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Soyabean Response to different levels of applied Phosphorus and Nitrogen in the Southern Guinea Savanna of Nigeria

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Abstract

Two cultivars of soyaben (Glycine max (L) Merrill) were grown for two years under field conditions to evaluate the effects of N and P on nodulation and yield components. Inhibitory effects of N and on nodulation were observed. Yield components of the profuse nodulating cultivar (TGM 597) were negatively correlated, while those of the poor nodulating cultivar (TGX 536 – 02D) were positively correlated with applied N, indicating differential cultivar response to N. Phosphorus increased nodulation and yield of the two cultivars. There were indications that the optimum level of P for optimum soyabean yield would vary significantly with the level of the native soil available P, emphasizing the importance of soil analysis in P recommendations for soyabean.

Introduction

Soyabean is relatively new in the Nigerian farming system. However, it has a considerable potential as a grain legume in the system. Presently it has been adopted as one of the major arable crops and its commercial cultivation has become evident in many parts of Nigeria, particularly in the Savanna agroecological zone (Oyekan, 1987).

With the present trend of soyabean cultivation in Nigeria, a knowledge of the optimum levels of management practices for its maximum performance is relevant to its profitable production. One of such important management practices is fertilizer management in the crop. Information on fertilizer requirement of soyabean in Nigeria is meagre and reports from Nigeria and elsewhere are divergent. For example, nitrogen application to soyabean has been reported to produce significant increase in pod number, grain yield and seed size (Kang, 1975; Sorenson and Penas, 1978). Pal et al., (1985 and 1986) reported obvious yield advantage due to split application of N in some promiscuous varieties of soyabean. Gates and Muller, (1979) observe that nodulation in soyabean was very sensitive to levels of combination of nitrogen, phosphorus and sulfur with extremes of inbalance among the three nutrient elements significantly reducing nodulation and lowering grain yield, particularly when only N was applied. Some studies in the Guinea Savanna of Nigeria indicated that the response of soyabean to fertilizer N was inconsistent (Goldsworthy and Heathcote, 1984).

The beneficial effects of P on nodule production and seed yield of soyabean have been demonstrated (Gates and Muller, 1979, Tomar and Dev., 1973). Ayodele and Aladesaiye (1987) obtained significant yield increase with the application of 30kg ha^{-1} each of N, $P_2 0 5$ and $K_2 0$ in the forest agroecological zone of Nigeria. However, other works have shown that P is not essential for nodulation and grain yield increase in soyabean (Singh and Sazena, 1973). de Mooy and Pesek, (1966) reported that P improved nodulation in soyabean only if sufficient calcium was applied.

The conflicts in soyabean response to fertilizers could perhaps be attributed to marked differences in environmental conditions under which the reported experiments were carried out, but more importantly it may be due to interaction effects of nutrient elements. The appreciable interaction effects of calcium and phosphorus (de Mooy and Pesek, 1966), nitrogen, phosphorus and sulfur (Gates and Muller, 1979), phosphorus and zinc (Pal *et al.* 1986) on soyabean nodulation and yield suggest that there is need for proper balance among certain essential nutrients for optimum soyabean performance.

In view of the above and the divergent reports, more information on the fertilizer requirements of soyabean is needed in the Guinea Savanna of Nigeria. This work was therefore designed to study the effects of different levels of N and P on nodulation and grain yield of two soyabean cultivars under field conditions in the southern Guinea Savanna agroecological zone of Nigeria.

Materials and Methods

Two experiments were conducted on a loamy sand soil at the University of Ilorin Teaching and Research farm, Nigeria in 1993 and 1994. The location of the farm is 8^0 29'N and 4^0 35'E and about 307m above sea level. The characteristics of the soil before the commencement of the experiments in 1993 were: PH, 6.2; organic matter 1.1%; total N, 0.08%; available P,4.6ppm; exchangeable Ca, Mg, Na and K, 0.72, 0.18, 0.16 and 0.23 C'–mol (+) Kg^{-1} soil, respectively. In 1994, the crop was planted on a plot adjacent to the plot used in 1993 but it was not cropped in 1993.

