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Research Paper

Studies on Effects of Density and Phosphorus on Performance of Mungbean (*Vigna radiata* (L) Wilezek) Grown on Soils of Basement Complex in Bauchi State, Nigeria

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The study was carried out to examine the effect of plant density and phosphorus fertilizer on performance of mungbean (*Vigna radiata*(L) Wilczek) grown on soils derived from basement complex parent material at the Abubakar Tafawa Balewa University Teaching and Research farm Bauchi. The land was prepared and soil samples collected at the 0-20cm depth for laboratory analysis, the analytical results showed that the soil was moderately acidic and had low total nitrogen, available phosphorus and organic carbon contents. The treatment variables consisted of four phosphorus levels (0, 20, 30 and 40 kgPha^{-1}) and three intra-row spacing (20, 30 and 40 cm).These treatments were combined using factorial method and laid out in a randomized complete block design, with three replications. Results obtained showed that plant dry matter yield at 8WAS, pods and seed yield were significantly influenced by density/ spacing with the higher spacing giving higher plant dry matter than the lower spacing, while lower spacing gave higher pod and seed yields. The application of phosphorus fertilizer only had significant effect on pod and seed yields. It is concluded that lower spacing (250.000 plant population density) and 30 – 40 kg ha^{-1} phosphorus fertilization enhances the performance of mungbean and therefore recommended for the type of soil studied.

Key words: Basement complex**,** Density, Mung bean, , Performance, Phosphorous

INTRODUCTION

Mungbean (*Vigna radiata* (L) Wilezek) also known as green-gram is an edible crop of economic importance that can easily replace other legumes in human diet. This crop was believed to have originated from India and it is now grown throughout the tropics (Daisy, 1979). It is an annual legume belonging to the sub genus *ceratotropics* in the genus *vigna*. It is nutritious food stuff with high digestibility and it is popular for its relative freedom from flatulence effect and it is frequently used for feeding children, invalids geriatrics (old).The crop is good source of vitamins and minerals (Falaki *et al.,* 1987).

The cultivars are mainly grown as pasture spices for hay or folders as well as being used for green manure and as cover crop. It has been reported that in China it is regarded as a cooling food: it also has anti cancer qualities and also used by oriental herbalists for treating all hot inflammatory conditions ranging from systematic infection to heat stroke and hypertension (Fernadez and Shanmugasundaram, 1988).

Mungbean competes favourably with other edible beans most especially cowpea in terms of its food and nutritional qualities, in addition to its ability to fix nitrogen to the soil.

The present increase in human population in Nigeria has also resulted to an increase in food and plant protein consumption; hence cowpea and other legume including soybean production cannot meet the increasing needs of humans including livestock for food and protein demand as a result of pest infestation, diseases both in the field and in storage and decline yield. Therefore, it is important to seek other plant protein sources that can effectively replace or supplement cowpea and soybean demand in Nigeria for food and plant protein security. This can be done through planting of mungbean. This crop is relatively new in Nigeria and there is no record of its commercial production. However, the crop has been in cultivation on small scale around plateau state as for some years now (Falaki *et al.,* 1987).its cultivation is gradually spreading to neighbouring states like Nasarawa, Bauchi and Kaduna States where it is mostly grown in backyard farms (Falaki *et al.,* 1987). Parent material is any material that the soil is formed from or presumed to be formed from (Ibanga, 2006). The first step in the development of soil is the formation of parent materials accumulated largely through rock weathering. The composition of parent materials has direct impact on the physicochemical, morphological, biological and mineralogical characteristics of soils they give rise to (Akamigbo and Asadu, 1983). Major differences in the appearance of profiles excavated close to one another are usually a reflection of the differences in materials from which they were derived. Esu, (1999) identified parent materials as the most dominant soil forming factor to contribute to differences in soil properties. Knowledge of the differences in soil properties especially within short distances is very essential as this may explain variations in crop yields of farmers within and outside the same location, and influence potential management for sustainable productivity.

