had fewer pod-bearing branches per plant but produced more branches and that with an increase in density 1000-seed weight increased. Planting density of Bambara groundnut is often low (< 100,000 plants ha-1) in farmers' fields (Egbe *et al.,* 2009) and especially when the crop is not grown in rows (Ngugi, 1998), resulting in low yields. Recently research work on Bambara groundnut is receiving better attention than before, especially in countries like Tanzania and Swaziland where it is a staple food and research grants were provided. This has led to generation of little information (Fleissner, 2000; Massawe *et al.*, 2004; Mwale *et al.*, 2004) on agronomy, nutrition and improvement of this crop. Nevertheless, in Nigeria, information about this crop in terms of agronomic practices such as planting density, phosphorus sources, and rate is limited because it is produced at subsistence level by rural farmers and only few workers are interested in its research. Therefore, the study evaluated the effects of plant population density and phosphorus sources on nitrogen uptake, growth and yield of Bambara nut in an Ultisol.

Materials and Methods

Experimental site

The experiment was carried out for two consecutive growing seasons (2015 and 2016) at the Research Site of Agronomy Section, Kabba College of Agriculture, Kabba. The site is located at latitude of 07° 35' N and longitude of 06° 08' E and is 432 m above sea level, in Southern Guinea Savanna Agro Ecological Zone of Nigeria, where the dry seasons are dry and hot while, wet seasons are cool. The rainfall spans between April to November with peak in June. The dry season extends from December to March. The mean annual rainfall is 1350mm per annum with an annual temperature range of 18°C - 32°C. The mean relative humidity (RH) is 60% (Meterological data, 2016). The major soil order within the experimental site is Ultisol (Higgins, 1957; Babalola, 2010).

Field work

The Bambara nut seeds were source from Agricultural Development Project Office, Aiyetoro, Kogi State, Nigeria. A split plot design experiment was laid out in a randomized complete block design (RCBD) with three replications to randomize the population density and phosphorus sources in the main and sub-plots, respectively. The experiment comprised of four population densities, i.e. 100 cm x 75 cm (13,333 plants/ha), 75 cm x 50 cm (26,666 plants/ha), 50 cm x 30 cm (66,666 plants/ha) and 40 cm x 25 cm (100,000 plants/ha) and three phosphorus sources i.e. poultry manure, cow dung, single superphosphate and no phosphorus source application (control).

The treatments were carried out on the same plots in 2015 and 2016 growing seasons. The size of each plot was 4.0 m long and 3.0 m wide. A buffer zone of 1 m spacing was provided between plots. In both growing seasons, Burkina variety was planted manually on a raised bed. Ten plants were randomly selected and harvested at maturity from the second and third rows. In this plants using, plant height, number of branches per plant, fruit number per plant, yield were researched. Fruit yield was calculated over all plants in the plot.

Soil sampling and data collection

The soil were collected from different parts of each experimental field from a depth of 0-15 cm and bulked into a composite sample and used for the determination of the physical and chemical properties of the soil (Table 1) before planting. The soil samples were air-dried at room temperature for one week, ground (using mortar and pestle) to pass through a 0.3 mm screen for chemical analysis. Mechanical analysis was carried out by the hydrometer method described by Bouyoucos (1962). Soil pH was obtained using a 1:2.5 soil-water ratio. Total organic carbon was determined by the use of an improved chromic acid digestion and spectrophotometric method (Heanes, 1984) and organic matter was estimated by multiplying the organic carbon figure by 1.724. Available phosphorus was determined by using Bray1 procedure (Bray and Kurtz, 1944). Nitrogen in soil was estimated by phenols colour formation method (Chaykin, 1969) after micro-Kjeldahl digestion; exchangeable potassium and calcium were determined using the methods described by Juo (1979). Magnesium was assessed using the methodology developed by Tel and Rao (1982).

Data analysis

Data were statistically analyzed using GENSTAT. The analysis of variance (ANOVA) was performed to find out the significance of variation among the treatments while the significant difference between mean treatments were separated using least significance Difference at 5% level of probability.