The treatments consisted of factorial combinations of 0, 20, 40 and 60 kg N ha^{-1} and 0, 40, 80 and 120 kg of P_2O5 ha^{-1}, on two cultivars of soyabean, in randomized complete block design with four replications. The experimental plot size per treatment combination was 6m x 4m. The sources of phosphorus and nitrogen were 18% single superphosphate and 26% calcium ammonium nitrate, respectively. The P fertilizer was broadcast and incorporated into soil with hoe just before planting and the nitrogen fertilizer was applied along the crop rows two weeks after planting (WAP). Potassium was applied at the rate of 30 kg K_20 ha^{-1} to all plots at the planting time as muriate of potash.

Soyabean, cultivars TGM 579 and TGX 536 – 02D were planted at 100 kg seeds ha^{-1}, drilled in rows spaced 60 cm apart. TGM 579 is tall growing (90 – 100 cm), indeterminate and nodulate profusely while TGX 536 – 02D is determinate with medium height (65 – 70cm) and poor nodulation. The two varieties mature in about 100 to 110 days. Planting was done on 26 June each year.

For nodule number and weight at 7 WAP, plants within an area measuring 50cm x 50cm in the outer two rows of crop in each plot were carefully dug up to a depth of about 50cm and the soil carefully shaken away and the roots washed and the nodules recovered. The number of plants which occupied the 50cm by 50cm area were also counted. Two of such samples were taken per plot. The nodules were counted and later dried in the oven at 70^0C for nodule dry weight. Grain yield was obtained from the inner $12m^2$ per plot, adjusted to 12% moisture content. All the data were subjected to statistical analysis. Quadratic form of regression model was also employed to relate nodulation characteristics or grain yield of each soyabean cultivar, Y to factors of phosphorus (P) or nitrogen (N) fertilizers as follows:

$$Y = a + b_1 p + b_2p^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{Equation (1)}$$

$$Y = a + b_1N + b_2N^2 \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad \text{Equation (2)}$$

Where applicable linear form of regression model was also used.

Results and Discussion

The effects of fertilizer N and P on pod number and grain yield of the two soyabean cultivars are presented in Table 1 and figure 1, respectively. Response to applied N varied significantly with cultivar. Variety TGM 579 showed negative response to increasing levels of N while TGX 536 – 02D responded positively. Generally, levels of N between 0 and 40kgha^{-1} did not significantly reduce pod number in TGM 579 but the number dropped appreciably when N was increased to 60 kg ha^{-1} (Table 1). Applied N did not improve the grain yield in TGM 579. Application of

N at 20 kg ha^{-1} significantly increased pod number in TGX 536–02D over the no-nitrogen treatment but further increase in pod number with increasing levels of N above 20kgha–1 was not appreciable. Similar trends were observed in the grain yield of TGX 536–02D (Figure 1). Highly significant negative correlation ($r = -0.92$) and positive correlation ($r = 0.94$) between pod number $plant^{-1}$ and levels of N were obtained for TGM 576 and TGX 536–02D, respectively, which indicated that applied N impared the yield performance of the profuse nodulating cultivar TGM 579, while it improved that of the poor nodulating cultivar TGX 536–02D. The result is in line with that of chandel *et al,* (1989) who reported that increasing levels of applied N consistently increased grain yield of non-nodulated soyabean cultivars. Pal *et al,* (1985) demonstrated the obvious yield advantage due to split applications of N in some promiscous varieties of soyabean and pointed out that such varieties are not capable of fixing enough nitrogen symbiotically for production of maximum yield. It is then clear from the results that while applied N is important for the nitrogen nutrition of TGX 536–02D, it is not for TGM 579. Chandel *et al* (1989) obtained increases in tissue nitrogen content of non-nodulated soyabean cultivars with increasing rates of applied N. The differential cultivar response is an indication that N application to improve soyabean performance could vary significantly with cultivars. A general recommendation of N application to soyabean without cognisance of differences in varietal response would therefore not be appropriate.

