Response of Yield and Yield Components of Field Pea (*Pisum sativum* L.) to Application of Nitrogen and Phosphorus Fertilizers.

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Abstract: A field experiment was conducted during the 2015, 2016 and 2017 growing seasons at the National Root Crop Research Institute experimental farm Vom Plateau State, Nigeria to study the response of Field pea (*Pisum sativum* L.) yield and its components to application of nitrogen and phosphorus fertilizers. The treatment consisted of three nitrogen rates *viz;* 0, 20 and 40 kg N ha^{-1} and three phosphorus rates viz; 0, 30 and 60 kg P ha^{-1} which were factorially laid in a randomized complete block design and replicated three times. The characters studied were; number of pods, pod length (cm), pod weight (g), pod yield (kg ha^{-1}), number of seeds, 100 seed weight (g), seed yield (kg ha^{-1}) and harvest index (%). Results revealed that there was a significant ($P \leq 0.05$) and positive response of these characters to application of nitrogen and phosphorus rates during the period under investigation. Application of 40 kg N ha^{-1} recorded higher seed yield than the other rates used, similarly, phosphorus application at 60 kg P ha^{-1} recorded higher seed yield compared to 30 kg P ha^{-1} and control plots. Regardless of the factor used, the lowest values in respect to the characters measured were obtained from control plots. The interaction of 40 kg N and 30 kg P ha^{-1} gave significantly highest seed yield than other treatments used and seem more promising for optimum seed yield.

Field pea, Nitrogen, Phosphorus, Yield components

1. INTRODUCTION

Field pea (*Pisum sativum* L.) is a temperate crop that is now grown in most climatic zones including the tropical highlands, where it is grown under cooler conditions at higher elevations. It is an important grain legume crop in human and animal nutrition. The crop is a major source of protein (21% - 25%) with high levels of amino acids, lysine and tryptophan that have high nutritional value (Bhat *et al*. 2013; Gregory *et al*. 2016). In Nigeria, very little is known about the production of field pea crop, however, the cultivation of the crop is gaining popularity in Jos plateau during the recent years mainly because the climatic condition of the area is more of temperate than other parts of the country, so also that the demand of the crop is increasing in the market. Despite its nutritional, yield potential, agronomic benefits and economic value, the productivity of the crop is generally low. The low productivity is attributed to poor soil fertility (due to tin mining, erosion of topsoil by intense rainfall and continuous cultivation of the land) and agronomic practices by farmers, hence yield under farmer's condition is often below optimal (Nannim *et al.*, 2018).

The management of fertilizer is very important and can greatly affects the growth and yield attributes of field pea. Nitrogen and phosphorus are among the major yield limiting factors of field pea and these nutrients are almost deficient in most soils in the tropics and Africa. Field pea is highly efficient nitrogen-fixing crops and may obtain its total nitrogen requirement from fixation under good condition. However, due to the lag period between rhizobium root colonization and the onset of nodule functioning, the young legume plants may require an additional N to achieve vigorous growth and establish the N-fixing symbiosis especially when the crop is sown on land with less than 13.6 kg h^{-1} of available nitrate N in the top 2 feet of the soil profile (Gan *et al.*, 2004; Gregory *et al*. 2016). Lal *et al*. (2004) found that the application of nitrogen at 0, 20, 40 and 60 kg N ha^{-1} resulted in increased seed yield kg ha^{-1}.

Phosphorus has also been identified as one of the most limiting nutrient elements to crop production in tropical soils. Deficiency of phosphorus has also been shown to be an important fertility constraint limiting legume production in the tropics. Getachew *et al*. (2003) and Amare *et al*. (2005) in their work reported a significantly increased in grain yield due to application of phosphorus fertilizer. Work regarding the response of nitrogen and phosphorus fertilizer on the productivity of field pea has not been conducted under local condition. Therefore, this research was initiated to determine the response of field pea yield and its component to application of nitrogen and phosphorus rate.

2. MATERIALS AND METHODS

2.1 Description of Study Area

The study was conducted during the 2015, 2016 and 2017 growing season at the National Root Crop Research Institute experimental area in Vom Plateau State, Nigeria located at a latitude of 90 41'36.27 N longitude 80 52'16.33 E and altitude of 1242m above sea level. Average minimum temperature in the area is about 10.40C during the dry season (December to February) and 150C during the raining season (May to August) while maximum temperature rarely exceeds 34.40C with an average rainfall of about 1400mm (Nigeria meteorological office Jos).