Results and Discussion

Table 1 shows the physico - chemical properties of the soil before planting. The percentage (%) sand, silt and clay were 61.6, 18.0 and 20.4 respectively indicating the soil to be of sand clay loam with the pH of 8.14. The nitrogen content of the soil was 0.14% which is considerably low compared to the recommended critical level (1.5%) for Nigerian soils for most crops (Senjobi, 2013). The available phosphorus content of the soil was very low compared to the critical levels (10 - 12 mg/kg) and the exchangeable potassium content of the soil was also low compared to recommended critical level of 0.17 cmol/kg for Nigerian soils (Omotosho *et al*., 2008). The Ca, Mg and organic matter contents available in the soil were low and the soil pH indicates that the soil is slightly alkaline. The chemical compositions of organic manure used are shown in Table 2. The materials were relatively high in phosphorus. Organic manure has been found to have beneficial effects on soil, its application brought about increases in pod seed weight of both soybean and egusi melon (Odu and Mba, 1991). The results of effect of different phosphorus sources and plant population density on nitrogen content of shoot, root and seed of Bambara groundnut are presented in Table 3. The results show that effect of phosphorus sources was not significant on nitrogen con tent of the shoot and root. Similar result was reported by Eltelib *et al.* (2006). This response might be due to soil factors affecting phosphorus availability, such as phosphorus fixation by the clay soil in which the experiment was conducted or that the experimental soil has high fixing capacity for the applied phosphorous in the top layer which reduced the availability of phosphorous to the plant. Yang and Jacobsen (1990) observed that when phosphorus fertilizer was added to soil with pH of 8.5, phosphorus quickly reacts to form less soluble compounds with calcium and possibly magnesium.

Table 1: Physical and Chemical Properties of Soil before the Experiment

PROPERTIES	*2014*
Sand (%)	61.6
Clay (%)	20.4
Silt (%)	18.0
Soil texture	Sand clay loam
pH	8.14
Bulk density(g/cm^3)	1.46
Total porosity (%)	43.8
Organic matter (%)	1.83
Total N (%)	0.14
Available P (mg/kg)	3.16
3Exchangeable K (cmol/kg)	0.34
Exchangeable Ca (cmol/kg)	1.68
ExchangeableMg (cmol/kg)	1.43

Table 2: Composition of phosphorus sources

Phosphorus Sources	*Phosphorus (%)*
Cowdung	1.38
Poultry manure	3.80
SSP	-

Table 3: Different Population Density of Bambara nut

Inter row spacing (cm)	*Intra row spacing (cm)*	*Plant Density (plant/ha)*
100	75	13,333
75	50	26,666
50	30	66,666
40	25	100,000

Significant difference was observed in nitrogen content of the seeds. Significantly improved seed N content observed due to the treatment applied was in line with the findings of Ogundare (2011) that organic manure has positive effect on the concentration of N in grain tissue. Since seed is the sink for Photosynthates, hence more nitrogen was seen directed to the seed. Nitrogen content of shoot and root was highest in plots with poultry manure application, while the highest content on nitrogen in seed occurred in plots amended with single superphosphate fertilizer. The least nitrogen content of shoot, root and seed were observed in the control plots. This observation confirmed the claims that organic material improves N availability to crop. Plant population density had no significant effect on nitrogen content in shoot, root and seed of Bambara groundnut in this experiment (Table 3). Number of nodule produced in the roots of Bambara groundnut are presented in Table 4. Number of nodule produced, fresh and dry weights of nodules were significantly affected by different phosphorus sources. The highest numbers of nodules, fresh and dry weight of nodules were recorded in plots with single superphosphate fertilizer, followed by plots with poultry manure application. Phosphorus, when optimally available, helps in cellular processes, being a component of RNA and DNA (Ajilore, 2008). It aids cell division and fast growth and can be found mainly in large quantities in seed of plants (Schlegel, 1986). Plots with cow dung manure recorded the lowest number of nodules, fresh and dry weight nodules among the amended plots. All these were significantly better than control plots. Table 4 also shows that plant population densities significantly affect number of nodules produced and both fresh and dry weight of nodules. Higher number and heavier nodules were recorded in plots with low population densities (13,333 and 26,666 plants per ha. These were significantly better than plots with higher population densities (66,666 and 100,000 plants per ha. Nodule number increased in all the amended plots over the control. The findings of Senerirantue *et al.* (2000) have shown that P fertilizer sources promote plant growth and increase grain yield in crop. Phosphorus aids the mining of nitrogen in the soil, this show the importance of nitrogen fixation in the tropic even with p fertilizer incorporation. In legumes production, phosphorus application and inoculation with the appropriate *Rhizobium* strains have quite prominent effects on nodulation, growth and yield parameters (Shahid *et al.*, 2009). The factors which control the amount of nitrogen fixed include available soil nitrogen, genetic determinants of compatibility in both symbiotic partners and lack of other yield-limiting factors like edaphic factors associated with phosphorus deficiency, soil acidity, mineral elements nitrogen and other various microelements like Cu, Mo, Co, B which are necessary for N2 fixation (Harold *et al.*, 1992). The possibility that ATP synthesis was limited by deprivation in P uptake can also be considered (Sa and Israel, 1991). P deficiency might have caused a negative effect on the processes of nitrogen fixation by decreasing nodule capacity to fix atmospheric N_2 as result of lowered nodule size.

