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YIELD RESPONSE OF SOYBEANS TO LEVELS OF NITROGEN AND POTASSIUM FERTILIZER IN THE HUMID TROPICS

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ABSTRACT

A field trial was conducted at the University of Uyo Teaching and Research Farm in a high rainfall area of South eastern Nigeria to assess the yield response of soybeans [*Glycine max* (L.) Merril] to different levels of nitrogen and potassium fertilizers. The results showed that the number of pods/plant, threshing percentage and grain yield (t/ha) were significantly influenced by nitrogen fertilizer application. Nitrogen applied at the rate of 45kg N/ha was more consistent in influencing soybean yield. Potassium on the other hand, significantly influenced number of branches/plant, number of pods per plant, 100 seed weight and grain yield. Beneficial range of doses of application of potassium was found to be 30 - 75kg/ha. Moreso, response of soybean to nitrogen was more at higher doses of potassium.

Key Words: Yield Components, *Glycine max*, Levels of Fertilization, Threshing Percentage

INTRODUCTION

Nitrogen and potassium are two important nutrients for soybeans. Weiss (1983) provided evidence that modern cultivars of soybeans differ not only in their responses to varying levels of nutrition but also to individual nutrients within a particular area. Soil type can considerably influence the availability and profitability of fertilizer use. Furthermore, Dobereiner (1979) reported that response of soybeans to any particular fertilizer will depend on soil fertility, soil moisture, soil texture and pH of the soil. Pal and Adedzwa (1983) observed visual symptoms of nitrogen deficiency in 26% of the farms surveyed in Benue State, a dominant soybean belt in Nigeria. However, Fisher (1980) and Balarabe, *et al*. (1982) reported a mild response of soybean to nitrogen in Samaru and Bida areas of Northern Nigeria. Brevedan (1978) found that nitrogen has no effect on seed size and seed number per pod and ascribed increases in yield to pod number per plant. Sable and Khuspe (1977) observed that the application of 30-60kgN/ha on soybean or seed inoculation increased pod number, seed weight and seed yield. Bezdicek, *et al*. (1974) reported increases in dry matter, nitrogen uptake, seed oil content and grain yield due to nitrogen application. Another report by Harrow (1962) also indicated that nitrogen addition did not consistently increase seed yield. A higher yield of soybean has been obtained with elevated levels of total N (Leffel, 1989).

Many workers including, Pal and Adedzwa (1983) and Goldsworthy and Heathcote (1960) have concluded that potassium is not necessary for soybean growth and grain yield but Roselem, *et al*. (1988) and Metcalfe and Elkim (1980) described soybean as an efficient and heavy user of potassium. However, potassium responses are governed by several other factors. Mascarenhas, *et al*. (1976) described how tropical red soils raise the level of available potassium and other nutrients enough to render any rate of applied potassium ineffective in increasing soybean yield. Therefore, almost limitless range of potassium requirement can be anticipated from

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a variety of soils in combination with climatic factors. Cox and Uribe (1992) suggested that higher rates of potassium be applied to fine textured soils. Camper and Lutz (1977) had a significant yield response of soybeans to potassium on sandy loam soils. Also, Chesney (1973) reported a significant yield response of soybean to potassium application on sandy loams of the humid tropics and the effect of potassium were larger with higher rates of nitrogen. Application of potassium was found to increase potassium uptake as well as nitrogen and phosphorous content of seeds. Beringer (1980) noted that potassium is an important nutrient for the efficient transport of solute from source (leaf) to the sink (seed). Soybean also needs potassium throughout the growing period since the uptake of this nutrient is essentially linear from 40-120 days as indicated by Henderson and Kamprath (1970). These reports on the response of soybeans to nitrogen and potassium have however not addressed the effects of these two nutrients in the coastal plain sandy soils of South Eastern Nigeria where soybean cultivation is assuming greater importance.

