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Nutrient Composition Of Soybean (*Glycine max* L.) In Response To Phosphorus Fertilizer Concentrations

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Abstract

The types and amount of nutrient applied to the soil are key factors in crop production. A field experiment was carried out at the out – station of the Institute of Agricultural Research and Training (IAR&T), Ikenne, Ogun State to examine the effect of different Phosphorus Concentrations on yield, protein, mineral and vitamin content of Soybean Seed. The experiment was laid out in the Randomized Complete Block Design (RCBD) with three replicates. Each replicate measured 11.2 x 2m^2 separated by 1m apart consisting of 4 plots of 2 x 2.4m^2 separated by 0.5m. The treatment were different rates of phosphorus fertilizer applied at 20kg/ha, 40kg/ha, 60kg/ha and at zero level. Soybean seed used was TGX 1440 – IE. Cultural practices were carried out and data taken. At maturity soybean grains were harvested, threshed and weighed in kg/ha. The grains were analyzed for proximate and mineral composition. The result showed that application of 60kg P/ha significantly ($p<0.05$) gave the highest grain yield of 190.76 kg/ha than other treatments. Proximate analysis result showed that soybean treated with 60kg/ha of phosphorus had the highest protein content (39.50%). While crude fat, was not affected by application of phosphorus. Phosphorus at zero levels gave high values of iron and calcium content (18.01mg/kg and 324.02Cmol/kg respectively) while 20kg/ha level of phosphorus gave highest value for magnesium content (338.74Cmol/kg). The study therefore recommends application of Phosphorus at the rate of 60kg/ha for optimum soybean grain yield with high protein content.

Key words: *Soybean, Phosphorus, Grain, Yield, Proximate*

Introduction

Soybeans are a widely consumed agricultural commodity around the world in many forms, such as the whole soybean, soy oil and soy meal (Fearnside, 2001). Soybean as described is known as “miracle bean” or the “golden bean” because it is a cheap, protein rich grain with a high protein content of about 40% which is superior to all other plant foods and it has a good balance of the essential Amino acids (Omotayo *et al.*, 2007).

Soybean quality and protein content is influenced by nutrient availability and phosphorus has a positive effect upon its protein content. Phosphorus application is necessary for high protein and yield of soybean grains (Shah *et al., 2001)* and yield components like the straw (Cheizey 2001). Soybean contains approximately 37 – 41% protein, 18 – 21% oil, 30 – 40% carbohydrate and 4 -5 Ash research has shown that (Morrison *et al, 2000*). Generally, soybean is regarded as a highly versatile and multipurpose agricultural product that has about three hundred and sixty-five (365) application in the formulation of both human, animal foods and other industrial uses, soybean has the highest protein content of all field crops and is the second only to groundnut in terms of oil content among the food legumes. (Hungria and Mendes, 2015). The protein in soybean contains amino acids required for human nutrition and that of livestock (Zarei et al; 2012). For this reasons soybean has been recognized as one of the premier agricultural crops today, thus it is the best source of protein and oil, and now been recognized as potential supplementary source of nutritious food (Wilcox and Shibbles, 2001).

Phosphorus has significant implications on growth and yield of soybean attributes (Kumaga and Ofori, 2004). Small quantity of phosphorus in the soil is a key obstacle to the growth as well as yield of soybean. Soybeans thrives well on a relatively well – drained loamy soil rich in phosphorus with a pH range of 4.5 to 8.5, but performs badly on drought stressed soils and water soaked soils and soil lack of phosphorus (Mofa, 2006).

A major constraint for Soybean production on disturbed soil is Phosphorus (Ferguson *et al.,* 2006). Phosphorus nutrition has strong impact on photosynthesis and yield quality of Soybean (Singh *et al.*, 2014).

Phosphorus is the main nutrient contributing protein in soybean, phosphorus from the soil is imperceptible, it is the most nutritive nutrients that soybean productivity comes from; phosphorus deficiency in soybean can limit the nodule formation while the Phosphorus fertilization does not only overcome the deficiency but also promote nutrient uptake and and eventual yield of the crop. (Carsky *et al*, 2001).

Phosphorus application is also necessary for high protein and oil yield from Soybean grains (Shah *et al.*, 2001). Damodar *et al*., (2000) and Manna et al., (2007) reported that manure application along with Phosphorus inorganic

fertilizer is an effective strategy to help improve soybean nutrient like iron, calcium and magnesium also phosphorus in the soil. It has been reported that, Phosphorus application through Single Super Phosphate significantly increased the grain yield and oil content in the crop (Tanwar and Shaktawat, 2003).

