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Response of soybean to zinc and phosphorus in charnockitic soils of Ekiti state, Nigeria

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ABSTRACT

Field Studies were conducted in order to determine the component of yield and response of soybean to soil applied Zinc and phosphorus in the Charnockitic soil of Ekiti State Nigeria. Three $ZnSO_4$ treatments 0,2 and 4kg/ha were applied to soybean in2006-2007 and grain yield was consistently and significantly increased by the 2kg/ha $ZnSO_4$ treatment. Three phosphorus treatments 0, 30 and 60kg/ha were applied to soybean in 2006-2007, but only 30kg/ha P treatment increased grain yield significantly in 2006-2007. 30kg P/ha applied increased leaf P in the charnockitic soil.

Introduction

Studies have been conducted periodically over the years in Nigeria on the need of micronutrients especially zinc by soybean. However, an evaluation of the need for and response to micronutrients, especially to Zn has not been conducted on charnockitic soils of Ekiti State. Charnockite are found on every continent, it occurs in Africa at locations which include Ekiti State of Nigeria. Charnockite is a deeply batholith, grouped as a basement complex member. The basement complex rocks include igneous and metamorphic rocks of diverse origin and chemical composition. It is found in the following local government areas (LGAs) of Ekiti State. Ado Ekiti, Gboyin in areas around Ijan, Aisegba, Ode, Ikere and Ikole comprising Ijesa-Isu, Ipao, Ayebode Ekiti (Ekiti investor Handbook 2002). Similarly, all over the world poor growth of soybean has also been attributed to number of factors that include low p^H , high level number of Al, Mn and H, low levels of Ca and the Phosphorus(P) Fagena, (1994). The components that determine the final seed yield of soybeans are Pod/m^2 seeds/pod and seed weight (Ohki, 2007), each of which is influenced by nutrition such as Zinc and Phosphorus. The effect of Zn and P nutrition on yield and other yield components in the charnockitic soils have not been documented to date.

This study was therefore undertaken to test the response of an improved soybean TGX1444-LE which is high yield and relatively resistant to shattering to varying levels of zinc and phosphorus fertilizers.

Materials and Methods

Field experiments were done in each of two years at Ikere (7^0 47^1 N 5^0 23E), Ado (7^0 49^1 N 5^0 27E) and Ijan(7^0 38^1N 5^0 23^1E) during the rainy seasons of 2006 and 2007 representing respectively some of the charnockitic soils of Ekiti in Nigeria. Soils at Ikere, Ado and Ijan are ferric lixisols, derived from basement complex rock (USDA 1975).

The experiments were randomised complete block design with three replicate and three levels of Zinc; 0, 2 and 4kg/ha $ZnSO_4$ and three levels of phosphorus (0, 30 and 60kg/ha single super phosphate (SSP). Each treatment plot size was 3×3m. An improved soybean variety TGX 1440-LE released by interaction institute for Tropical Agriculture (IITA) was sown on flat at 75cm×10cm and thinned to two seedling per stand (equivalent to 1333,333 plants/ha).

Planting was done with early rains in April across the three sites. All the fertilizer was branded on one side of a soybean row in each plot at planting 7.5cm away from the the seed row. Basal application of starter N at the rate of 15kg/ha as Urea (46%N) was applied to all treatments.

The plots were kept free of weeds by applying Galex pre-emergence (metachlorx metabronron in the ratio 1:1)

Ten plants per plot were sampled to determined effects of treatments on such parameters such as pod yield per plant, 100-seed weight. Grain yield was determined by hand-harvesting the four inner rows of the plot (10.2m^2) the harvested plants were hand-threshed, winnowed and cleaned and the grain collected.

The data collected for each year were analysed individually, and both years were combined and analysed statistically. The treatment were compared using least significant difference (LSD) as described by Snedecor and Cochran(1982).The experiment was repeated on different charnockitic sites of Ikere, Ado and Ijan in 2006 and 2007.

