PLANTING DATE AND FERTILIZER TYPE INFLUENCED SOIL QUALITY INDICES AND SOYBEAN (*Glycine max* L.) YIELDS IN DERIVED SAVANNAH OF NIGERIA

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ABSTRACT
Soybean is grown in many parts of Northern Nigeria, with little climatic challenges and soil organic matter. There is need to investigate possible influence of planting date of the crop in Southeastern Nigeria, an environment that is rather foreign to the crop. A study was carried out in 2018 and 2019 cropping seasons at Federal College of Agriculture, Ishiagu, Ebonyi State, to evaluate the influence of different planting dates and fertilizer types on selected soil physical and chemical properties, growth and yield of soybean. A split plot in a randomized complete block design was used with planting date (May and June) as the main plots, while six fertilizer types (poultry-droppings manure 5 t ha^{-1}, swine-droppings manure 5 t ha^{-1}, rice-husk dust 5 t ha^{-1}, NPK 15:15:15 at 150 kg ha^{-1}, urea at 100 kg ha^{-1} and the control) constituted the sub-plots. At crop maturity, some soil quality indices and pod and grain yields (t ha^{-1}) of soybean were assessed. Soil organic carbon (SOC) and total nitrogen contents were significantly (p < 0.05) influenced by both planting date and fertilizer type in 2018 and 2019, while soil pH was improved significantly (p < 0.05) only by fertilizer type in these two cropping seasons. Mean-weight diameter of aggregates, soil bulk density and SOC stock as well as soybean yields were significantly (p < 0.05) influenced by both planting date and fertilizer type in the two seasons. Generally, planting in May improved soil total nitrogen and soybean pod yield whereas planting in June improved the other soil quality indices and soybean grain yield, the best soil amendment in either case being poultry-droppings manure but sometimes parameter-specific. The choice of planting date (May or June) in soybean production in the derived savannah and the soil amendment to use in the enterprise thus has both agronomic and environmental implications. Such a choice would depend on the indices of soil quality and/or the aspects of soybean yields (pod or grain) whose improvements the farmer intends to achieve at crop maturity.

Key words: early planting, organic amendments, soil physico-chemical properties, soybean grain yield

INTRODUCTION

Soybean *(Glycine max* L. Merrill) is the world's leading source of oil and protein. (Fekadu *et al.,* 2009; Alghamdi, 2004). The spread of soybean from its native land of origins has been mainly due to its adaptability and predominant use as a food crop for human nutrition, source of protein for animals (Yusuf and Idowu, 2001). Traditionally, soybean is widely grown in the middle belt or the savannah zone of Nigeria (Okpara and Ibiam, 2000), but its production had presently expanded beyond the traditional production areas otherwise considered unsuitable or marginal for soybean production (Asiegbu and Okpara, 2002; Obalum *et al*., 2011a).

However, the planting time of soybean in these new areas varies due to differences in weather and soil type. Planting date is a critical factor affecting soybean growth, grain yield (Zhang *et al.,* 2010), and grain quality (Rahman *et al.,* 2005). Sowing date is the variable with the largest effect on crop yield (Calvino *et al.,* 2003). Effects of planting date on soybean yield and other traits vary according to locations (Naeve *et al.,* 2004). Environmental conditions associated with late sowing affect crop features related to the capture of radiation and other portions of crop resources such as vegetative growth at all phenological stages of the crop including the reproductive phases (Kantolic and Slafer, 2001).

Early planting of legume crops aids in early plant cover which provide good coverage and organic matter. The cover decreases the bulk density of the soil due to organic matter effect (Calegari, 2006). Early planting thus improves the physical, chemical and biological conditions of the soil while also contributing to weed control and water conservation. Research has shown that cropping systems in relation to time of planting usually influence the level of soil carbon stock in the tropics (Lal, 2003). Determination of appropriate period of planting different crops is a strategy of improving carbon sequestration and reducing carbon accumulation in the atmosphere (Jarecki and Lal, 2003).

For centuries, organic materials have been applied as manures to agricultural soils as a means of enhancing the status of soil organic carbon (SOC) with numerous benefits to soil structure, soil fertility (Balashor *et al.,* 2010), and overall soil quality (Obalum *et al.,* 2017). Manures are, therefore, fundamental for carbon recycling and sequestration in the soil which often promote soil aggregation, water retentivity and plant nutrients availability (Ohu *et al.,* 2009). Indeed, use of manures in soil fertility management, by virtue of affecting SOC, may have a far-reaching impact because of the critical role of the soil in the global carbon cycle (Bronick and Lal, 2005; Eshel *et al.,* 2007; Adesodun and Odejimi, 2010).