MATERIALS AND METHODS

The trials were conducted at the University of Uyo Teaching and Research Farm in 1994 and 1995. The soil was conventionally tilled before planting. Soil samples were also obtained prior to planting, and analysed using standard laboratory procedures. Particle size analysis was determined by Bouyoucos hydrometer method (Bouyoucos, 1962). Total nitrogen was estimated by microkjedahl method (IITA, 1979). Organic carbon was determined by Walkey and Black (1934) method. Available phosphorous of the soil was extracted using Bray I extraction procedure (Bray and Kurtz, 1945) and read from the spectrophotometer. Exchangeable bases including calcium, sodium, magnesium and potassium, were extracted with neutral ammonium acetate. Thereafter, magnesium was read from atomic absorption spectrophotometer, while sodium, potassium and calcium content of the soil were measured by flame photometry.

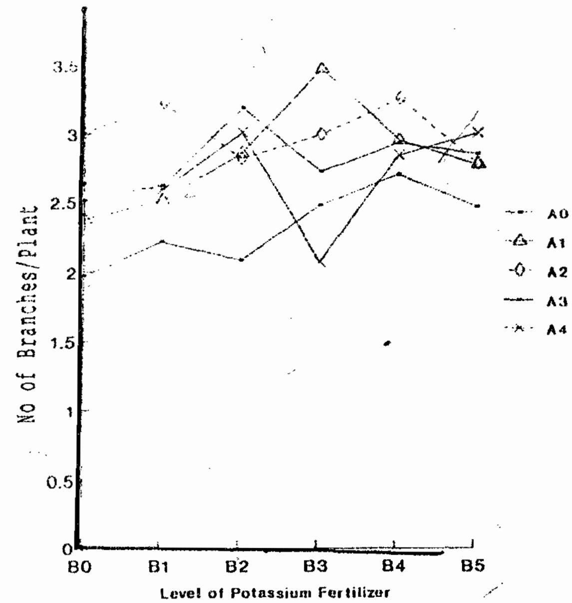

Fig. 1: Effect of Nitrogen and Potassium Interaction on Number of Branches 1995.

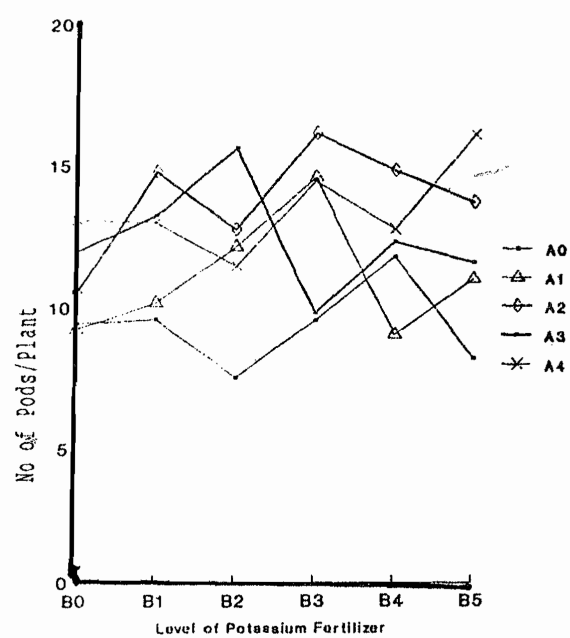

Fig. 3: Effect of Nitrogen and Potassium Interaction on Number of Pods/Plant in 1995.