Plant population densities significantly affect number of nodules produced and both fresh and dry weight of nodules. Nodules productions in legumes were control by availability of rhizobium in the soil and best it can use the available nutrients especially P and B and this depend on availability of these nutrients in the soil. Hence, Bambara nut with less population density recorded highest nodules parameters. Application of phosphorus through different sources out yielded significantly the control in cases of growth and yield of Bambara nut. This is in agreement with the results obtained by Tran Thi Thu Ha (2003) in groundnut. An adequate supply of phosphorus has been associated with increased root growth, which in turn resulted in better uptake of nutrients and water in the development of nodules. This could be a possible explanation for increase in growth and yield of Bambara nut with phosphorus application (Gobarah *et al.*, 2006). Agarwal *et al.* (2007) emphasized that phosphorus helps in the formation of more nodules, more vigorous root development, better nitrogen fixation and overall better development of plants. Nayak *et al.* (2006) also reported that phosphorus is important in root development and translocation of photosynthates. Being a constituent of nucleic acids, phytin and phospholipids, phosphorus application increased growth and yield attributing parameters. Among organic manures, poultry manure increased the yield significantly more than other manures. Prabakaran and James Pitchai (2002) reported that among organic nutrient sources, application of poultry manure improved the crop parameters most. This might be due to the availability of all essential macro- and micronutrients which are necessary for crop growth and development. Poultry manure contains all essential plant nutrients since solid and liquid portion of the poultry excreta are excreted together.

Table 4: Nodules produced in the root of Bambara nut in response to population densities and phosphorus sources in an ultisol

Treatment	**Number of nodule produced**	**Fresh weight of nodules**	**Dry weight of nodules**
Phosphorus sources (PS)			
SSP	56.14	0.91	0.36
PTY	41.27	0.78	0.33
CWD	39.74	0.78	0.31
CTR	18.19	0.56	0.17
LSD (0.05)	16.14	0.14	0.09
Plant Population Density (PD)			
13,333	47	0.88	0 43
26,666	52	0.89	0.43
66,666	24	0.49	0.31
100,000	19	0.47	0.29
LSD (0.05)	06.11	0.06	0.02
PS VS PD	ns	ns	ns

Legend: SSP = single superphosphate, PTY= poultry manure, CWD= cow dung manure, PS = phosphorus sources, PD= plant population density.

Growth characters of Bambara groundnut as influenced by different phosphorus sources are presented in Table 5. Growth characters of Bambara groundnut were significantly affected by different phosphorus sources. Amended plots were better in plant height, number of leaves, number of branches per plant, root length and number of flower produced at 10 weeks after planting (WAP) when compared with control plots. Plots with poultry manure application produced the tallest plants, number of leaves, number of branches per plant, root length and number of flower produced per plant. This was followed by plots with single superphosphate and then followed by plots with cow dung manure. Control plots recorded the shortest plant, least number of leaves, branches and flowers (Table 5). Bambara nut pod yield and yield components were significantly affected by different phosphorus sources expect in number of seed per pod. Plots with single superphosphate and poultry manure were significantly better in number of pods per plant, grain yield per plant and grain yield per land area. The effect of phosphorus sources on1000 grain weight was similar in plots treated with cow dung and the control (Table 6). Control plots recorded the least values of number of pods per plant, number of seed per pod, 1000 grain weight, grain yield per plant and grain yield per land area.