Results And Discussion

Charnockitic soils of Ikere had lower silt plus clay content, N, organic matter, Zinc contents, than the charnockitic soils of Ijan and Ado (Table 1). The level of zinc at Ikere soils is attributed to the low level of organic matter, silt plus clay content . Armour et.al 1999,. Chude and Obigbesan 1983 found correlations between organic matter, slit plus clay content and extractable Zinc in the soils of Western Australia and soils of

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Western Nigeria respectively. The soils are generally sandy, Sand is the dominant fine earth fraction(less than2mm) portion. The high sand (an average of 70%) content of the soils is largely a reflection of the parent materials from which the soils were formed. The silt content in all the soils ranged from 4-10%.This content agrees with those soils from most other sandy soils of the south western Nigeria characterized by low silt(<10-15%content) Shittu and Fasina 2004

The available P is low and fluctuated irregularly across the sites. The available P critical level status for southwest Nigeria soils is between 8-20mg/kg.

Zinc Experiments

Application of $ZnSO_4$ at 2kg/ha consistently increased the pod yield per plant in three locations (Ikere, Ado and Ijan in both years). (Tables 2, 3 and 4) Application of Zn fertilizer significantly($p<0.05$) increased pod yield per plant when applied at 2kg Zn ha^{-1} than 4kg Zn ha^{-1} which in turn was greater than application of 0kg $Znha^{-1}$ .Soybean grain yield per plant, however, was increased by 2kg/ha $ZnSo_4$. This consistently gave the largest yield and the response was significant.($p<0.05$). The 0kg/ha $ZnSo_4$ tended to produce the smallest increase in grain yield in all the sites at the second season (2007). Application of 2kg/ha $ZnSo_4$ gave significantly better 100-seed weight over the 4kg/$ZnSo_4$ in 2006 and 2007 respectively. Application of Zn increased 100- seed weight in both years with 2kg $ZnSo_4$ /ha producing the heaviest seeds in all the locations.

The response to $Znso_4$ was larger in ikere where the soil had least extractable zinc, the concentration being slightly less than the critical value of 1mg/kg for soybean (Sims and Johnson 2001). The high level of soil Zn in Ado and Ijan is attributed to the extra organic matter and silt plus clay. Chude and Obigbesan (1983), Armorr et al. 1996 found significant positive correlation between organic matter, silt plus clay content and extractable Zn in soils of Western Nigeria and Western Australia.

There is a significant difference($p<0.05$) in pod yield per plant, 100-seed weight and grain yield per plant between control and treatments having 2kg $ZnSo_4$ ha^{-1} in all locations. The control had the smallest pod yield per plant of 18.01g and 18.56g in 2006 and 2007 seasons. Lowest seed weight of 10.06 and 10.26g compared with the highest values in treatments containing 2kg $ZnSo_4$ ha^{-1} (14.13 and 15.46g) in 2006 and 2007 respectively. Similar results were obtained by Okpara and Ibiam(2000) who evaluated soybean varieties for suitability to a humid tropical environment and found that TGX 1440-IE had low pod number(10.3) but high seed weight(14.3g) and so gave the second highest yield of 1111.1kg/ha. Moragham(1970) had noted that larger seed size is associated with higher yield. Yield increases most often result from increase in pod yield per plant and seed weight. As indicated in the results, there was significant difference ($p<0.05$) in pod yield per plant between control and treatment having 2kg $ZnSo_4$ ha^{-1} . This can be explained by the fact that soybean plant is unique in a way that an increase in one component may be compensated for by other component influencing yield.

Phosphorus Experiments

Application of P fertilizer had significant effect on pod yield per plant in the year 2006 and 2007 in all the locations.(Tables5,6 and7) P application at 30kg p ha^{-1} was significantly ($p<0.05$) higher in both years than when 0kg P ha^{-1} was applied. The 30kg p/ha treatment consistently increased the pod yield per plant in all location. There was no significant effect of P on seed weight in both years in all the locations. The 30kg P ha treatment consistently increased the 100-seed weight in the three locations. The increase in 100-seed weight was not significant. P-fertilizer had no effect on grain yield per plant in both years in all locations. P applied at 30kg P ha^{-1} in 2006 and 2007 gave seed yield/plant higher than the respective control but the effect was not significant.