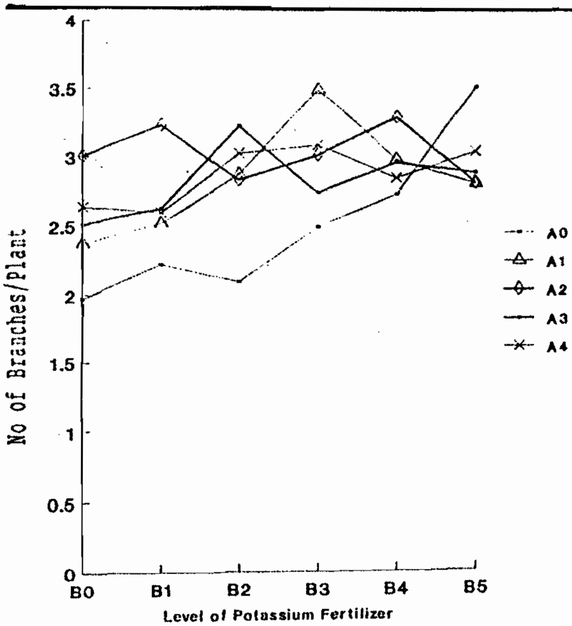

Fig. 2: Effect of Nitrogen and Potassium Interaction on Number of Branches per Plant in 1994/95

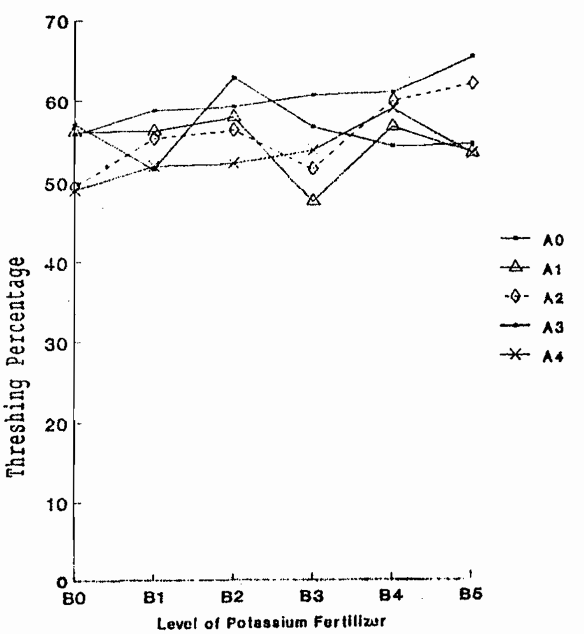

Fig. 4: Effect of Nitrogen and Potassium Interaction on Threshing Percentage in 1995

Soil pH and exchangeable acidity of the soil were determined by the 1.2 in 0.01m $CaCl_2$ and 1NKCl extraction procedures respectively. Effective cation exchange capacity of and Base saturation of the soil were obtained by the methods described by (IITA, 1979).

Soybean variety TGx 536-62D was planted on 19th September, 1994 and 15th September, 1995 respectively at spacing 50 x 10cm as recommended by Oko, *et al.* (1991). The experiment was laid out in a split plot design arranged in completely randomized blocks. The main plot treatment consisted of five levels of nitrogen (0, 15, 30, 45 and 60kgN/ha respectively) applied as Urea. The sub-plot treatments were six levels of potassium (0, 15, 30, 45, 60 and 75kgk$_2$0/ha) applied as Muriate of Potash. The fertilizer treatments were applied to the soil seven days after emergency. Also, each of these treatments was replicated four times. There were 120 subplots and each measured 2m x 2m. The plots were kept weed-free by hoeing between rows and handpulling within rows throughout the duration of the experiment. Sampling for the parameters under study were done on 1m² area of each sub-plot. Data collected were the number of branches per plant at maturity, number of pods per plant, threshing percentage, 100 seed weight in grammes and total grain yield in tonnes/hectare. Analysis of variance (ANOVA) was carried out on data collected and means that differed significantly were separated by the Fisher's least significance difference (LSD) at P = 0.05 as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The physical chemical properties of the soils (Table 1) revealed that the soil is a sandy loam. The soils are generally loose and non-cohensive chemically, the soils are acidic, low in organic matter total nitrogen and exchangeable bases but moderately endowed with available phosphorus. This is consistent with the findings of Enwesor, *et al.*, (1981).