However, the well-known pressure on agricultural soils and declining soil fertility has necessitated the use of both manures and mineral fertilizers in crop production (Nottidge *et al.,* 2005; Nwite *et al.*, 2012a,b; Nwite *et al.*, 2013; Unagwu *et al.*, 2013; Nwite *et al.*, 2016a; Nnadi *et al.*, 2021). Sole use of fertilizers is cost-prohibitive and not sustainable due to ensuing soil-related problems such as soil acidity, nutrient imbalance and deterioration of soil structure (Nottidge *et al.*, 2005). These undesirable effects in the soil rarely occur and not as evident with manures (Nwite *et al.,* 2016b). With respect to soil properties and crop yields, complementary use of manures and mineral fertilizers has been widely advocated.

Within the context of the integrated soil fertility management, co-application of poultry manure and NPK fertilizer for tuberizing cover crops has shown to be promising with regard to soil properties and crop yields in the derived savannah of southeastern Nigeria (Nnadi *et al.*, 2020; Obalum *et al.*, 2020). For the dominant coarse-textured soils in this zone, indications are that the one to improve soil fertility indices over the other between poultry manure and NPK fertilizer under leguminous cover crops in index-specific; the former for soil pH, total nitrogen (N) and available phosphorus (P), but the latter for exchangeable potassium (K) and other relevant soil cation exchange indices (Umeugokwe *et al.*, 2021). For a better understanding, the effects of these and other soil amendments on soil fertility need to be co-studied with confounding environmental factors and evaluated too using leguminous cover crops.

In their study of tillage-mulch management practices in the zone, Obalum *et al.* (2011a) found that soybean was not affected by management-induced changes in soil structure. They reported, however, that the tillage-mulch practices influenced root-zone moisture storage (Obalum *et al.*, 2012a), and selected indices of soil quality and fertility (Obalum *et al.*, 2011b), though not necessarily in a congruent pattern. This suggests that relative wetness of the soil environment as expected to progressively increase from the onset of rains till the time of planting could influence nutrients release in the soil, such that planting date could be a critical factor in soybean production. The insensitivity of soybean to soil structure may extend to changes in soil structure due to use of manures and mineral fertilizers, if such changes are not obliterated by the surface coverage offered by the crop. This study, therefore, aimed at evaluating the effects of different planting dates of soybean and fertilizer types on selected soil physical and chemical properties (including carbon stock) and yield responses of soybean in the derived savannah.

MATERIALS AND METHODS
Description of Experimental Site
The experiment was carried out at the Research and Teaching Farm of Federal College of Agriculture, Ishiagu, Ebonyi State, Nigeria, during 2018 and 2019 cropping seasons, located by 05° 56′ N and 07° 41′ E. Mean annual rainfall and mean monthly temperature are 1350 mm and 30°C, respectively. The area lies within the derived savannah zone of southeastern Nigeria. There are two distinct seasons, dry season (Nov. to Mar.) and rainy season (Apr. to Oct.).

The meteorological data of the study area showed that in 2018, the highest rainfall amount (304.8 mm) was recorded in the month of October with a temperature of 32°C while in 2019 the highest amount of rainfall (420 mm) in the area was obtained in the month of August (Table 1). No rainfall was recorded in the months of February and January in 2018 and 2019, respectively in the area. Generally, low rainfall was recorded in the early part of the two years of study.

Geologically the area is underlain by sedimentary rock derived from successive deposit of the cretaceous and tertiary period and lies within Asu River group (Lekwa *et al.,* 1995). This geological formation consists of olive brown sandy shale, fine grained micaeous sandstones and mudstones deposited in an alternating sequence.