One major cause of poor yield of crops in the tropics including mungbean is the very low inherent fertility of the soils (Onyekwere, 2004). For yield to be sustained in crop production in the tropics and to ensure food security, the soil nutrients need to be managed effectively, the most effective way of soil nutrient management is fertilizer application. Applications of phosphorus potassium, calcium, magnesium and sulfur have been found to stimulate crop yields (Tindall, 1983). Soil nutrients management for mungbean by peasant farmers currently growing the crop is the addition of farmyard manure, compost or natural fertilizer. Biological sources of soil fertility have the potential to increase yield of legumes (Carter, 1991), though relatively new crop the use of mineral fertilizer such as phosphorous is yet to be used in the production of this crop.

Consequently, it is an established fact that the closer the spacing of any crops the higher the population per unit area. With very high population density, the tendency is that plants enter into keen competition for available soil nutrients, space, soil moisture and sunlight. The report of Mahmud *et al. (*1996) showed significant increase in plant height, pod and seed yield per plant and grain yield per hectare. Mahmud *et al. (*1996) also reported that increase plant density led to earlier canopy development and Biomass accumulation,and to increase seed yield in growing season. Therefore, the objective of this study was to investigate the effectiveness of plant density and phosphorus mineral fertilizer on the yield and yield attributes of mungbean grown on soils derived from basement complex parent material in Bauchi State northeast Nigeria for sustainable production of mungbean in the area.

MATERIALS AND METHODS

The experiment was conducted during the 2015 cropping season at the Abubakar Tafawa Balewa University teaching and research farm, Bauchi, Bauchi. The study area is located within Latitude10° 22'N and Longitude 9° 47'E and on altitude 609.45 m above sea level in the North-East geographical region of Nigeria. The soil of the study area is derived from unidentified basement complex parent material, the vegetation is Sudan savannah. Data on rainfall, temperature and relative humidity of the experimental site, during the period of the experiment were recorded (Table 1).These data were collected at the Abubakar Tafawa Balew University Meteorological centre Bauchi. The land was slashed, ploughed and harrowed to obtain fine tilt using tractor drawn implements. The field was then marked into 36 plots of 6m (3×2 m) each with paths 1 m and 0.5 m allowed between replications and plots respectively. Soil samples were taken from the experimental plots after ploughing using auger and were taken at 0 -20 cm depth and the samples were composited into composite samples.Samples were taken to the laboratory for physicochemical analysis.

The soil samples collected from the profile pits were air dried; gently ground and sieved using a 2 mm sieve preparatory for laboratory analysis. Samples for total N and organic C were passed through a 0.5 mm sieve. Soil particle size analysis was determined after dispersing 51.00 g of air-dried soil samples with 5% sodium hexametaphosphate overnight that is the Boyoucous hydrometer method as contained in the method of soil analysis by International Soil Reference and Information Center and Food and Agricultural Organization **(**ISRIC and FAO, 2002).

The chemical properties of the soils were determined according to standard laboratory procedures as contained in the method of soil analysis by International Soil Reference and Information Center and Food and Agricultural Organization **(**ISRIC and FAO, 2002). Soil pH (H_2O) was determined in 1:1 soil/ distilled water suspensions using a glass electrode. Organic carbon was determined by Walkley and Black titration method, which involved soil organic matter oxidation with potassium

Table 1. Monthly rainfall, temperature and relative humidity of the experimental site in 2015.

Months	Rainfall (mm)	Temperature (°C)	Relative humidity (%)
January	-	29.7	26.9
February	-	37.0	24.0
March	-	38.5	28.8
April	10.99	37.8	36.6
May	17.6	34.9	60.1
June	146.3	32.4	71.1
July	405.38	29.4	79.4
August	489.4	29.0	82.4
September	222.6	30.9	76.8
October	19.2	33.0	61.1
November	-	-	-
December	-	-	-
Total	1311.38		