The results obtained from the study are summarized in Tables 1, 2 and 3. The analysis of

Table 1: Selected Physico-Chemical Properties of the Soil at University of Uyo Teaching and Research Farm

Particle Size	
Sand (%)	89.80
Silt (%)	3.80
Clay (%)	6.40
Chemical Properties	
pH (1:2 soil : water)	4.90
Organic carbon %	2.23
Total nitrogen %	0.11
Exchangeable phosphorus (mg/kg of soil)	93.32
Exchangeable potassium (meq/100gm)	0.19
Exchangeable calcium (meq/100gm)	2.18
Exchangeable magnesium (meq/100gm)	1.80
Exchangeable sodium (meq/100gm)	0.44
Exchangeable acidity (meq/100gm)	3.04
Effective cation exchange capacity	7.55
Base saturation (%)	59.73

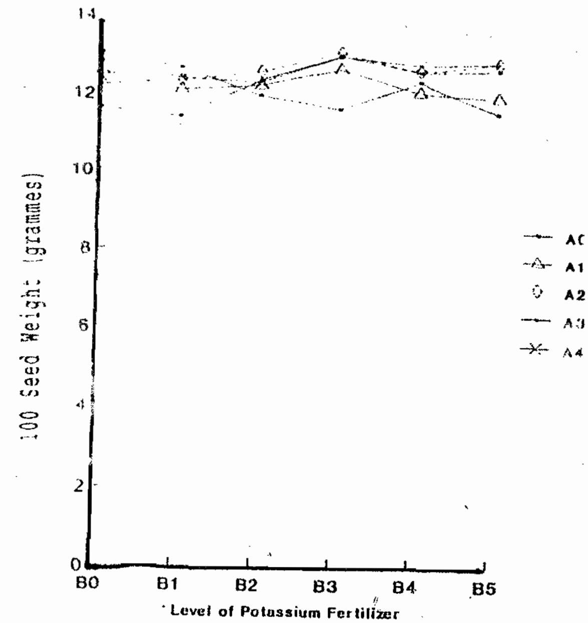

Fig. 5: Effect of Nitrogen and Potassium Interaction on 100 Seed Weight for 1995

data for number of branches showed that applied nitrogen had no beneficial effect on branching in 1994 and 19955 but it had a statistically significant effect on the two year average. The 30kgN/ha nitrogen application had the largest number of branches though statistically similar to branching at 15, 45 and 60kgN/ha. Lowest number of branches were observed in the control plot which received no nitrogen fertilizer treatment. Harrow (1962) observed that nitrogen fertilization increased the number of branches in soybean but branching could be affected by other factors such as spacing, soil moisture and plant species (Oko, *et al.*, 1991). On the other hand,

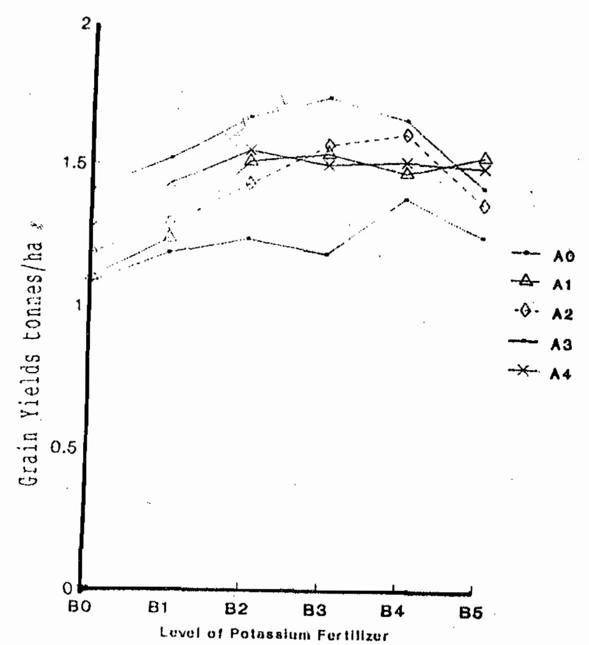

Fig. 7: Effect of Nitrogen and Potassium Interaction on Total Grain Yield for 1994/95.