2.2 Experimental Design and Treatments

The treatments consisted of three rates of nitrogen viz. 0, 20 and 40 kg ha^{-1} and three rates of phosphorus viz. 0, 30 and 60 P kg ha^{-1}, which were factorially combined and laid in a Randomized Complete Block Design (RCBD) with three replications. A plot size of 9m^2 containing 10 rows was maintained from which a sampling unit of 3.6m^2 with 4 rows as net plot was determined at the middle of each plot in both seasons for measurement of the yield and yield components. Two seeds per hole of field pea were sown at a depth of 4 cm with 25 and 30cm intra and inter row spacing. The sources of nitrogen and phosphorus were urea and single super phosphate. The N rates were applied at five days after emergence, while the P treatments were applied at sowing. Both fertilizers during application were incorporated into the soil and covered properly.

2.3 Data collection

Data on number of pods plant^{-1}, pod length (cm), weight of pod plant^{-1} (g), pod yield (kg ha^{-1}), number of seeds pod^{-1}, 100 seed weight (g), seed yield (kg ha^{-1}) and harvest index (%), designated as; NP, PL, WP, PY, NS, SW, SY and HI were taken at physiological maturity. The field pea stands were harvested within the net plot (3.6m^2) when about 85% of pods had turned brown. Ten plants were randomly taken from the net plot of each treatment (plot) in all the replicates. Pods from the samples stands were counted and the average value recorded. Pod length (cm) was measured by placing a measuring tape at one end of the pod to the other end and the average value of ten samples was recorded accordingly. To obtain pod weight plant^{-1}, pods from the ten (10) randomly selected plants were picked and weighed. The values obtained were then averaged. Pod yield (kg ha^{-1}) on the other was obtained from all the stands within the net plots. The pods were first weighed and the average was recorded and later converted to pod yield in kilogram per hectare. Seeds per pod was counted from ten randomly selected plants from the net plot and the average value was recorded as number of seeds per pod and was considered on per plant basis. One hundred seeds were first counted randomly for each plot and then weighed and the average values were then recorded. To obtained grain yield data, all plants in the net plots were harvested dried, threshed and clean from any dirt, weighed and the average values were recorded according to the treatments and later converted to seed yield per hectare. Harvest Index was however, obtained by Economic yield (seed) / Biological Yield (total biomass) x 100. Weight of pods plant^{-1}, pod yield and grain yield were both measured using digital scale (M_X-RADY electronic balance).

2.4 Data analysis

Data collected for the three years of the experiment were subjected to analysis of variance using SPSS Statistics v. 20 (software) and means observed to be significantly different were however, separated by Least Significant Difference (LSD) at 5% probability level using Duncan's Multiple Range Test (DMRT).

3. RESULTS AND DISCUSSION

3.1 Soil

The soil where the experiment was conducted was loam, low in organic matter (0.95%), total nitrogen (0.07%), available phosphorus (3.60 mg kg^{-1}) and available K (198 mg kg^{-1}) and pH of 5.65 (table 1). Generally, the soil analysis indicates that the soil was depleted, hence in such soils the amount of the primary nutrient that could immediately be available to the crop becomes inadequate.

3.2 Response of Field pea Yield and its Components to Application of Nitrogen and Phosphorus

Response of yield and yield components of field pea to application of nitrogen in the three growing seasons of 2015, 2016 and 2017 is presented in tables 2, 3 and 4. The tables indicated that throughout the three-year trial, increase in application of nitrogen from 0 to 40 kg N ha^{-1} resulted in significant ($P \leq 0.05$) and progressive increase in number of pods, pod length, pod weight, pod yield, number of seeds, 100 seed weight and seed yield. Higher values of all the characters measured were obtained from the application of 40 kg N ha^{-1} except for number of seed pod^{-1} and 100 seed weight which was significantly at par with 20 kg N in 2016 and 2017 seasons. The control plots on the other, produced the lowest values for all the characters studied. Significantly higher seed yield observed at 40 kg N ha^{-1} could be due to greater partitioning of dry matter into the economic portion i.e., to seed and favourable growth nutrient uptake, higher number of seeds plant^{-1} and heavier seed . This was evident by the consistent results exhibited by application nitrogen in all the seasons. Lal *et al*. (2004) found that the application of nitrogen (at 0, 20, 40 and 60 kg N ha^{-1}) on seed yield of pea and bean resulted in increased seed yield kg ha^{-1}. Low pod yield recorded under control plots during the study could be due to insufficient essential element at certain growth stages like that of flowering, seed formation and seed maturity.