Source: Abubakar Tafawa Balewa University Meteorological Centre ,Bauchi

dichromate ($K_2Cr_2O_7$) and sulphuric acid (H_2SO_4). Total nitrogen was determined by using the modified macro - Kjeldahl method of digestion, distillation and titration. Available phosphorus was extracted using Bray P-1 extract of Bray and Kurtz method, and measured colorometrically.The experiment comprised of the following variables, four levels of phosphorus (0, 20, 30 and 40 kgP/ha and three intra -row spacing (20, 30 and 40 cm) at 40 inter-row spacing. The experiment was laid out in a randomized complete block design under factorial arrangement with three replications. The unit plot size was 2mx3m having 12 plots in each replication with a gross net land size of 22.5 m ×1 7.5 m. Healthy clean and disease free seeds were planted three to four seeds per stand at 3-5 cm depth at an inter-row spacing of 40cm according to the treatments (20, 30 and 40 cm). Thinning was done two weeks after emergence to maintain two plants per stand to give plant population density of 250,000,166,500 and 125,000 stands ha^{-1}. Phosphate fertilizer (single super phosphate) was applied at sowing through topdressing according to the treatments (0, 20, 30 and 40) kg.

Weeds were controlled manually by the use of hand hoe; the plots were kept weed free throughout the growing period of the crop.Insects that were noticed were predominantly termites and ants which were controlled using a dust formulation (piff-paff) with active ingredients formula as pyrethrums 0.60% and gammalin 20. Disease observed was the Cercospora canenscens (leaf spot disease).It is characterized by small yellow, brown spots which causes older leaves to fall. No control measure was adopted. Harvesting was carried out when the pods were matured as indicated by their turning black at approximately nine (9) weeks after sowing (WAS). The pods were handpicked after every two days and stored in a cool dry place. After all the pods have been harvested, they were threshed using mortar and pistol. To assess various growth characters five plants were randomly selected from each plot for sampling at 2, 4, 6 and 8 weeks after planting. The following growth parameters were assessed, (Plant height, number of leaves and nodulation count). Plant height was measured from ground level to the tip of the plant in centimetres (cm) using a meter rule. Numbers of leaves per plant of five randomly marked plants were taken and averaged worked out to give the number of leaves per plant. Nodulation count was determined by carefully uprooting randomly selected 5 plants from a plot. The roots and nodule were carefully washed with clean water to remove sand particle before the nodules were counted and recorded as active (584) and non-active (256). The following parameters were assessed after harvesting. Total pod yield, total seed weight, 100 seed weight. The total pod yield per plot was determined by weighing the pods harvested from each plot using a weighing balance. The total seed weight per hectare was determined by threshing the entire pods. The threshed grains were then weighed to determine the seed weight. One hundred seeds were counted from each plot and weighed to determine weight of 100 seeds. The data collected were analyzed statistically with Analysis of Variance (ANOVA) and means were separated using LSD at 5 % probability, using SAS (2002) computer package.

RESULTS AND DISCUSSION

Soil

Table 2 shows the result of some physic-chemical analysis of the soils studied. The soil reaction had a pH value of 5.5, an indication that the soil is moderately acidic (Federal Ministry of Agriculture and Natural Resources, 1990). The moderate acidic nature of the soil could be attributed to moderate rainfall and low cropping intensity in the area. The organic carbon content was low

Table 2. Physio-chemical properties of soil of the experimental site.

Parameter	Value
Sand (%)	73.90
Silt (%)	12.94
Clay (%)	13.14
Texture Class	Sandy loam
pH (1:1 Soil water ratio)	5.5
Organic carbon (gkg^{-1})	7.05
Available phosphorus ($mgkg^{-1}$)	8.29
Total nitrogen (gkg^{-1})	0.51

Table 3. Effect of density / spacing and phosphorus fertilizer on plant height at 2,4,6 and 8 WAS.

Density (stds ha^{-1})/Spacing (cm)	2WAS	4WAS	6WAS	8WAS
(250,000) 20x40	6.05	9.62	31.41	47.80
(166,500) 30x40	5.82	9.80	31.82	50.25
(125,000) 40x40	5.15	9.01	29.74	46.80
SE±	0.41	0.67	2.94	2.83
LSD(P=0.05)	NS	NS	NS	NS
Phosphorus levels ($kgha^{-1}$)				
0	5.95	10.12	32.33	51.04
20	5.50	9.40	29.52	47.53
30	5.20	9.62	30.71	49.63
40	6.80	8.78	31.38	44.92
SE±	0.47	0.77	3.38	3.26
LSD(P=0.05)	NS	NS	NS	NS

with a value of7.05 gkg^{-1}. The low organic carbon content in the soil studied could be attributed to any or all of the following: inadequate supply of organic litter, bush burning, long dry season and intensive mineralization during the rainy season (Dogie *et al*., 2008). Maintenance of a satisfactory organic matter status is essential to the production of most of the nitrogen and half of the phosphorus taken up by unfertilized crops (Von Uxekull, 1986). The total nitrogen content of the soil was low with a value of 0.51 gkg^{-1}.