The response of applied P was not spectacular despite the low levels of available P in the soil yield component such as grain yield per plant, 100-seedweight were not significantly influenced by P application contrary to findings of Chiezey et al(1991 and 1992), Olufajo et al (1984). Lower response to P observed in 2007 on grain yield per plant and 100-seed weight could be due to early cessations of the rains which probably caused non completion of grain filling. However, the results of 2007 in the locations showed a positive response, indicating that P is crucial to soybean yield components such that yield of pods per plant increased significantly ($p<0.05$). Ogoke et al (2004) working in the guinea savannah reported that sites were responses were observed due to low initial soil test P, 30kg P ha^{-1} application may not be desirable for soybean even when soil test P is low.

The response of soybean pod yield per plant to applied P in the three locations can be attributed to the initial level of the extractable soil P, which was less than 15mg/kg,the value above which yield response unlikely(Adepetu, 1976). Pod yield and 100- seed weight which is important determination of grain yield increased across the locations with P application.

These resulted in increase in grain yield per plant though not significant ($p<0.05$). The response to P application on grain yield was more visible in 2006 because of the low level of P in the experimental plot in 2006 compared with the P level in soils of 2007.

In 2007, the experimental sites had about between five to seven times the levels of P compared to the initial soil of 2006, therefore the response to extra P was minimal. There was significant response to P application at 30kgP/ha in all the three locations, this same response was observed by Pal et al.1983 and Chiezey et al.1992.It could therefore be concluded that application of P not exceeding 30kgP/ha will significantly increase grain yield of soybean

Chemical analysis of the vegetative portion at 50% flowering (8WAS) revealed that 30kgP/ha application in all the locations gave a higher P-content than when 60kgP/ha was applied (Table8). It is suggested that repeated application of P increased values of leaf P and K content than when 60kgP/ha was applied. The values of leaf- P due to P-fertilization application across the sites were above the critical values of 0.25 -0.39% for soybean (Ohlrogee1960, Nelsonand Barber1934, Melstead et al.1969, and deMooy1965) in the second year 2007

Conclusion:

Zinc applied at 2kg $ZnS0_4$ /ha and Phosphorus applied at30kgSSP/ha significantly improved the availability of nutrients to soybean plants in chanockitic soils testing low in P and Zn..Higher rates of Zn and P applied had no significant yield advantage The improved availabilities of N,P,K,Ca and Mg as indicated by leaf analysis were matched by increases in yield and yield components. Results from the study sites presented here suggest that application of 2kg$ZnSO_4$/ha and 30kgSSP/ha will increase soybean production significantly in charnockitic soils of Ekiti, Nigeria. Zn at the rate of 2kg/ha and P at the rate of 30kg/ha are recommended for inclusion in fertilizer programmes for soybean.

Table 1. Results of soil analysis at three charnockitic locations in Ekiti state

Location	pH	organic matter (%)	Nitrogen (%)	Sand (%)	Slit (%)	Clay (%)	phosphorus mg/kg	Zinc mg/kg
			2006					
Ado	6.30	5.60	0.21	83.24	9.00	7.76	0.06	0.53
Ikere	7.00	4.00	0.04	89.24	5.00	5.76	1.36	0.42
Ijan	7.50	5.04	0.08	83.24	10.00	6.76	0.27	0.58
			2007					
Ado	6.40	5.66	0.23	78.24	6.00	7.78	5.58	0.58
Ikere	7.08	4.52	0.08	78.24	4.00	5.86	6.65	0.53
Ijan	7.55	5.26	0.15	82.38	10.00	5.82	6.58	0.67

Table 2: Effect of three rates of zinc application on yield and yield components of soybean in charnokitic soils of Ado Ekiti

Year	$ZnSO_4$ Applied kg/ha	Pod Yield per plant(g)	100 seed weight(g)	Grain Yield per plant(g)	Grain Yield in kg/ha
2006	0	17.60b	10.06b	8.75b	2486.5b
	2	21.30a	13.21a	11.30a	4046.3a
	4	18.01b	11.20b	9.72b	4067.5a
2007	0	18.56c	10.26b	11.74b	1986.8b
	2	23.16a	12.73a	15.32a	3056.3a
	4	20.71b	11.96b	12.48b	29644.8a

Means with the same letter in each column for each rates are not significantly different by DMRT. $P<0.05$

Table 3: Effect of three rates of zinc application on yield and yield components of soybean in charnokitic soils of Ikere Ekiti.