Table 5: Growth parameters of Bambara nut in response to population densities and phosphorus sources in an ultisol

Treatment	Plant height (cm)	Number of leaves (10WAP)	Number of branches per plant	Root Length (cm)	Number of flower at 10 WAP
Phosphorus sources (PS)					
SSP	36.3	164.3	41.53	34.54	42.44
PTY	38.7	172.8	37.42	37.13	43.16
CWD	36.6	161.0	38.14	19.47	29.17
CTR	21.6	146.3	24.13	14.54	12.16
LSD (0.05)	5.41	12.63	8.41	5.16	17.43
Plant Population Density (PD)					
13,333	37.6	168.5	53.94	41.42	47.04
26,666	37.1	156.7	54.18	37.51	43.18
66,666	30.3	156.3	39.71	30.43	34.98
100,000	23.66	134.9	21.66	21.17	23.85
LSD (0.05)	6.46	23.17	12.71	13.41	11.93
PS VS PD	ns	ns	ns	ns	ns

Legend: SSP = single superphosphate, PTY= poultry manure, CWD= cow dung manure, PS = phosphorus sources, PD= plant population density.

Plant population densities significantly affect growth characters of Bambara nut (Table 5). Growth characters increase with decrease in plant population density. Plots with the population density (13333 and 26666 plants per ha produced similar effect on plant height, number of leaves, number of branches per plant, root length and number of flower produced. All these were significantly better than plots with 66666 and 100000 plants per ha. Plots with 100000 plants per ha consistently recorded the least values growth characters observed in this experiment. The superior performance of low density Bambara nut as compared to high density crops in growth characters per plant is a further confirmation of previous findings of Moriri *et al.* (2010) and Egbe *et al.* (2010). These researchers had reported negative influence of increase in population density on individual crop growth and attributed this to depressive effects of inter- and intra- plant competition for both above and below ground growth factors (light, air, water, nutrients, etc.). Interaction of phosphorus sources and plan population density was not significant on growth characters of Bambara groundnut. Yield and yield characters of Bambara nut were significantly affected by different population density. Highest number of pods per plant, 1000 seed weight and grain yield per plant decrease with increase in population density. Similar effect were observed in number of pods per plant, 1000 seed weight and grain yield per plant in plots with population densities of 13,333 and 26,666 plants per ha. These were significantly better than plots with either 66,666 or 100,000 plants per ha when comparing the performance of individual plant. Al-Barzinjy *et al.* (1999) concluded that pods per plant, seed weights and dry matter per plant decreased as plant density increased. Leach et al. (1999) also reported that plants grown at high density had fewer pod-bearing branches per plant but produced more branches and that with an increase in density 1000-seed weight increased.

Table 6: Pod yield of Bambara nut in response to population densities and phosphorus sources in an ultisol

Treatments	Number of pod /plant	Number of seed/pod	1000 grain weight(kg)	Grain yield /plant (kg)	Grain yield (tons/ha)
Phosphorus sources (PS)					
SSP	44.7	2.07	0.61	0.46	12.47
PTY	33.8	2.56	0.48	0.48	13.02
CWD	28.4	2.08	0.26	0.32	08.43
CTR	19.1	2.05	0.21	0.14	05.51
LSD (0.05)	07.61	ns	0.21	0.09	4.67
Plant Population Density (PD)					
13,333	40.16	3.17	0.63	0.41	05.46
26,666	38.37	2.61	0.31	0.33	08.79
66,666	18.65	2.25	0.26	0.20	13.33
100,000	15.44	2.15	0.27	0.12	12.00
LSD (0.05)	9.71	0.36	0.21	0.09	2.98
PS VS PD					

Legend: SSP = single superphosphate, PTY= poultry manure, CWD= cow dung manure, PS = phosphorus sources, PD= plant population density.