Table 1: Some meteorological data for 2018 and 2019 cropping seasons of the study area

Months	% Rel. humidity		Rainfall (mm)		Temp. (°C)	
	2018	2019	2018	2019	2018	2019
Jan.	58.0	62.0	2.5	0.0	35.0	32.0
Feb.	77.0	83.0	0.0	36.4	35.0	33.0
Mar.	80.0	86.0	17.7	62.8	37.0	34.0
Apr.	68.0	88.0	8.6	181.6	37.0	31.0
May	76.0	90.0	158.7	341.3	35.0	31.0
Jun.	86.0	89.0	158.7	262.1	30.0	32.0
Jul.	89.0	94.0	214.8	300.4	31.0	30.0
Aug.	90.0	92.0	283.7	420.0	29.0	32.0
Sep.	53.0	90.0	212.2	342.7	31.0	32.0
Oct.	53.0	78.0	304.8	114.9	32.0	30.0
Nov.	86.0	88.0	122.3	80.0	34.0	32.0
Dec.	75.0	-	2.3		36.0	-
Total			1486.3	2142.2		

Experimental Design and Field Layout
A split plot in randomized complete block design was used to assess two factors at different levels. Two planting dates (May and June) were the main plots, while the five different fertilizer types and the control constituted the sub-plots replicated three times. The sub-plots were swine-droppings manure at 5 t ha^{-1}, poultry-droppings manure at 5 t ha^{-1}, rice-husk dust at 5 t ha^{-1}, NPK-15:15:15 at 150 kg ha^{-1}, Urea (NPK 46:0:0) at 100 kg ha^{-1} and control. Because the N-fixing ability of soybean positively relates with soil P (Ogoke *et al.*, 2006), rice-husk ash at 5 t ha^{-1} was uniformly added to boost the soil's P status and as basal organic lime (Nwite *et al.*, 2011, 2012c). The nutrient contents of the organic amendments are shown in Table 2.

The land for the study was cleared and the trashes removed from the site. It was ploughed, harrowed and later manually made into 1.5 m × 1.5 m beds which were the sub-plots. The organic amendments were applied uniformly and incorporated into the soil. A period of one week was allowed for their decomposition before planting. The NPK and urea were applied two weeks after planting (WAP). Rice-husk ash was applied basally two days before planting. The soybean seeds were sown at two seeds per hole at a spacing of 30 cm × 30 cm on 10th May and 10th June in both years of the study. Weeding was done manually at 4 and 8 WAP.

Data Collection
Collection of plant parameters
Yield attributes measured were weight of pods and grain yield at harvest. Weight of pods was obtained as the weight of all the soybean pods harvested from a given treatment plot and extrapolated to its equivalent in t ha^{-1}. After threshing these pods, the seeds got were weighed to obtain their weight regarded as grain yield, which too was extrapolated to its equivalent in t ha^{-1}. For both parameters, weights were measured using a weighing balance.

Soil sampling and laboratory techniques
At the commencement of the study, soil sampling was done from random points at the site. The soil samples were collected from the 0-20 cm depth using a soil auger; these were merged into a composite sample. At the end of soybean harvest, another set of auger samples was collected from the top-(0-20 cm) soil depth of strategic sampling points in each plot and composited for laboratory analysis. Soil cores were also collected from about the plots for the determination of soil bulk density.

Table 2: Nutrient compositions (g kg^{-1}) of some of the organic soil amendments

Property	Poultry droppings	Rice-husk dust	Rice-husk ash
Organic carbon	165.2	337.5	38.9
Nitrogen	21.0	7.0	0.6
Phosphorus	25.5	4.9	119.4
Potassium	4.8	1.2	17.7
Calcium	144.0	3.6	16.0
Magnesium	12.0	3.9	15.0
Sodium	3.4	2.2	3.3

Soil fractions less than 2 mm from individual samples were then analyzed for soil pH in a 1:2.5 soil and 0.1 M KCl suspensions (McLean, 1982), SOC by the Walkley-Black method as described by Nelson and Sommers (1982), and total nitrogen (N) by semi-micro Kjeldahl digestion method using sulphuric acid and $CuSO_4$ and Na_2SO_4 catalyst mixture (Bremner and Mulvaney, 1982).

Mean-weight diameter (MWD) of aggregates (Kemper and Rosenau, 1986) was calculated as:

$$MWD_w = \sum_{i=1}^{n}(X_i W_i);$$

where X_i is the mean diameter of the ith sieve size and W_i is the proportion of the total aggregates in the ith fraction. The higher the MWD values, the higher proportion of macro-aggregates in the sample and thus better stability. Core samples were allowed to drain freely for 24 h before determination of soil bulk density by Blake and Hartge's (1986) method. Carbon stock in kg m^{-2} was estimated as %carbon/100 × soil bulk density × area of hectare (10,000 m^2) × soil depth (m) (Obalum *et al.*, 2012b).