Pod number and grain yield significantly increased with P application in the two soyabean cultivars. The no-phosphorus treatment gave the least while 80kg ha^{-1} of P produced the highest grain yield and number of pods $plant^{-1}$. However, levels of P exceeding 80 kg ha^{-1} resulted in reduction in pod number and grain yield. Similar trends of response to P was observed at each level of applied N in the two cultivars. The NxP and other interactions were not significant. The results generally indicate a highly significant curvilinear effect of P on grain yield which responded strongly to P with high regression coefficient (R^2) values for the regression (Figure 1). This is an indication that P is very important for soyabean grain production. Pal & Kalu (1987) recorded 104% yield increase averaged over 3 soyabean cultivars when the level of applied P was increased from 0 to 32 kg P_205 ha^{-1} in the northern Guinea savanna of Nigeria. The yield increase was even more dramatic when adequate amount of zinc was applied together with P. As shown in figure 1, the optimum level of P for soyabean on the soil used in this study was between 60 and 80kg ha^{-1}. Pal & Kalu (1987) did not get grain yield response to P, beyond 32 kg P_205 ha^{-1} in the northern Guinea savanna of Nigeria. The level of the soil native P in their study was however not indicated. Ham *et al* (1973) recorded increasing seed yield for 3 soyabean cultivars with increasing levels of P in the range of 0 to 60 kg P_205ha^{-1}, on soils where the native soil available P ranged from 7 – 10 ppm. The soil used in this present study is inherently poor in P and P-bearing minerals, the native soil available P being 4.6ppm. It is therefore, reasonable to infer from the results that P for optimum soyabean performance would vary significantly with the level of soil available P. There is therefore the need to stress the importance of soil analysis in recommendation of P for soyabean.

The effects of nitrogen and phosphorus fertilizers on nodule number and dry weight are presented in figures 2 and 3. There was marked difference in nodulation between the two soyabean cultivars when grown without fertilizers. TGX 536 – 02D had the lower nodule number and weight. This cultivar has been identified as promiscuous (Pal *et al*), (1986). Nodule number and weight responded positively to increasing levels of P up to 80kg P_205ha_{-1} but negatively to increasing N levels in the two cultivars. Interactions were not significant.

Applied N inhibited nodulation and its increasing level aggravated reduction in nodule number and weight in the two cultivars. Inhibitory effects of N on nodulation in cowpea has been reported (Olofintoye, 1986). It has been mentioned earlier in this text that applied N improved the nitrogen nutrition of the promiscus cultivar TGX 536–02D. However, the nodulation response of the two cultivars to N has clearly shown that the beneficial effects of applied N on the nitrogen nutrition of the promiscuous cultivar is neither via nodule number nor development.

Nodule number and weight response to increasing P levels was quadratic, the curves sloping up at a decreasing rate as P increased from 0 to 80 $kgha^{-1}$ and came to a peak at 80 kg P ha^{-1} after which there was either a decrease or no more increase (figures 2 and 3). de Mooy and Pesek (1966) obtained significant increase in nodule number, weight and nodule leghemoglobin content in five soyabean plant introductions with increasing level of P. The leghemoglobin content of soyabean nodules has been strongly positively correlated with N – fixing capacity (de Mooy and Pesek, 1966). The results therefore, indicate that P increase the nitrogen nutrition of soyabean and thus confirm the observation made earlier in the text that P is very important for soyabean grain production.