Table 2: Effect of Nitrogen and Potassium on yield and yield components of soybean in 1994 and 1995.

	1994					1995				
Nutrient/Level Nutrient in kg/ha	No. of branches/ plants	No. of pods/ plants	Threshing percentage	100-seed weight (g)	Grain yield in tons/ha	No. of branches/ plants	No. of pods/ plants	Threshing percentage	100-seed weight (g)	Grain yield in ton/ha
Nitrogen										
0	2.83	17.04	59.74	12.16	1.74	1.88	9.32	55.96	12.18	0.70
15	3.05	19.93	60.49	12.67	1.88	2.20	11.05	54.43	12.40	0.91
30	3.43	19.46	62.65	12.42	1.89	2.59	13.75	55.54	12.59	0.92
45	3.23	20.22	64.51	13.04	2.13	2.50	12.96	59.92	12.59	1.00
60	3.17	19.65	62.86	12.92	1.94	2.53	14.06	52.94	12.67	0.97
Potassium										
0	2.66	18.54	60.42	12.05	1.58	2.29	10.90	53.56	12.45	0.83
15	2.88	18.91	61.54	12.59	1.80	2.43	12.59	54.68	12.57	0.86
30	3.2	18.80	62.50	12.78	2.00	2.47	12.49	57.54	12.27	0.96
45	3.29	20.75	64.18	13.13	2.02	2.56	13.08	53.74	12.65	0.98
60	3.52	18.67	62.99	12.85	2.15	2.34	12.14	57.82	12.46	0.89
75	3.32	17.50	60.99	12.46	1.95	2.22	16.88	57.27	12.34	0.87
LSD 0.05 between levels of Nitrogen	NS	2.28	3.87	NS	0.31	NS	N.S	NS	NS	0.02
LSD 0.05 between levels of Potassium	0.24	2.09	NS	0.2	0.15	NS	NS	NS	NS	NS
Interaction effect						*	*		*	*

NS - Non significant

*Significant interaction between nitrogen and potassium

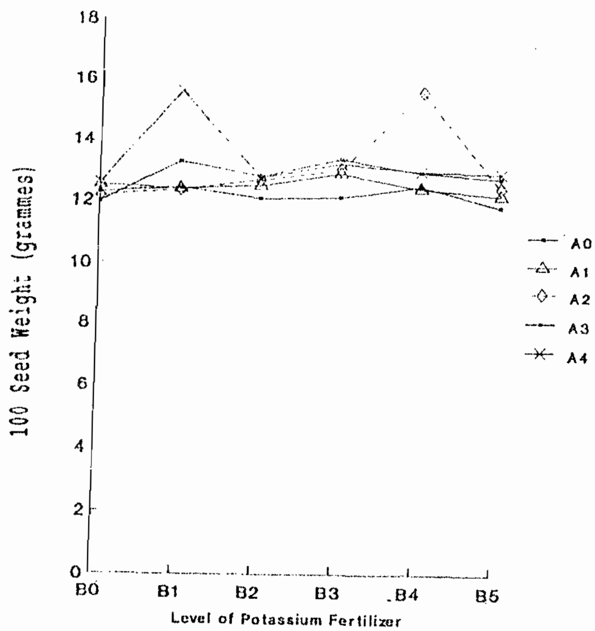

Fig. 6: Effect of Nitrogen and Potassium Interaction on 100 Seed Weight for 1994/95

KEY

A0 - 0kgN/ha	B0 - 0kgK_2O/ha
A1 - 15kgN/ha	B1 - 15kgK_2O/ha
A2 - 30kgN/ha	B2 - 30kgK_2O/ha
A3 - 45kgN/ha	B3 - 45kgK_2O/ha
A4 - 60kgN/ha	B4 - 60kgK_2O/ha
	B5 - 75kgK_2O/ha

potassium fertilization had significant effect on branching in 1994 and on the two year average.