The low content of total N in the soil studied could be attributed to low organic carbon content of the soil, since inorganic N is accounting for only a small portion of total N in soils (Almu and Audu, 2001). The total N content of the soil is a reflection of the organic carbon content of the soil. The low level also could be attributed to the rate of mineralization of organic matter, thus negatively affecting the level of soil total N content (Senjobi *et al.,* 2013). The available phosphorus content of the soil was low; with a value of 8.29 mg kg^{-1}.The low value of available P as observed in the soil studied could be attributed to interaction of P and other soil constituents and due to low phosphate potentials of the parent rocks (Onyekwere, 2004). This result showed that there will be positive response in yield of mungbean upon application of phosphorus fertilizer in the soil studied. The texture of the soil studied was sandy loam, an indication that the soil is ideal for sustainable crop production.

Yield

Table 3 shows the effect of density/spacing and phosphorus fertilizer on plant height of mungbean at 2, 4, 6 and 8 weeks after sowing. Plant height was not significantly influenced by both spacing and phosphorus fertilizer. The non significant difference could be due to the genetic makeup of this variety of mungbean whose height could not be increased as a result of competitive stress. Table 4 shows the effect of density/spacing and phosphorus fertilizer on number of leaves per plant at 2, 4, 6 and 8 weeks after sowing. Density/spacing did not give any significant difference in numbers of leaves per plant. Phosphorus application at 6 WAS significantly (P=0.05) influenced the number of leaves per plant. The application of 20-30 kg phosphorus per hectare produced significantly higher number of leaves than the control. However, the 40 kgP/ha^{-1} application was not significantly different from both the control and rate that gave the highest number of leaves. Table 5 shows the effect of density/spacing and phosphorus on plant dry matter at 8WAS; plant dry matter was significantly (P=0.05) influenced by density/spacing. The 166, 500 stands ha^{-1} population density (30cm spacing) gave significantly higher plant dry matter than the control but was not significantly different from the 250, 000 stands ha^{-1} population density (20 cm spacing) in plant dry matter at 8WAS. Phosphorus application at different levels did not

Table 4. Effect of density/ spacing and phosphorus fertilizer on plant numbers of leaves at 2, 4, 6 and 8WAS.

Density (Stds ha^{-1})/Spacing (cm)	2was	4was	6was	8was
(250,000) 20x40	4.17	15.00	31.00	46.00
(166,500) 30x40	4.45	15.00	30.00	47.00
(125,000) 40x40	3.94	14.14	29.00	45.67
SE±	0.41	0.83	2.36	4.67
LSD(P=0.05)	NS	NS	NS	NS
Phosphorus levels (kgha^{-1})				
0	3.26	14.00	25.11b	43.00
20	4.44	15.00	33.00a	49.11
30	4.00	14.44	32.78a	49.33
40	4.44	15.33	30.56ab	42.56
SE±	0.47	0.95	2.73	5.39
LSD(P=0.05)	NS	NS	5.66	NS

Table 5. Effect of density/spacing and phosphorus fertilizer on plant dry matter, 100 seed (g), total pod yield (kgha^{-1}), seed yield (kg^{-1}).