Data Analysis
Data analysis was performed using GenStat 3 7.2 edition. Treatment means were separated and compared using Least Significant Difference and all inferences were made at 5% level of probability.

RESULTS AND DISCUSSION
Selected Physical and Chemical Properties of the Soil (0-20 cm) Soil Depth
The physical and chemical properties of the soil before application of amendments are shown in Table 3. The soil is a sandy-loam with total sand, silt and clay contents as 71%, 19% and 10%, respectively. Some of the chemical components of the soil showed that N, P, K, Ca, Mg and Na contents including SOC concentration were low at the beginning of the study. These low values are expected to be improved through the application of manure (Nwite *et al.,* 2008; Nwite *et al.,* 2019). The pH was slightly acidic with a value of 5.8.

Table 3: Initial physical and chemical characteristics of the studied soil before planting

Soil properties	Values
Particle size distribution (g kg^{-1})	
Clay	100
Silt	190
Fine sand	530
Coarse sand	180
Texture class	Sandy loam
Organic carbon (g kg^{-1})	7.19
Total nitrogen (g kg^{-1})	1.12
pH (H_2O)	5.80
Exchangeable bases (me 100g^{-1})	
Sodium (Na^+)	0.04
Calcium (Ca^{2+})	1.60
Potassium (K^+)	0.07
Magnesium (mg^{2+})	1.20
Cation exchange capacity (cmol kg^{-1})	13.20
Exchangeable acidity (cmol kg^{-1})	1.20
Available phosphorous (mg kg^{-1})	7.46

Influence of Planting Date and Fertilizer Type on Soil pH, Total Nitrogen and Organic Carbon

Soil pH did not significantly ($p > 0.05$) vary due to planting dates in 2018 and 2019 (Table 4). Soil amendments had significant ($p < 0.05$) effects on soil pH. Thus, the soil amendments positively influenced soil pH, with highest and lowest values in poultry droppings-amended and the control plots, respectively in both cropping seasons. This could be attributed to the required level of temperature and moisture as well as the nutrient elements for the enhancement of the soil pH. This is in conformity with the work of Mbah *et al.* (2017) who reported pH increase following the application of organic manure. However, interaction of rice husk dust × plants sown in June significantly ($p < 0.05$) gave the highest pH value (6.83) in 2019.

Soil organic carbon (SOC) was significantly ($p < 0.05$) higher in June than May in both years of the study (Table 4). Soil amendments also significantly increased the SOC pool in those two years. Poultry droppings increased SOC, similar to urea and rice-husk dust in 2018 and 2019, respectively. This is in conformity with the Bronick and Lal (2005) who reported a direct relationship between organic matter application and the final SOC.

Total nitrogen (N) content varied significantly ($p < 0.05$) with planting time and soil amendments in the two years of the study. It was higher in May than June in both years. This could be attributed to low temperature and soil moisture content in May when the planting was made, which reduced the evaporation and leaching of N in the soil. Rainfall and temperature effects on soil N content has been reported (Wan *et al.,* 2001). Nitrogen is easily lost by volatilization from a system during an intense temperature (Fatubarin and Olojugba, 2014). The results (Table 4) indicated significant ($p < 0.05$) improvement in total N with poultry-droppings and swine-droppings manures giving higher values (1.08 and 1.00 g kg^{-1}, respectively) in 2019. This could be attributed to the gradual decomposition of manure and its slow release of N (Liu *et al.,* 2010).

The interaction planting dates × fertilizer types significantly ($p < 0.05$) influenced SOC in both years of the study, whereby the highest values were due to poultry droppings or rice-husk dust applied in June. The effect of rice-husk dust here is linked to its high carbon (Adubasim *et al*., 2018) However, the interaction showed that rice-husk dust applied in May enhanced total N more than the other treatments in 2018, with a tendency for similar effect in 2019.