There were more branches at 60 and 75kgk_2O/ha closely followed by 30 and 45kgk^2O/ha. The least number of branches were recorded 0, and 15kgk_2O/ha. In 1994, the number of branches obtained from the plot that received at 15, 30, 45, 60 and 75kgk_2O/ha were not statistically different, but there were more branches from the plot that had 45kgk_2O/ha. Also, from Figs 1 & 2, a significant interaction effect of nitrogen and potassium on branching were recorded in 1995 and on the two-year average. The highest number of branches were recorded when 15kgN/ha combined with 45kgk_2O/ha for 1995 and the two-year average respectively. Potassium has been found to increase the uptake of nitrogen (Chevalier, 1976), and is most likely to be more beneficial in the acid soils of Uyo confirming the finding of Enwesor, *et al.*, 1981.

Pod number per plant was significantly influenced by both nitrogen and potassium fertilizer treatments in 1994 and the two year average. Nitrogen showed more beneficial effect on podding at 45kgN/ha though this was not significantly different from podding at 30 and 60kgN/ha in 1995, whereas on the two year average, 30kgN had a more beneficial effect which was not statistically different from the pod numbers obtained from plots that had 15, 45 and 60kgN/ha. Also, applied potassium at 45kgk_2O/ha offered more promise in terms of number of pods per plant but it was not statistically different from K applied at 15, 30 and 60kgk_2O/ha. Lower number of pods were recorded for 0 and 75kgk_2O/ha. It can be seen that for both potassium and nitrogen fertilizer treatments, the number of pods increased to a maximum when 45kg/ha of the nutrient was applied. The trend of the increase was however irregular. This includes the effect of nitrogen on the two-year average. When the combined effects of potassium and nitrogen on pod formation in 1995 were considered, in Fig 3 the largest pod number was obtained at an application rate of 75kgk_2O/ha and 60kgN/ha. Higher rates of potassium seemed to be needed to mobilize nitrogen in acid soil.

Threshing percentage was significantly influenced by nitrogen application in 1994 only. Threshing percentages were statistically similar at the application rate of 30, 45 and 60kgN/ha though 45kgN/ha had the highest threshing percentage. Enhanced nitrogen levels on soybean is expected to increase threshing percentage as nitrogen is implicated for increased seed weights (Kang, 1975). Fig. 4 shows that there was an interaction between nitrogen and potassium on threshing percentage in 1995 in which 45kgN/ha and 75kgk_2O/ha gave the highest threshing percentage.

Table 3: Effect of Nitrogen and Potassium on yield and yield components of soybean-two-year average of 1994 and 1995

Nutrients/Levels of Nutrients in kg/ha		No. of branches per plant	No. of pods/ plant	Threshing percentage	100 seed weight in grammes	Grain yield in tonnes/ha
Nitrogen	0	2.31	12.20	58.22	12.17	1.22
	15	2.82	14.49	56.89	12.46	1.40
	30	3.01	16.61	60.03	12.51	1.41
	45	2.80	18.89	60.87	12.82	1.57
	60	2.85	16.86	57.9	12.80	1.46
Potassium	0	2.50	14.74	56.96	12.25	1.21
	15	2.63	15.75	58.08	12.53	1.33
	30	2.79	15.05	60.02	12.58	1.48
	45	2.94	16.92	58.37	12.89	1.51
	60	2.93	15.41	60.42	12.65	1.52
	75	2.77	14.84	58.84	12.40	1.41
LSD 0.05 between of N		0.60	2.80	NS	NS	0.19
LSD 0.05 between level of K_2O		0.33	1.14	NS	0.30	0.11
Interaction effect		*	—	—	*	*