Similar to the effect of nitrogen application, field pea responded positively to application of phosphorus during the trials (Tables 2, 3 and 4). Increase in phosphorus application from 0 up to 60 kg ha^{-1} also led to an increase in number of pods, pod length, pod weight, pod yield, number of seeds, 100 seed weight and seed yield table 2, 3 and 4. Significantly ($P \leq 0.05$) higher value of these characters were observed with the application of phosphorus at 60 kg ha^{-1}. Higher number of seed obtained with the 60 kg P ha^{-1} was however, at par with 30 kg P ha^{-1} in 2015 season. On the other hand, phosphorus application had no significant effect on number of seed pod^{-1} and 100 seed weight in 2016 and 2017 growing seasons, and on weight of pod plant^{-1} 2017 season only. Control plots had the least values for all the characters measured throughout the study period. Generally, field pea develops poorly when grown in phosphorus deficient soil and its low rate may lead to low productivity which may be the case with yield under the control plot in this study. Increase in the values of the characters studied with increasing P application from 0 up to 60 kg P ha^{-1} indicates the essentiality of phosphorus as an essential nutrient for field pea. Higher values from plots treated with 60 kg P ha^{-1} shows that increase rate of phosphorus leads to better and efficient nodulation, which resulted in increased assimilation of nitrogen, well filled pods and higher yield. The result was in agreement with the findings of Nadeem *et al.* (2003) and Uniyal and Mishra (2009) who reported that increasing rate of phosphorus to field pea resulted in a corresponding increase in yield and yield parameters such as number of pod, pod length, number of grains per pod and pod weight. Maximum seed yield kg ha^{-1} recorded as a result of highest rate of phosphorus applied in this study concord with the findings of Sinha *et al*. (2000), Getachew *et al*. (2003), Lal *et al*. (2004) and Amare *et al*. (2005).

Harvest index varied significantly ($P \leq 0.05$) with the application of nitrogen and phosphorus in three years of the investigation (tables 2,3 and 4). The results indicated that application of at 40 kg N ha^{-1} led to the production of higher harvest index, however, the different between the value obtained from the application of 20 and 40 kg N ha^{-1} was found non-significant. Sinclair (2004) reported that increasing seed yield and crop harvest index with high nitrogen grain requires a concomitant increase in crop nitrogen accumulation. At the different phosphorus rates tested, significant difference was also observed in the three-year study. Maximum mean harvest index was obtained from application of 60 kg P ha^{-1}, which was higher than the other rates used. Increase harvest index as a result of increase in phosphorus rate could be due to the influence of greater fruit and seed setting than above ground biomass yield. The result found in this study was in agreement with that of Malik *et al.* (2006) who reported that harvest index was significantly influenced by increased in applied phosphorus rate in soybean crop. Chanda *et al*. (2002) also reported that significantly higher harvest index could be due to comparatively higher increase of grain yield than that of respective vegetative yield of the crop. Irrespective of nitrogen or phosphorus rate used, control plots recorded the least harvest index in all the seasons.