The quality of soybean is also influenced by nutrient availability with phosphorus having a positive impact on Soybean nutrient composition (Borges and Mallarino, 2000). Several researchers have pointed out that the use of Phosphorus significantly improves the content of Soybean nutrient composition (Brennan and Bollan, 2004). It becomes imperative therefore to determine the quantity of phosphorus level that should be applied to soybean to obtain optimum nutrient quality in soybean; hence, this study.

Materials And Method

The field experiment was carried out at the out-station of the institute of Agricultural Research and Training (IAR&T) Ikenne, Ogun State. The experimental plot measuring 11.1 × 35 m was prepared by ploughing and harrowing and laid out into 12 plots 11.1 × 2 m^2 Phosphorus fertilizers (P) at different rates were incorporated into the soil a week before planting. The different rate of phosphorus fertilizer are 20 kg/ha, 40 kg/ha, 60 kg/ha, and zero level which is the control rate.

The soybean (*Glycine max* L) seed used was early maturing TGX 1440 - IE which was obtained from the seed store of the Institute of Agricultural Research and Training (IAR&T) Moor Plantation, Ibadan. The experiment was laid out in the randomized complete Block Design (RCBD) with three replicates. Each replicate measures 11.1 × 2 m^2 separated by 1m apart and each replicate was divided into 4 plots of 2 × 2.4 m^{-2} separated by 0.5m.

Soybean seeds were sown at two seeds per stand, agronomic practices were carried out and data collected on growth and yield parameters. At maturity, soybean seeds were harvested, threshed and weighed and weight recorded in kg/ha. Then the seeds were taken to the laboratory for proximate analysis and mineral composition analysis. The data collected were subjected to statistical analysis using ANOVA to test the level of significance of treatment on the measured

parameters and the significant means were compared and separated using least significant difference (LSD) at 5% levels of probability.

Result And Discussion

The result of physical and chemical properties of the pre cropping soil is presented in table I. It showed that the soil was slightly acidic with a pH of 6.14. Total Nitrogen was very low (0.083%), compare to the standard value of (1 - 1.5) available phosphorus (7.63 mg/kg) compared to the standard value of (7 - 7.20) and organic carbon (0.83%) compared to the standard value of (1.0 - 1.4) were low. Exchangeable base: Potassium, Calcium, Magnesium and Sodium of the soil range from 0.29 – 1.10 and 0.40 cmol/kg, the texture of the soil was sandy loamy soil with sand, silt and clay content of 861, 79 and 60 g/kg respectively.

Effect of Phosphorus concentration on Soybean yield (kg/ha) and yield components

The effect of treatment on the yield of soybean is presented in Table 2, The yield of soybean was significantly ($p<0.05$) higher with the application of 60 kg P/ha than other levels of P with a yield difference of 52.56% for zero application, 21.24 and 36.6 % for 40 and 20 P respectively. This study buttresses the fact that Phosphorus, an essential mineral nutrient is required in relatively large amount to maintain growth and play a vital role in improving Soybean yield and quality (Jack and Sara, 2001) and that it has strong impact on photosynthesis and yield quality of Soybean grains (Singh *et al.*, 2014)..

Effect of phosphorus concentration on Proximate analysis of soybean seeds

The result of proximate analysis of soybean is presented in Table 3. It was observed that treatment effect was not significant on moisture content of soybean; while for crude protein, treatment effect was significant. Soybean treated with 60kg of phosphorus had the highest value of protein content 39.50% which was significantly higher than other treatments. This corroborates the work of Tanwar and Shaktawat (2003) who also opined that phosphorus application significantly increased the seed protein content (SPC) of soybean. Treatment effect was not significant on crude fat. This is in contrast to the work of Brennan and Bolland (2004) who submitted that, Phosphorus significantly improves the oil content of many oil seed crops.

The study however support the findings of Rogerio *et al* (2013) who stated that different level of Phosphorus in oil seed crops (Crambe) does not significantly increased oil content of the crop. Considering the crude fiber content, the control (0P) was significantly higher than other treatments except that of 20P. Meanwhile, there is no significant difference between the crude fibre content of soybean at 20 P and 60 P application. This indicates that enough crude fibre content can still be derived with the application of 60 kg P/ha which also supports optimum yield and protein content in soybean For total ash there was no significant difference among the treatments.