Year	$ZnSO_4$ Applied kg/ha	Pod Yield per plant(g)	100 seed weight(g)	Grain Yield per plant(g)	Grain Yield in kg/ha
2006	0	20.32b	13.06b	10.75b	3512.3c
	2	24.60a	14.13a	13.94a	4831.2a
	4	21.71b	13.56b	11.49b	4214.3b
2007	0	21.29b	13.49b	13.23b	2000.4b
	2	26.73a	15.46a	17.41a	2932.6a
	4	23.29b	12.58b	14.43b	2816.4a

Means with the same letter in each column for each rate are not significantly different by DMRT. $P<0.05$

Table 4: Effect of three rates of zinc application on yield and yield components of soybean in charnokitic soils of Ijan-Ekiti

Year	$ZnSO_4$ Applied kg/ha	Pod Yield per plant(g)	100 seed weight(g)	Grain Yield per plant(g)	Grain Yield in kg/ha
2006	0	20.52b	12.06b	10.60b	3120.4b
	2	23.72a	14.05a	12.81a	4067.4a
	4	18.65c	13.62b	11.02b	4129.9a
2007	0	21.16b	12.14b	13.84b	2100.4b
	2	25.14a	15.23a	16.52a	2816.3a
	4	22.20b	13.50b	14.58b	2808.8a

Means with the same letter in each column for each rate are not significantly different by DMRT. $P<0.05$

Table 5: Effect of three rates of phophorus application on yield and yield components of soybean in charnokitic soils of Ijan Ekiti

Year	SSP Kg/ha	Pod Yield per Plant (g)	100 Seed Weight (g)	Grain Yield per Plant in g	Grain Yield kg/ha.
2006	0	17.60b	11.58	12.58	1720.3b
	30	19.28a	12.67	12.78	2458.8a
	60	19.10a	12.42	13.26	2300.2a
2007	0	19.68b	9.58	12.43b	1473.6b
	30	21.42a	10.76	14.78a	1654.8a
	60	20.36a	10.78	14.92a	1621.4a

Means with the same letter in each column for each rate are not significantly different by DMRT. $P<0.05$

Table 6: Effect of three rates of phosphorus application on yield and yield components of soybean in charnokitic soils of Ado-Ekiti

Year	SSP Kg/ha	Pod Yield per Plant (g)	100 Seed Weight (g)	Grain Yield per Plant in g	Grain Yield kg/ha.
2006	0	20.60b	14.28	13.98	1516.5b
	30	23.42a	14.72	14.26	2400.2a
	60	20.78b	14.34	14.14	2318.5a
2007	0	20.46	9.58	14.26	1315.5b
	30	22.75	10.76	16.78	1519.6a
	60	21.43a	10.28	15.47	1582.7a

Means with the same letter in each column for each rate are not significantly different by DMRT. $P<0.05$

Table 7: Effect of three rates of phosphorus application on yield and yield components of soybean in charnokitic soils of Ikere Ekiti

Year	SSP Kg/ha	Pod Yield per Plant (g)	100 Seed Weight (g)	Grain Yield per Plant in g	Grain Yield kg/ha.
2006	0	21.80b	13.56	13.05	1665.5b
	30	24.38a	13.61	13.88	24500.2a
	60	21.93b	12.53	13.45	2386.1a
2007	0	21.80	11.33	12.93	1487.5
	30	23.38	12.53	13.11	1667.8
	60	22.43	11.93	13.07	1618.9

Means with the same letter in each column for each rate are not significantly different by DMRT. P<0.05

Table 8: Mean leaf chemical composition of soybean under phophorus treatment in all locations (Ado, Ikere, Ijan) in 2007

Location	Phosphorus applied	N%	P%	K%	Ca%	Mg%
Ikere	0	3.6	0.04	2.7	0.4	0.3
	30	4.8	0.68	2.8	0.4	0.3
	60	2.9	0.18	1.30	0.4	0.3
Ijan	0	3.5	0.02	2.5	0.4	0.2
	30	3.8	0.64	2.6	0.4	0.3
	60	2.07	0.14	1.27	0.4	0.3
Ado	0	3.2	0.02	2.5	0.5	0.2
	30	3.6	0.58	2.5	0.5	0.2
	60	2.05	0.10	1.27	0.5	0.2

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