Density (stds ha^{-1})Spacing (cm) dry	Matter (g)100 seed	Weight (g)	Total pod yield (kgha^{-1})	Seed yield (kgha-^{1})
(250,000) 20x40	20.19b	4.42	1138.1a	721.75a
(166,500) 30x40	29.52a	4.50	1004.0ab	646.03ab
(125,000) 40x40	21.42ab	4.75	894.9b	584.00b
SE±	4.0	0.21	106.1	65.2
LSD(P=0.05)	8.5	NS	220.1	135.3
Phosphorus level (kgha^{-1})				
0	21.67	4.56	1031.1ab	761.98a
20	28.11	4.44	995.0ab	678.26ab
30	24.89	4.67	861.56b	630.67ab
40	20.78	4.56	1161.6a	531.48b
SE±	4.7	0.24	112.5	75.3
LSD(P=0.05)	NS	NS	254.2	156.2

Table 6. Effect of density/ spacing and phosphorus on total nodule count, active and non-active 8 WAS.

Density Stds (ha^{-1}) Spacing(cm)	Total Nodule count	Active Nodule count	Non-Active Nodule
(250,000) 20x40	22.67	15.92	6.75
(166,500) 30x40	22.83	15.08	7.75
(125,000) 40x40	24.42	18.33	5.92
SE±	3.2	2.9	2.1
LSD(P=0.05)	NS	NS	NS
Phosphorus levels (kgha^{-1})			
0	10.89b	6.79c	4.11b
20	17.44b	12.22c	5.00ab
30	28.44a	19.67b	8.78ab
40	36.44a	27.11a	9.33a
SE±	3.7	3.4	2.4
LSD (P=0.05)	8.0	7.0	5.0

give any significant difference in plant dry matter. The total pod yield (kgha^{-1}) was significantly (P=0.05) influenced by density/ spacing. The 250,000 stands ha^{-1} population density (20cm spacing) produced significantly higher total pod weight (1138.1kgha^{-1}) than the 125, 000 stands ha^{-1} population density (40cm spacing). The 166, 500 stands ha^{-1} population density (30cm spacing) gave similar pod yield to the 250,000 stands ha^{-1} population density (20cm) and 125, 000 stands ha^{-1} population density (40cm spacing) respectively. Pod dry weight generally declined with increase in spacing. Total seed yield (kgha^{-1}) was also significantly influenced by spacing following the same trend as the total pod weight. The 250,000 stands ha^{-1} population density (20cm spacing) produced significantly (P=0.05) higher seed than the 125,000 stands ha^{-1} population density (40 cm spacing) which gave the lowest yield although it was not significantly different from the 166, 500 stands ha^{-1} population density (30 cm spacing). 100 seed weight was however, not influenced by spacing. Phosphorus fertilizer also had a significant (P=0.05) influence on total pod and seed yields. The application of 40 $kgPha^{-1}$ produced significantly higher and lower pod yield and seed yield respectively than the other levels of application. The application of 40kgp ha^{-1} produced significantly higher dry matter and lower pod yield and seed yields respectively than the other levels of application. The application of 40 $kgPha^{-1}$ gave the lowest pod yield (861.5 kg) although it was significantly different from the control and 20 $kgPha^{-1}$ application. The highest seed yield per ha was produced by 0 $kgPha^{-1}$ application. Table 6 shows the effect of density/spacing and phosphorus fertilizer on total nodule count, active and non-active nodules. Density /spacing had no significant influence on total nodule count, and active and non-active nodule count**.** Phosphorus application however, had significant influence on nodulation at 8WAS. Total nodule count was significantly higher with 30 and 40 $kgPha^{-1}$ application while the control gave the lowest nodule count although it was not significantly different from the 20 $kgPha^{-1}$ application. The active nodule count was significantly highest at 40 $kgPha^{-1}$ application which was followed by 30 $kgPha^{-1}$ application. The lowest active nodule count was produced with 0 $kgPha^{-1}$(6.79), which was not significantly different from 20 $kgPha^{-1}$ application (12.22).The 40 $kgPha^{-1}$ application also gave the highest number of active nodules.

Conclusion

Based on these findings it is concluded that the soil of the study area is ideal for mungbean production based on the soil texture, the soil pH, is moderately acidic, the soil is characterized with low organic carbon, total nitrogen and available phosphorous content. Application of phosphorus fertilizer will have positive influence on yield of mungbean. Plant population density of 250,000 stands ha^{-1} that is lower spacing (20x40cm) and moderate to high phosphorus fertilization (30 – 40 $kgPha^{-1}$) enhance the performance of mungbean and is therefore recommended.

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