3.3 Interaction of Nitrogen and Phosphorus rates (Pooled over three years)

Results of interaction between the factors under investigation shows a significant ($P \leq 0.05$) effect on all the characters measured except on number of seed pod^{-1} and harvest index (table 5). Combined application of 40 kg N ha^{-1} and 60 kg P ha^{-1} produced higher number of pods plant^{-1} which was at par with interaction of 40 kg N and 30 kg P ha^{-1}. Similarly, the interaction between 40 kg N and 60 kg P ha^{-1} P ha^{-1} produced longer pods than the other combination. However, the value obtained did not differ significantly from the interaction between 40 kg N ha^{-1} and 30 kg P ha^{-1}, 40 kg N and 0 kg P ha^{-1}, 20 kg N and 60 kg P ha^{-1}, and 20 kg N and 30 kg P ha^{-1} respectively. Significantly heavier pods plant^{-1} and higher pod yield kg ha^{-1} were recorded from the interaction of 40 kg N and 60 kg P ha^{-1}. Heavier 100 seeds were produced from the interaction between 20 kg N and 30 kg P ha^{-1}, this was however, at par with the values obtained from the interaction between 20 kg N and 60 kg P ha^{-1}, 40 kg N and 30 kg P ha^{-1}, 40 kg N and 60 kg P ha^{-1}, and 40 kg N and 0 kg P ha^{-1}respectively. With regard to seed yield kg ha^{-1}, the table shows that interaction of nitrogen and phosphorus at 40 and 30 kg ha^{-1} and that of 40 and 60 kg ha^{-1} do not differ significantly. Control application of both factors led to the production of lower seed yield among all the treatment combination applied. The positive interaction between nitrogen and phosphorus rates on number of pods, pod length, pod weight, pod yield, 100 seed weight and seed yield could be a proof of better uptake and assimilation of available nutrients by the plants during the entire growth period therefore, meeting the demand of the crop for development and yield of field pea crop (Kumar *et al*. 2009 and Valenciano *et al*. 2010). Waseem *et al.*, (2008) also observed that the application of balance nutrients promotes vigorous growth of the plant which ultimately increase the size of pod as well as seed.

Table 1: Some soil properties (0-30 cm) of experimental field at Vom, prior to sowing

	Value at 0 – 30cm depth		
	2015	2016	2017
Particle Size Distribution (gkg^{-1})			
Sand	46.84	46.84	47.00
Silt	29.00	29.00	28.60
Clay	24.16	24.16	24.40
Textural class	Loam	Loam	Loam
Chemical property			
pH	5.65	6.40	6.14
EC(dsm/m)	0.12	0.17	0.18
Organic Matter (gkg^{-1})	0.95	0.93	0.86
Total N (%)	0.10	0.07	0.08
Available P (mg kg^{-1})	3.60	4.89	6.21
Available K (mg kg^{-1})	198	201	199

Table 2: Response of Field pea (*Pisum sativum* L.) yield and its components to application of nitrogen rates during the 2015 rainy seasons

Treatment	Yield and yield components							
	NP	PL	WP	PY	NS	SW	SY	HI
N (kg ha^{-1})								
0	10.44c	4.94c	15.94c	1288.11c	4.61c	22.61c	1076.72c	27.28c
20	14.44b	6.33b	21.72b	1914.94b	5.17b	24.30b	1810.00b	33.76a
40	17.00a	6.78a	26.33a	2279.28a	5.61a	25.17a	2064.20a	33.33a
	*	*	*	*	*	*	*	*
P (kg ha^{-1})								
0	9.72c	5.67c	19.61c	1302.11c	4.77b	23.30c	1090.61c	24.13c
30	13.11b	5.94b	21.50b	1709.89b	5.28a	24.00b	1584.00b	34.33b
60	15.06a	6.44a	22.89a	1870.33a	5.33a	24.33a	1791.28a	36.13a
	*	*	*	*	*	*	*	*
SE±	0.31	0.10	0.64	60.31	0.18	0.15	36.92	0.50

Means followed by same letter (s) on the same column do not differ significantly at 5% probability level by Duncan Multiple Range Test. N = Nitrogen P = Phosphorus *=Significant

Table 3: Response of Field pea (*Pisum sativum* L.) yield and its components to application of nitrogen rates during the 2016 rainy seasons