Significant difference was observed among the treatments for nitrogen free extract in which Soybean treated with 40 P was significantly higher than those treated with 60 P but was comparable to those of 0 Phosphorus and 20 Phosphorus statistically. This is also an indication that application of Phosphorus for soybean support the availability of free Nitrogen extract. This is consistent with the findings of Malik *et al.* (2006).

Table 1. Physical and chemical characteristics of experimental soil

Parameters	Value
pH	6.14
Total Nitrogen	0.08
Organic carbon (g/kg)	0.83
Available phosphorus (g/kg)	7.63
Exchangeable Cations (cmol/kg)	
Ca^{2+}	0.59
Mg^{2+}	1.10
Na^{+}	0.40
K^{+}	1.01
H^{+}	1.01
ECEC	3.39
Particle size distribution (g/kg)	
Sand	861
Clay	60
Silt	79
Textural class	Sandy loam

Source: Authors

Table 2. Effect of phosphorus concentration on Yield of Soybean (kg/ha)

Treatment (kg P/ha)	Yield (kg/ha)
0(Control)	90.50
20	120.92
40	150.25
60	190.76
LSD (0.05)	80.52

The means were separated using LSD at 5% level of Significant

Table 3. Proximate analysis of soybean

Treatment (kgP/ha)	Moisture (%)	Crude Protein (%)	Crude Fat (%)	Crude Fiber (%)	Total Ash (%)	NFE (%)
0(control)	9.58	34.57	24.22	6.69	5.49	19.44
20	9.68	35.75	23.46	6.22	5.29	19.50
40	9.35	37.19	22.82	5.38	4.88	20.38
60	9.69	39.50	23.91	5.97	5.04	15.89
LSD (P= 0.05)	ns	1.50	ns	0.58	ns	3.45

Significant means were separated by LSD P<0.05; Source: Authors

Effect of phosphorus concentration on Mineral Composition of soybean

The result of treatment effect on mineral Analysis of Soybean is presented in Table 4. The result revealed that, there was significant differences in iron content among all the treatment, soybean with no treatment (control) had the highest iron content of 18.01%, which was significantly higher than other treatments. This indicates internal inactivation of Iron by the Phosphorus this is because, phosphorus deficiency has been shown to result in increased Iron concentration. (Hirsch et al., 2006). Likewise, for calcium content there were significant difference across the treatments. Soybean not treated with phosphorus (control) had the highest calcium content of 324.02%, while the soybean treated with phosphorus were significantly lower in calcium content, with 40 kg P/ ha having the least followed by 20 P then 60 P. These results showed that application of Phosphorus fertilizer to the soil in soybean field has nothing to do with the iron content and calcium content in soybean. These minerals can be gotten by soybean from other sources. Meanwhile, effect of treatment on magnesium content of soybean seed showed that there were significant differences among the treatments in which soybean treated with 20kg of phosphorus had the highest magnesium content of 338.74% which is comparable statistically with those 40 and 60 level of phosphorus while the 0 level of Phosphorus had the least value of magnesium content of 281.03% different from those of 40 and 60 level of Phosphorus.

Conclusion And Recommendation

Phosphorus concentration of 60 kg/ha gave the highest soybean yield of 190.76 kg/ha and high protein content (39.50%). Mineral content like Magnesium also responds to application of Phosphorus in soybean. However, crude fat does not response to phosphorus application in soybean. Also with zero Phosphorus fertilizer application to soybean, enough minerals like iron and calcium which are beneficial to humans can be derived from the crop.
Selective Phosphorus concentration can be used in precision soybean cultivation to improve target nutrients in Soybean. This will encourage the production of Soybean selectively rich in predetermined class of nutrients. Soybean production is targeted to make protein for man hence, the applications of 60kg/ha of phosphorus is recommended to achieve optimum yield and high protein content in soybean which does not however affect the availability of oil in the crop adversely.

Table 4. Mineral Composition Analysis

Treatment (kgP/ha)	Fe (Mg/kg)	Ca (Cmol/kg)	Mg (Cmol/kg)
0(control)	18.01	324.02	281.03
20	10.78	211.70	338.74
40	13.53	201.56	325.56
60	14.68	232.49	325.56
LSD (0.05)	0.03	0.79	0.53

Significant means were separated by LSD P<0.05; Source: Authors

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