Table 4: Effects of different planting dates and fertilizer types on soil pH, total nitrogen, and soil organic carbon

Amendments	2018			2019		
	May	June	*Mean*	May	June	*Mean*
Soil pH - H$_2$O						
Control	5.33	5.40	*5.37*	5.23	5.43	*5.33*
NPK-15:15:15	5.77	5.70	*5.73*	5.63	5.53	*5.58*
Poultry-droppings manure	6.00	6.27	*6.13*	6.60	6.77	*6.68*
Rice-husk dust	5.73	5.83	*5.78*	6.13	6.83	*6.48*
Swine-droppings manure	5.80	5.77	*5.78*	6.10	6.10	*6.10*
Urea N-fertilizer	5.47	5.50	*5.48*	5.40	5.47	*5.43*
Mean	*5.68*	*5.74*	*5.71*	*5.85*	*6.02*	*5.94*
LSD$_{0.05}$ for planting dates		NS			NS	
LSD$_{0.05}$ for amendments		0.15			0.21	
LSD$_{0.05}$ for planting dates × amendments		NS			0.30	
Soil organic carbon (g kg^{-1})						
Control	0.329	0.881	*0.605*	0.427	0.782	*0.604*
NPK-15:15:15	0.522	1.095	*0.809*	0.867	1.088	*0.978*
Poultry-droppings manure	0.980	1.157	*1.069*	1.152	1.182	*1.167*
Rice-husk dust	0.779	1.129	*0.954*	1.079	1.217	*1.148*
Swine-droppings manure	0.886	1.015	*0.950*	0.917	1.071	*0.994*
Urea N-fertilizer	1.050	1.047	*1.049*	1.094	1.078	*1.086*
Mean	*0.758*	*1.054*	*0.906*	*0.923*	*1.070*	*0.996*
LSD$_{0.05}$ for planting dates		0.150			0.050	
LSD$_{0.05}$ for amendments		0.102			0.094	
LSD$_{0.05}$ for planting dates × amendments		0.152			0.124	
Total nitrogen (g kg^{-1})						
Control	0.70	0.74	*0.72*	0.86	0.75	*0.80*
NPK-15:15:15	1.27	0.61	*0.94*	1.01	0.71	*0.86*
Poultry-droppings manure	1.16	0.75	*0.96*	1.17	1.00	*1.08*
Rice-husk dust	1.03	0.65	*0.84*	1.05	0.81	*0.93*
Swine-droppings manure	1.03	0.65	*0.84*	1.03	0.95	*1.00*
Urea N-fertilizer	0.45	0.65	*0.55*	0.84	0.73	*0.79*
Mean	*0.94*	*0.67*	*0.806*	*1.00*	*0.82*	*0.91*
LSD$_{0.05}$ for planting dates		0.16			0.01	
LSD$_{0.05}$ for amendments		0.13			0.12	
LSD$_{0.05}$ for planting dates × amendments		0.18			NS	

LSD, least significant difference; NS, non-significant

Influence of Planting Date and Fertilizer type on Mean-Weight Diameter of Soil Aggregates, Soil Bulk Density and Soil Organic Carbon Stock
The MWD was significantly ($p < 0.05$) higher in June than in May (Table 5). This could be attributed to the increased rainfall and temperature which leads to quick decomposition of the organic amendments and improvement on the soil aggregates. The higher MWD recorded in June in both 2018 and 2019 (0.6839 and 0.6379 mm, respectively) indicated increased macro-aggregates in the soil which can be attributed to increased leaching below 20 cm soil depth of most silt and clay materials on the topsoil. This situation depicts an increased natural drainage in the soil during the study. This could be good attributes for arable crops grown in the studied area as the soil will always be drained. Soil amendments caused significant ($p < 0.05$) variations in the MWD with the highest values in the NPK amended soil in the two years of study.

Soil bulk density was significantly ($p < 0.05$) higher (1.71 and 1.68 Mg m^{-3}) in plots planted in the month of May in 2018 and 2019 seasons, respectively. This implies that plots cultivated in June reduced bulk density drastically than those cultivated in May, which could be attributed to variation in the environmental factor. The decrease in soil bulk density in June could be related to the increased aggregation as a result of higher level of MWD, hence increase in rooting depth of plants.

The results show that swine-droppings manure significantly ($p < 0.05$) reduced soil bulk density (1.58 Mg m^{-3}) better in 2018, while rice-husk dust significantly ($p < 0.05$) decreased it (1.51 Mg m^{-3}) in 2019 (Table 5). In these two years, control plots increased the soil bulk density compared to the amended plots. This indicates that application of manure to cultivated soils increases SOC level in them. Specifically, management-induced increases in the organic carbon level of sandy-loam soils often reflect as a reduction in their bulk density and hence an increase in their aggregate stability (Bhattacharyya *et al.*, 2007; Obalum and Obi, 2014).