Planting density of Bambara nut is often low (< 100,000 plants ha-1) in farmers' fields (Egbe *et al.*, 2009) and especially when the crop is not grown in rows (Ngugi, 1998), resulting in low yields. This could be the result of less competition for water, air and nutrients enjoy by crops planted at low density. The superior performance of low density Bambara nut as compared to high density crops in grain yields per plant is a further confirmation of previous findings of Moriri *et al.* (2010) and Egbe *et al.* (2010). These researchers had reported negative influence of increase in population density on individual crop yields and attributed this to depressive effects of inter- and intra- plant competition for both above- and below- ground growth factors (light, air, water, nutrients, etc.).

Grain yield per land area increases with increase in plant population density. In terms of yield per land area, Bambara nut planted at high density recorded higher yield compare to plots planted at low population density. Grain yield per land increases with increase in plant population density. Plots with plant population density of 66, 666 plants per ha recorded the greatest tons of Bambara nut yield (13.33 tons/ha) this was similar to plots with plant population density of 100,000 plants per ha. All these were significantly better than plots with plant population density of either 13,333 or 26,666 plants per ha. These results indicate that the landraces of Bambara nuts used for this study are better suited for planting at high densities. The superior performance of high density Bambara nut as compared to low density crops in grain yields per land area indicate how efficient the land could be used when planted the crop at high density.

Conclusion and Recommendations

The experiment was conducted to determine the effect of population densities and phosphorus sources on nitrogen uptake, growth and yield of Bambara nut. The result of the experiment shows that, growth and yield of Bambara groundnut is greatly influenced by population densities and different phosphorus sources. Nitrogen uptake was higher in phosphorus sources amended plots irrespective of the source compare to control. Poultry manure plots recorded highest growth and yield among the amended plots. Individual plant growth characters increase with decrease in plant population density but In terms of yield per land area, Bambara nut planted at high density recorded higher yield compare to plots planted at low population density. Population density of 66,666 plants per hectare recorded the highest yield and therefore recommended for farmers in the study area.

References

Agarwal B. K., Binod Kumar Surendra Singh Singh, R.N. and Asha Kumari Sinha., (2007), Effect of phosphorus and liming on yield, phosphorus uptake and protein content of pea in acidic upland soil of East Singhbhum, Journal of the Indian Society of Soil Science, 55 (3), pp 364-366.

Al-Barzinjy M., Stolen O., Christiansen J.L. and Jensen J.E. (1999): Relationship between plant density and yield for two spring cultivars of oilseed rape (*Brassica napus* L.). Acta Agr. Scand. Sect. B, Soil Plant Sci., 49: 129–133.

Babalola, T. S. (2010). Land evaluation studies of two wetland soils in Nigeria. Unpublished MSc thesis, Department of Crop, Soil and Environmental Sciences, University of Ado Ekiti. 141pp.

Balasubramanian V. and Nnadi, L.A. (1980). Crop residue management and soil productivity in Savannah areas of Nigeria. In *FAO Soil Bulletin* No. 43. Organic Recycling in Africa. FAO Rome. 107pp.

Bouyoucos, G.O. (1962). Hydrometer method improved for making particles size analysis of soils. Agronomy Journal 54, 464 – 465.

Bray, R.H.and Kurtz, L.T. (1945), “Determination of total, organic and available forms of phosphorus in soils”, *Soil Science,* Vol. 59 pp. 39-45.

Berg RK and Lynd JQ (1985). Soil fertility effects on growth, yield, nodulation and nitrogenase activity of Australian winter pea. Journal of Plant Nutrition. 8:131-145.

Chaykin, S. (1969) “Assay of nicotinamide deaminase. Determination of ammonium by the indolphenol reaction”,*Annals of Biochemistry*, Vol. 32, pp.375-382.

Diepenbrock W. (2000): Yield analysis of winter oilseed rape (*Brassica napus* L.): a review. Field Crops Res., *67*: 35–49.