Treatment	Yield and yield components							
	NP	PL	WP	PY	NS	SW	SY	HI
N (kg ha^{-1})								
0	9.83c	5.56c	16.44c	1410.78c	4.33b	23.61b	1211.06c	26.43c
20	14.22b	6.50b	22.16b	2046.67b	5.22a	24.17a	1926.83b	34.36a
40	16.67a	6.94a	26.22a	2251.89a	5.22a	24.22a	2109.67a	34.72a
	*	*	*	*	*	*	*	*
P (kg ha^{-1})								
0	10.06c	5.21c	20.22c	1263.22c	4.71	23.94	1155.88c	28.15c
30	14.12b	6.11b	21.72b	1789.20b	4.94	24.00	1629.67b	34.26b
60	15.00a	6.48a	22.87a	2156.94a	5.06	24.00	1857.00a	36.54a
LS	*	*	*	*	NS	NS	*	*
SE±	0.37	0.10	0.67	56.30	0.13	0.16	46.37	0.80

Means followed by same letter (s) on the same column do not differ significantly at 5% probability level by Duncan Multiple Range Test. N = Nitrogen P = Phosphorus *=Significant NS= Not Significant

Table 4: Response of Field pea (*Pisum sativum* L.) yield and its components to application of nitrogen rates during the 2017 rainy seasons

Treatment	Yield and yield components							
	NP	PL	WP	PY	NS	SW	SY	HI

N (kg ha^{-1})								
0	9.67c	5.22c	15.11c	1496.82c	5.21b	22.83c	1284.22c	24.36c
20	15.89b	6.33b	18.83b	2066.20b	6.00a	23.22a	1860.28b	36.56a
40	17.06a	6.44a	23.33a	2228.06a	6.22a	23.40a	2065.22a	38.12a
	*	*	*	*	*	*	*	*
P (kg ha^{-1})								
0	12.83c	5.83b	17.11	1366.50c	5.72	23.00	1183.61c	29.00c
30	13.83b	5.89b	19.61	1937.50b	5.83	23.00	1654.28b	32.16b
60	15.94a	6.28a	20.26	2087.11a	5.89	23.22	1889.83a	36.48a
LS	*	*	NS	*	NS	NS	*	*
SE±	0.32	0.10	0.81	44.88	0.10	0.15	43.10	0.80

Means followed by same letter (s) on the same column do not differ significantly at 5% probability level by Duncan Multiple Range Test. N = Nitrogen P = Phosphorus *=Significant NS= Not Significant

Table 5: Interaction of nitrogen and phosphorus rates on number of pods plant^{-1}, pod length, weight of pod, 100 seed weight and seed yield (Pooled over three years)

	Yield and yield components							
Treatment	NP	PL	WP	PY	NS	SW	SY	HI
N_0P_0	9.72f	4.56d	10.56e	912.06g	4.22	22.00d	743.22f	20.50
N_0P_{30}	10.00e	5.44c	16.11d	1477.33f	5.15	23.24c	1283.55e	26.44
N_0P_{60}	12.22d	5.52c	19.00bc	1806.39d	5.45	23.35bc	1621.56d	31.89
$N_{20}P_0$	14.00cd	6.03b	20.56b	1835.78d	5.50	23.48bc	1734.11cd	29.22
$N_{20}P_{30}$	13.86d	6.56a	19.33c	2012.94c	5.50	24.89a	2017.78b	34.78
$N_{20}P_{60}$	16.11b	6.58a	22.33b	2209.06b	5.39	24.43a	2128.17b	37.28
$N_{40}P_0$	15.22bc	6.67a	22.89b	2035.00c	5.72	24.11ab	1917.66bc	31.67
$N_{40}P_{30}$	16.89ab	6.78a	22.78b	2246.28b	5.67	24.45a	2365.33a	38.78
$N_{40}P_{60}$	18.44a	6.89a	25.00a	2428.94a	5.67	24.44a	2359.00a	39.22
	*	*	*	*	NS	*	*	NS
SE ±	0 .67	0.17	0.37	54.38	0.13	0.27	75.12	0.91

Means followed by same letter (s) on the same column do not differ significantly at 5% probability level by Duncan Multiple Range Test. N= Nitrogen P= Phosphorus *=Significant NS= Not Significant

4. CONCLUSION

The three-year results obtained revealed that increasing the rate of nitrogen and also that of phosphorus fertilizer up to 40 kg ha^{-1} and 60 kg ha^{-1} respectively exerted positive effect on field pea yield and its components. Similarly, combined application of the two at 40 kg N ha^{-1} and 30 kg P ha^{-1} could lead to better pod and seed yield of the crop.

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