Table 5 shows that soil carbon stock varied significantly ($p < 0.05$) between soils cultivated in May and June in both 2018 and 2019. Cultivation in June significantly ($p < 0.05$) improved the carbon stock higher than cultivation in May. This could be as a result of increased moisture content of the soil that had received fertilizers leading to increased SOC pool (Wang *et al.,* 2010). The results also showed variations in carbon stock due to amendments. In 2018 being the first year of the study, plots amended with urea fertilizer recorded the highest carbon stock followed by poultry droppings treated plots. In 2019, poultry droppings treated plots significantly ($p < 0.05$) improved the soil carbon stock more, followed by rice-husk dust and urea fertilizer amended plots.

Table 5: Effects of planting date and fertilizer type on soil aggregation and organic carbon stock

Amendments	2018			2019		
	May	June	*Mean*	May	June	*Mean*
	Mean-weight diameter (MWD) of soil aggregates (mm)					
Control	0.6286	0.6529	*0.6407*	0.6424	0.5967	*0.6195*
NPK-15:15:15	0.5397	1.1405	*0.8401*	0.5914	0.7859	*0.6887*
Poultry-droppings manure	0.5691	0.6810	*0.6250*	0.5613	0.6686	*0.6149*
Rice-husk dust	0.4766	0.4739	*0.4752*	0.6169	0.5764	*0.5967*
Swine-droppings manure	0.5750	0.5605	*0.5678*	0.5675	0.5961	*0.5818*
Urea N-fertilizer	0.5186	0.5944	*0.5565*	0.5745	0.6038	*0.5892*
Mean	*0.5513*	*0.6839*	*0.6176*	*0.5923*	*0.6379*	*0.6151*
LSD$_{0.05}$ for planting dates		0.0185			0.0386	
LSD$_{0.05}$ for amendments		0.0365			0.0599	
LSD$_{0.05}$ for planting dates × amendments		0.0478			0.0791	
	Soil bulk density (g cm^{-3})					
Control	1.82	1.75	*1.79*	1.70	1.62	*1.66*
NPK-15:15:15	1.76	1.68	*1.72*	1.70	1.56	*1.63*
Poultry-droppings manure	1.67	1.59	*1.63*	1.67	1.43	*1.55*
Rice-husk dust	1.63	1.56	*1.60*	1.50	1.51	*1.51*
Swine-droppings manure	1.66	1.50	*1.58*	1.58	1.48	*1.53*
Urea N-fertilizer	1.75	1.62	*1.69*	1.65	1.55	*1.60*
Mean	*1.72*	*1.62*	*1.67*	*1.64*	*1.52*	*1.58*
LSD$_{0.05}$ for planting dates		0.08			0.07	
LSD$_{0.05}$ for amendments		0.09			0.11	
LSD$_{0.05}$ for planting dates × amendments		NS			NS	
	Soil organic carbon stock (kg m^{-2})					
Control	11.98	31.00	*21.49*	14.59	25.35	*19.97*
NPK-15:15:15	18.34	36.75	*27.54*	29.48	33.81	*31.64*
Poultry-droppings manure	32.59	36.97	*34.78*	38.55	34.05	*36.30*
Rice-husk dust	25.36	35.23	*30.29*	32.47	36.70	*34.58*
Swine-droppings manure	29.48	30.48	*29.98*	28.93	31.78	*30.36*
Urea N-fertilizer	36.75	33.92	*35.34*	36.18	33.40	*34.79*
Mean	*25.75*	*34.06*	*29.90*	*30.03*	*32.51*	*31.27*
LSD$_{0.05}$ for planting dates		3.93			0.46	
LSD$_{0.05}$ for amendments		4.32			4.15	
LSD$_{0.05}$ for planting dates × amendments		5.85			5.36	

LSD, least significant difference; NS, non-significant

Influence of Planting Date and Fertilizer Type on Pod and Grain Yields of Soybean

Planting date significantly ($p < 0.05$) influenced soybean pod weight in this study (Table 6). Plots cultivated in May had higher weight (7.21 t ha^{-1}) than those cultivated in June (5.54 t ha^{-1}) in 2018. The former exceeded the latter by 2.28 t ha^{-1} in 2019. These differences between these two planting dates might have been due to varying environmental factors especially temperature and rainfall during seed development and maturation. The present study showed that when the temperature and rainfall increased towards the maturity of the plant, the biological and seed yield decreased. Rahman *et al.* (2005) reported that soybean yield decreased due to changes in sowing dates which related to the environmental conditions mostly observed during the plant life cycle.