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Table 1: **Effects of applied N and P at different levels on pod number (no plant^{-1}) of two soyabean cultivars^{+}.**

Cultivar TGM 579						Cultivar TGX 536 - 02D					
N applied (kg h^{a-1})	P applied (Kg h^{a-1})				Mean*	N applied (kg ha-1)	P applied (kg h^{a-1})				Mean*
	0	40	80	120			0	40	80	120	
0	76	82	74	59	72.8a	0	40	52	55	54	50.3b
20	56	76	80	78	72.5a	20	42	54	68	55	54.[illegible]a
40	53	70	88	71	70.5a	40	43	57	62	60	55.5a
60	52	70	71	71	66.0b	60	59	63	57	50	57.3a
Mean*	59.3c	74.5a	78.3a	69.8b		Mean*	46.0c	56.5ab	60.5a	54.8b	

+ Average for two experiments

* Means in a column or row followed by the same letters are not significantly different at 5% level of probability (Duncans multiple range test).

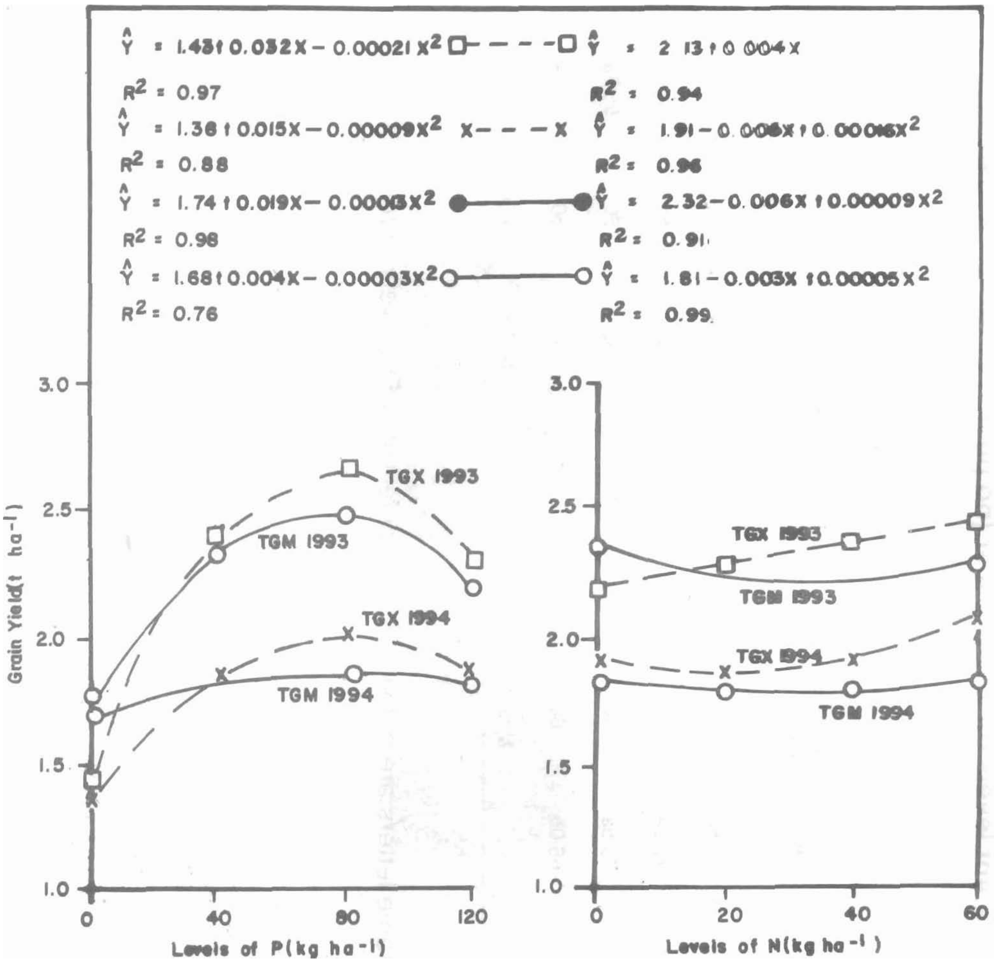

FIG. 1: YIELD RESPONSE OF TWO SOYA BEAN CULTIVARS (TGM 579 AND TGX 536-02D) TO LEVELS OF P AND N IN 1993 AND 1994

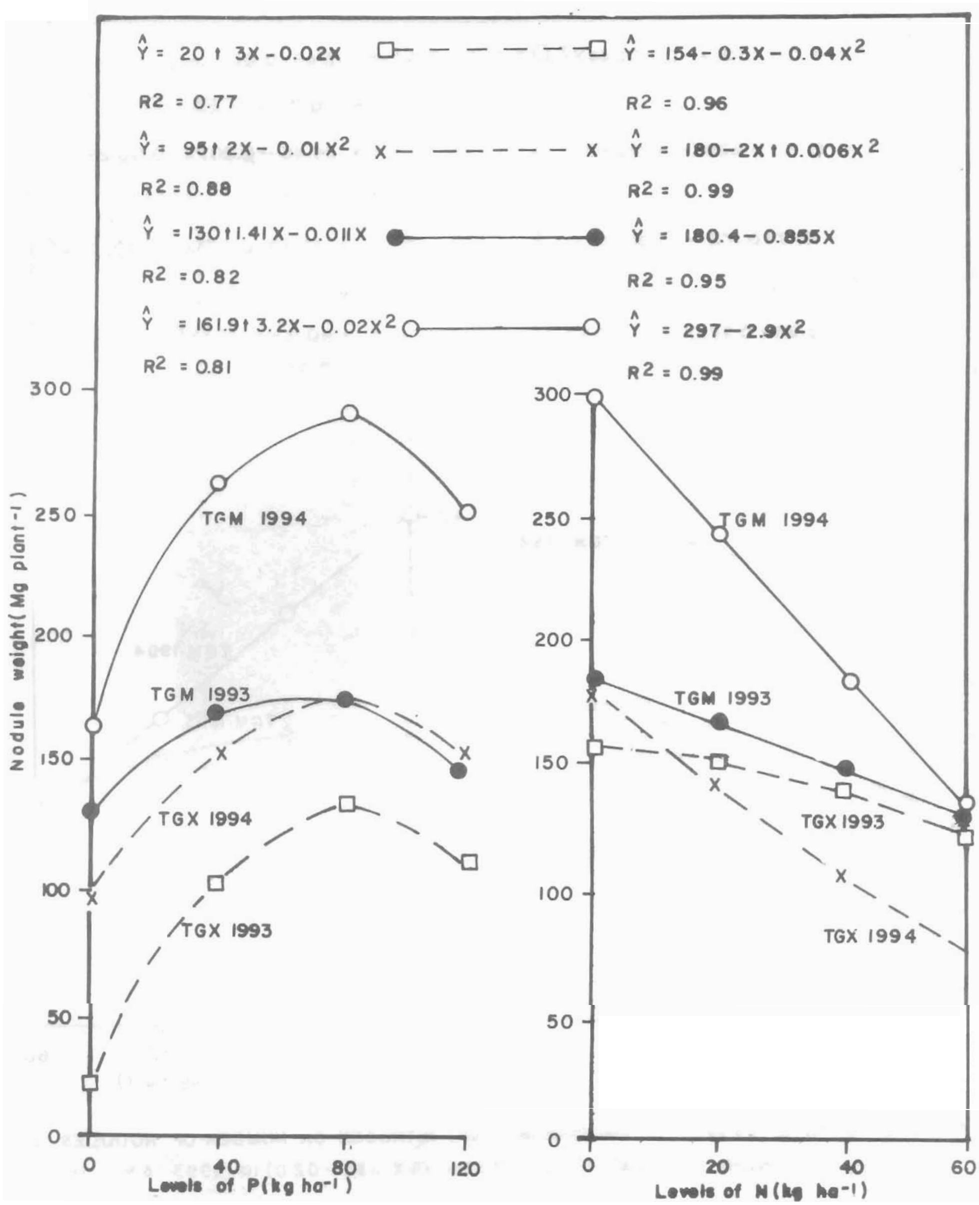

FIG. 2: EFFECTS OF LEVELS OF PHOSPHORUS AND NITROGEN ON NODULE WEIGHT OF TWO SOYA BEAN CULTIVARS(TGM 579 AND TGX 536-02D) IN 1993 AND 1994