NS-Non significant

* Significant interaction nitrogen and potassium

Nitrogen fertilization did not significantly affect the study with respect to 100 seed weight. Potassium however, had positive increases in 1994 and on the two year average. Potassium at 45kgk$_2$O/ha had a clearly significant beneficial effect on 100 seed weight from other levels of application. Analysis of the two year average revealed that 45kgk$_2$O/ha also beneficially influenced 100 seed weight even though this did not differ from those at 30 and 60kgk$_2$O/ha. When the combined effects of nitrogen and potassium on 100 seed weights were considered in Fig. 5, application rate of 30kgN/ha and 45kgk$_2$O/ha, 60kgN/ha and 45kgk$_2$O/ha and 45kgN/ha and 45kgk$_2$O/ha were beneficial combinations that gave higher 100 seed weights in 1995, whereas for the two year average shown in Fig. 6, 60kgN and 15kgk$_2$O/ha was the most beneficial combinations. The positive effect of potassium on 100 seed weight is indirect as Beringer (1980) indicated that potassium plays an active role in the active transport of photosynthete from source (leaf) to the sink (seed) and it is involved in the uptake of phosphorous which is an active participatant in the dry matter accumulation (Chevalier, 1976). Grain yield was significantly increased by nitrogen and potassium fertilizer treatments. The 45kgN/ha had a more beneficial effect on grain yield although its effect was not significantly different from those obtained from plots that receive 15, 30 and 60kgN/ha in 1994 and the two year average but in 1995, 45kgN/ha rate had the most beneficial effect that differed significantly from other levels of application. Potassium fertilization was beneficial in 1994 and on the two year average. Potassium application at the rates of 45kgk$_2$0/ha and 60kgk$_2$0/ha has statistically similar effect on grain yield whereas on the two year average, potassium fertilizer applied at the rate of 30, 45 and 60kgk$_2$0/ha had similar effect on grain yield with highest yield recorded at 60kgk$_2$0/ha. Also significant interaction effect between nitrogen and potassium fertilizers on grain yield was observed in Fig. 7, the highest grain yield was attained when 45kgN/ha and 45kgk_2O/ha are combined. The beneficial effect of nitrogen on grain yield may be due to the role of nitrogen in increasing the seed weight as was earlier observed by Kang (1975) or improved podding due to nitrogen application as observed by Brevedan (1980).

The beneficial effect of K on grain yield confirmed observations by Beringer (1980) that adequate potassium nutrition produces healthy plants with improved nodulation and reduced lodging which may have adverse effect on yield. Moreover, the role of potassium in active transport of photosynthate may account for the significant influence of potassium on grain yield of soybeans.

REFERENCES

Balarabe, R., Fisher, N.M., and Yusuf, Y. , 1982. Findings on recent agronomic research with soybeans at I.A.R., A.B.U., paper presented at the Second National Meeting of Soybean Scientists, Zaria.

Beringer, H., 1980. Functions of potassium in yield formation. In pro. of workshop jointly organized by Int'l Inst. of Tropical Agriculture (IITA) and International Potash Institute held in Basel Switzerland.

Bezdicek, D.F., Mulford, R.F. and Magee, B.H. 1974. Influence of organic nitrogen nodulation, nitrogen fixation and yield of soybeans. Proc. Soil Sc. Soc. America, 38: 268 - 273.

Bouyoucos, G.J., 1962. Improved hydrometer method for making particle size analysis of soils. Agron. J. 54: 464 - 465.

Bray, R.H. and Jurtz, L.T., 1945. Determination of total organic matter and available form of phosphorous in soil, Soil Science, 59: 39 - 45.

Brevedan, R.E., 1978. Influence of nitrogen nutrition on flower, pod abortion and yield of soybeans, Field Crop Abstract, 33(6): 456.

Camper, H.M. and Lutz Jr. J. A., 1977. Plowsole placement of fertilizer for soybeans and response to tillage of Plowsole Agron. J. 69: 701 - 704.