Egbe, O.M. and Bar-Nyam, M.N. (2010), “Pigeonpea/sorghum intercropping in Southern Guinea Savanna: effects of planting density of pigeonpea”, *Nature and Science*, Vol. 8 No.11, pp.156-167.

Eltelib, H.A., Hamad, M.A., Ali, E.E. (2006). The effect of nitrogen and phosphorous fertilization on growth, yield and quality of forage maize (*Zea mays* L.). Journal of Agronomy 5, 515–518.

Fleissner, K. 2001. Management practices and preferences of bambara groundnut (*Vigna subterranean*) producers in Oshna region, North Cental Namibia. *Proceedings of a mid-project* workshop on increasing the productivity of Bambara groundnut (Vigna subterranea) for sustainable food production in semi-arid Africa, Uni. of Swaziland, 28-30 August, 2001.

Gobarah M. E., Mohammad M. H., Tawfik M. M., (2006), Effect of phosphorus fertilizer and foliar spraying with zinc on growth, yield and quality of groundnut under reclaimed sandy soils, Journal of Applied Science Research, Pakistan, 2, pp 491-496.

Gyaneshwar P, Kumar GN, Parekh LJ, Poole PS (2002).Role of soil microorganisms in improving P nutrition of plants. Plant and Soil. 245: 83-93.

Harold H, Keyser, Li F (1992). Potential for increasing biological nitrogen fixation in soybean. Plant and Soil. 141: 119-135.

Heanes, D. (1984), "Determination of total organic C in soils by an improved chromic digestion and spectophotometric procedure", *Communications in Soil Science and Plant Analysis*, Vol.15, pp.1191-1213.

Higgins, G. M. 1957. Preliminary report on the detailed land, soil and contours survey of river line area of school of agriculture, Kabba. Soil Survey Bulletin No 31: 28p.

Meterological Report 2011. Kabba College of Agriculture Meterological Report.

Juo, A. S. R. (1979). *Selected methods for soil and plant analysis*. Manual series No.1. International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria.

Kamara, A. Y., R. Abaidoo, J.D.Kwari, and L.Omoigui (2007). Influence of P application on growth and yield of soybean genotypes in the tropical Savannas of northeast Nigeria. *Achieves of Agronomy and Soil Science* **53:** 1-14.

Kashturikrishna S and Ahlawat PS (1999). Growth and yield response of pea (*Pisum sativum*) to moisture stress, phosphorus, sulphur and zink fertilizers. Indian Journal of Agronomy. 44:588-596.

Kwari, J. D. (2005). *Soil fertility status in some communities of southern Borno*. Final report to PROSAB Project, Maiduguri, Nigeria. p. 21.

Leach J.E., Stevenson H.J., Rainbow A.J., Mullen L.A. (1999): Effects of high plant populations on the growth and yield of winter oilseed rape (*Brassica napus*). J. Agr. Sci., *132*: 173–180.

Linnemann, A.R. 1988. Cultivation of bambara groundnut in Northern Nigeria. Tropical crop communication, 15: 1-14.

Massawe F.J., Schenkel W., Basu S., Temba E.M. 2004. Artificial hybridsation in bambara groundnut (*Vigna subterranea* (L.) Verdc.). Proceedings of the International. Symposium on Bambara Groundnut, Botswana College of Agriculture, 8-12 September, 2003.

Moriri, S., Owoeye, L.G.and Marig,a I.K. (2010), "Influence of component crop densities and planting patterns on maize production in dry land maize/cowpea intercropping systems", *African Journal of Agricultural Research*, Vol.5 No.11, pp.1200-1207.

Mwale S.S., Azam-Ali, S.N., Massawe F.J., Roberts, J.A. 2004. Effect of soilmoisture on growth and development of bambara groundnut (*Vigna subterranea* (L.) Verdc.). Proceedings of the International. Symposium onBambara Groundnut, Botswana College of Agriculture, 8-12 September, 2003.

Nayak S. K., Singh P., Ahmed P., (2006), Effect of phosphorus and farmyard manure on growth and yield of soybean under rainfed condition of Nagaland, Journal of Soils and Crops, 16 (2), pp 274–277.