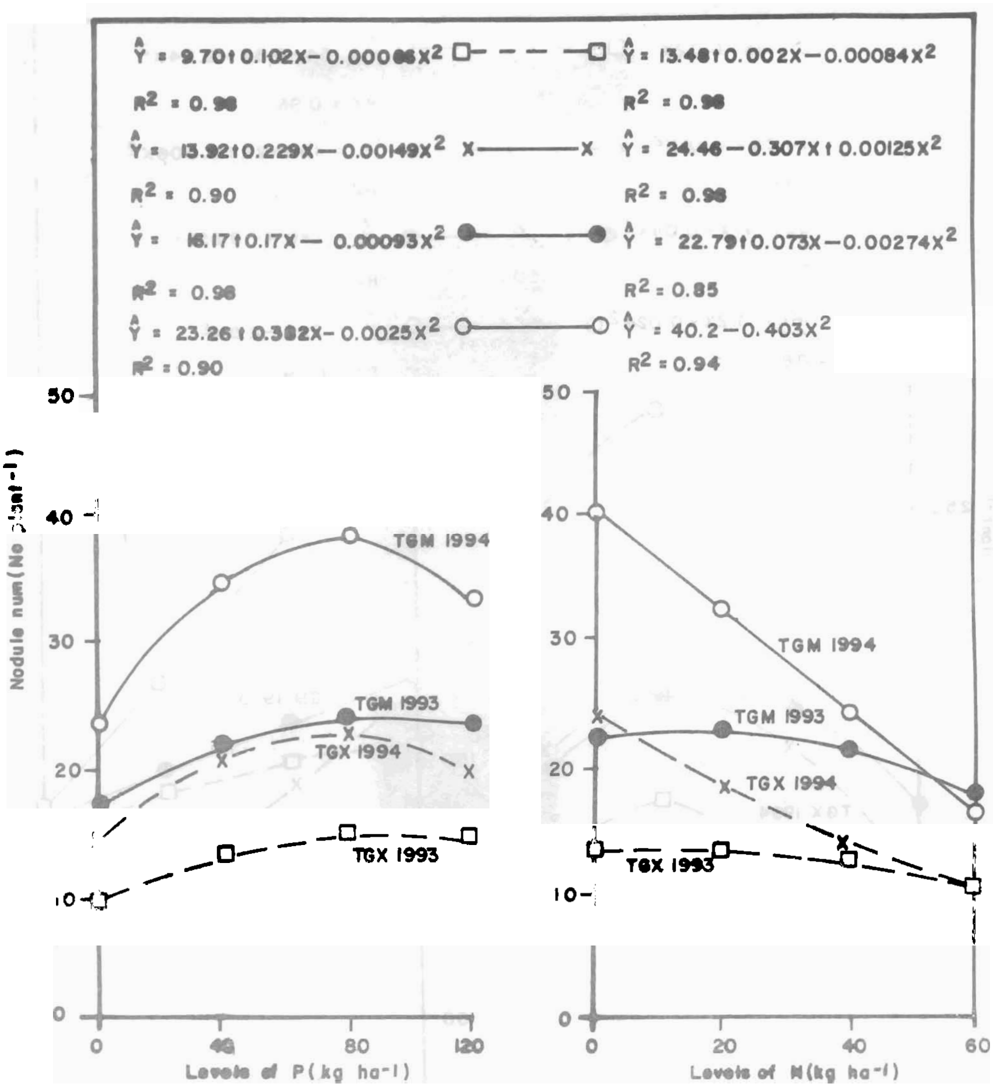

FIG. 3: EFFECTS OF LEVELS OF PHOSPHORUS AND NITROGEN ON NUMBER OF NODULES OF TWO SOYA BEAN CULTIVARS (TGM 579 AND TGX 536−02D) IN 1993 AND 1994