Soil amendments also significantly ($p < 0.05$) affected pod yield of soybean in the two cropping seasons, with highest values in urea fertilizer and poultry droppings amended plots in 2018 and 2019, respectively. The lowest pod yield in both years occurred in the unamended control plots. Notably, the highest-yielding plots amended with N-rich urea were similar only to poultry droppings amended plots in 2018, but higher than only rice-husk dust amended and control plots in 2019. This observation is ascribed to the N fixed by soybean in the first year which obliterated the effects of N from soil amendments in the second year (Uzoh *et al*., 2017). Planting date × fertilizer type interaction showed higher ($p < 0.05$) pod yield due to planting in May and amending with NPK and poultry droppings in 2018 and 2019 cropping seasons, respectively.

As shown in Table 6, soybean grain yield varied significantly ($p < 0.05$) in the two years of study due to differences in planting dates. These variations followed the trend of pod yield. This shows that the planted during the early part of the year and which took longer period to complete its life cycle had higher grain weight, while the one planted in June experienced higher temperature during the early phases and completed its life cycle rapidly, hence, lower grain weight. The result is in agreement with Yajam and Madani (2013) who observed that grain weight was affected by planting dates. The grain yield is the function of combined effects of all the yield components under the influence of a particular set of environmental conditions. The grain yield decreased little by little with delay in planting date.

Soil amendments significantly improved the soybean grain yield with poultry-droppings manure having the highest vales (3.83 and 4.23 t ha^{-1}) in 2018 and 2019 cropping seasons, respectively over other amendments in the study.

CONCLUSION

Planting date is an important factor in soybean production in the derived savannah. Generally, planting soybean earlier in May could be an option for enhancing soil content of total nitrogen and soybean pod yield. However, delaying the planting till June could enhance such indices of soil quality as soil organic carbon content, mean-weight diameter of soil aggregates and soil organic carbon stock, while also enhancing soybean grain yield. Though compatible and effective with either planting dates, poultry droppings may not always be the soil amendment of choice, depending on the soil quality and/or soybean agronomic yield parameters whose improvements are desired at crop maturity. Thus, in adapting soybean from the core savanna for cultivation in the derived savanna zones, the time of the cropping season when it is planted has both agronomic and environmental implications, but the appropriate fertilizer must be used to grow the crop for clearer manifestations of such implications.

Table 6: Effects of planting date and fertilizer type on soybean pod weight and grain yield (t ha^{-1})

Amendments	2018			2019		
	May	June	*Mean*	May	June	*Mean*
			Pod yield (t ha^{-1})			
Control	6.07	*5.69*	5.88	6.23	6.07	*6.15*
NPK-15:15:15	8.09	*4.70*	6.40	8.76	4.96	*6.86*
Poultry-droppings manure	7.24	*5.83*	6.54	8.77	6.00	*7.39*
Rice-husk dust	6.93	*5.17*	6.05	7.84	5.27	*6.56*
Swine-droppings manure	7.01	*5.82*	6.41	7.79	5.86	*6.82*
Urea N-fertilizer	7.91	*6.02*	6.97	8.39	5.93	*7.16*
Mean	*7.21*	*5.54*	*6.37*	*7.96*	*5.68*	*6.82*
LSD$_{0.05}$ for planting dates		1.32			1.11	
LSD$_{0.05}$ for amendments		0.56			0.52	
LSD$_{0.05}$ for planting dates ×		1.05			0.91	
			Grain yield (t ha^{-1})			
Control	4.19	*2.04*	3.11	4.19	2.67	*3.43*
NPK-15:15:15	4.94	*2.43*	3.68	5.07	3.02	*4.05*
Poultry-droppings manure	4.60	*3.05*	3.83	5.08	3.38	*4.23*
Rice-husk dust	3.58	*2.45*	3.01	4.08	3.11	*3.60*
Swine-droppings manure	4.56	*2.87*	3.71	4.89	3.18	*4.04*
Urea N-fertilizer	5.02	*2.56*	3.79	5.04	2.85	*3.95*
Mean	*4.48*	*2.57*	*3.52*	*4.72*	*3.04*	*3.88*
LSD$_{0.05}$ for planting dates		0.23			0.43	
LSD$_{0.05}$ for amendments		0.30			0.52	
LSD$_{0.05}$ for planting dates ×		0.40			NS	

LSD, least significant difference; NS, non-significant

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