Ngugi, G. W. 1998. Kenya. Proceedings of the Workshop on Conservation and Improvement of Bambara Groundnut (*Vigna subterranean* (L.) Verdc.), 14–16 November 1995, Harare, Zimbabwe. Institute of Plant Genetics and Crop Plant Research, Gatersleben, Department of Research & Specialist Services, Harare and International Plant Genetic Resources

Institute, Rome, Italy.

Omotosho, S. O. and Shittu (2008). Soil properties, leaf nutrient composition and yield of okra (*Abelmoschus esculentus* (L.) Moench) as affected by broiler litter and NPK 15:15:15 fertilizers in Ekiti State, Nigeria. *Int. J. Agric. Res., 3*, 140-147. http://dx.doi.org/10.3923/ijar.2008.140.147

Ogundare, S. K. 2011. Influence of organic manure types on soil physicochemical properties and yield of maize in Ejiba, Nigeria. Unpublished Ph. D thesis, Department of Crop, Soil and Pest Management. Federal University of Technology, Akure, Nigeria, 231pp.

Pacovsky RS, Bethlenfalvay GJ and Paul EA (1986).Comparisons between P-fertilized and mycorrhizal plants. Crop Sciences. 26:151-156.

Pradhan N, and lb sukla, I. B (2005), Solubilization of inorganic phosphates by fungi isolated from agriculture soil African Journal of Biotechnology Vol. 5 (10), pp. 850-854.

Prabakaran C., James Pitchai G., (2002), Effect of different organic nitrogen sources on pH, total soluble solids, titratable acidity, reducing and non-reducing sugars, crude protein and ascorbic acid content of tomato fruits, Journal of Soils and Crops, 12 (2), pp 160-166.

Rahman MM, Bhuiyan MMH, Sutradhar GNC, Paul AK (2008). Effect of Phosphorus, Molybdenum and *Rhizobium* Inoculation on yield and yield attributes of mungbean. International Journal of Sustainable Crop Production. 3(6): 26-33 (October 2008).

Sa T. M., D. W Israel, 1991. Energy status and functioning of phosphorus- deficient soybean nodules. Plant Physiol. 97, 928-935

Sara S, Morad M, Reza CM (2013). Effects of seed inoculation by *Rhizobium* strains on Chlorophyll content and protein percentage in common bean cultivars (*Phaseolus vulgaris L.*). International Journal of Biosciences .Vol 3, No. 3, p. 1-8.

Seneuiratne, G; L.H.J Van Holm, E.M.H.G.S. Ekanyake. 2000, Agronomic Benefits of Rhizobia Inoculants use. Over Nitrogen Fertilizer Application in Tropical Soyabean. *Field Crops Research* 68,199-203.

Senjobi, B. A 2003. Sandy Soil Improvement Using Organic Materials and Mineral Fertilizer on the Yield and Quality of Jute Plant (*Corchorus Olitorius*). *Journal of Biology and Life Science*, Vol. 4, No. 1

Shahid MQ, Saleem MF, Khan HZ, Anjum SA (2009). Performance of soybean (*Glycine max* L.) under different phosphorus levels and inoculation. Pakistan Journal of Agricultural Sciences. 46(4): 237-241.

Tel and Rao, P. (1982), "Automated and semi-automated methods for soil and plant analysis", IITA Manual Series NO.7

Tran Thi Thu Ha., (2003), Effect of Phosphorus Fertilizer on Groundnut Yield in Poor Alluvial and Sandy Soils of Thua Thien Hue. Better Crops, 17 (2), pp 16-17.

Uzoma, A. O.,A.O. Osunde, and A.Bala (2006). Effect of phosphorus and Rhizobium inoculation on the yield and yield components of cowpea breeding lines in Minna. In: Proceedings of 31st Annual Conference of Soil Science Society of Nigeria 13th – 17th November, 2006. ABU, Zaria.

Yang, J.E., Jacobsen, J.S. (1990). Soil inorganic fractions and their uptake relationships in calcareous soils. Soil Science Society of America Journal 54, 1666–1669.