Chesney, H.A.D., 1973. Performance of soybeans in Guyana in the wet tropics as affected by nitrogen, phosphorous and potassium, Agron J. 63: 887 - 889.

Chevalier, H.,1976. Response to potassium fertilizer absorption ,pattern of soybeans CV. Altoma. Station Agronomique 68 - Aspach le Bas France - Information Technique, 53: 2-5.

Cox, F.R. and Uribe, E., 1992. Potassium in two humid tropical ultisols under corn and soybeans. Cropping system II dynamics. Agron J. 84: 485 - 489.

Dobereiner, J., 1974. Inheritance of plant and soil factor in soybean nodulation in tropical and sub-tropical conditions. University of Illinois of Urban Champaign College of Agriculture. INTOSY SERIES 2: 87-96.

Enwesor, W.O.E., Udo, E.J. and Sobulo, R.A., 1981. Soil fertility status and productivity of acid sands of South Eastern Nigeria. Monograph No. 1, Soil Science Society of Nigeria, pp. 56 - 73.

Fisher, N.M., 1980. A note on the agronomic research of soybeans. Proceedings of the First National Meeting of Nigeria Soybean Scientist held at the I.A.R. & T., Ibadan, 3-4 November, 34 - 40p.

Gomez, K.A. and Gomez, A.A., 1984. Statistical procedures for agricultural research. John Wiley and Sons, New York, 91 - 97p.

Goldsworthy, P.R. and Heathcote, R.G., 1964. Fertilizer trials with soybeans in Northern Nigeria, Expt'l Agric. 32: 257 - 262.

Harrow, R., 1962. Spacing and fertilizer application for soybeans. Research report: Harrowing Research Station, Ontario.

Henderson, J.B. and Kamprath, E.J., 1970. Nutrients and dry matter accumulation by soybeans. North Carolina Agric. Expt. Stat. Technique Bulletin.

IITA, 1979. Selected method of soil and plant analysis. Manual series, No. 1.

Kang, B.T., 1975. Effect of inoculation and nitrogen fertilizer on soybean in the Western Nigeria, Expt'al Agriculture. 11(1): 23 - 31.

Leffel, R.C., 1989. Breeding soybean for enhanced nitrogen metabolism. Proceeding world soybean research conference, Buenos Aries, 5-9 March, 1125 - 1130.

Mascarenhas, H.A.A., Crallo, J.R., Van Raij, B., Ique, T. and Batalgia, O.C., 1976. Effects of liming on chemical characteristics of the soil and the nutrition of soybean on a red latosol distrophic cerrado soil. Bragantia 35: 273 - 278.

Metcalfe, D.S. and Elkim, D.M., 1980. Crop production: Principle and practice (4th ed.) Macmillan Publishing Company Inc., New York.

Oko, B.F.D., Solomon, M.G. and Bakoh, M.Y., 1991. A note on the effect of planting date and density on the productivity of soybeans in a humid tropical environment. Tropical Journal of Applied Science, 1(1):38-41.

Pal, U.R. and Adedzwa, D.K., 1983. Nutritional disorders in soybeans in Benue State of Nigeria: A survey paper presented at 3rd National Meeting of Soybean Scientists, Makurdi, 2: 41 - 46.

Roselem, C.A., Mechado, J.R. and Ribeiro, D.B.O. , 1988. Formes de. Potassio no solo e nitricao potassio da soja Rev. Brass Gene. Sol. 12: 121-125.

Sable, R.N. and Khuspe, V.S., 1977. Response of soybeans Var Clark to application of bacterial culture, nitrogen and phosphorous fertilizer. Journal of Maharshtra University 2(1): 65 - 67.

Walkey, A. and Black, A.I., 1934. An examination of Detjareff methods of determining soil organic matter and a proposed modification of the chronic acid titration method. Soil Sc. 37: 29 - 38.

Weiss, E.A., 1983. Oil seed crops. Tropical agricultural series, Longman New York, 358 - 360p.