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Responses of *Mucuna flagellipes* to Phosphorus Fertilizer Rates in an Ultisol

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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Original Research Article

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ABSTRACT

Two field experiments were conducted to investigate the responses of *Mucuna flagellipes* to single super phosphate fertilizer rates. The experiment consisted of five rates of single super phosphate fertilizer namely 0 kg P ha^{-1}, 30 kg P ha^{-1}, 40 kg P ha^{-1}, 50 kg P ha^{-1} and 70 kg P ha^{-1} laid out in a randomized complete block design and replicated four times in 2010 and 2011 cropping season at the Teaching and Research Farm of the Department of Agronomy, Cross River State University of Science and Technology, Obubra, Cross River State, South East Nigeria. The obtained results showed that number of leaves per plant, plant height, leaf area index, number of nodules per plant and nodule dry weight per plant were most significantly ($p < 0.05$) pronounced at 164 days after planting at the highest application rate of 70 kg P ha^{-1} than the other rates in 2010 and 2011 planting season. Pod yield per plant, seed yield per plant and seed yield per hectare were significantly ($p < 0.05$) the highest at 50 kg P ha^{-1}. Generally, there was a consistent significant

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difference ($p < 0.05$) among the single super phosphate fertilizer rates on the growth and yield of *Mucuna flagellipes*. Application of 50 kg P ha^{-1} and 70 kg P ha^{-1} of single super phosphate fertilizer should be used for the cultivation of *Mucuna flagellipes*.

Keywords: Mucuna flagellipes; single super phosphate fertilizer; ultisol; legume; nodulation.

1. INTRODUCTION

Mucuna flagellipes (vogel ex Hook) is of *Fabaceae* family and *papilioniodeae* sub family [1]. It is a climbing perennial legume with compound trifoliate leaves and is indigenous to Nigeria [2]. The crop is commonly known by the following names: *Ukpo', 'Ibaa' or Okobo* by the Igbos of eastern Nigeria, the *Yorubas* call it '*agbarin*' while the *Hausas* call it *'Karangiwa"* and the *Efiks* call it *"ibaba"* [3]. Unfortunately, the crop is lesser known, under-exploited and has not been fully integrated into the regular farming system. According to [4], the seed is milled into powdery flour and utilized in soup preparation for human consumption. *Mucuna flagellipes* has high nutritional value (55.10% carbohydrate, 21.2% protein, 6.5% dry matter, 2.4% ash and high in minerals) but low in fibre content. The leaves are used to formulate local hair dye [5]. The dye produced from the leaves is used for dyeing pillars of houses and for other home decorations.

Fabaceae is a family with large group of plants that form a cheap source of protein for man and livestock [6]. The group is estimated to contain between 16,000 and 19,000 species in which about 750 genera which add fix nitrogen in symbiosis with *Rhizobia* [7].

Literature shows that the application of phosphorus fertilizers significantly increased the growth and yield of legumes [8-10]. [11,12] working at the humid forest/derived savannah of Nsukka agro-ecology in Nigeria have shown that the soils (ultisols) are predominantly sandy loam, highly leached and acidic. Phosphorus under such a situation constitutes a problem in crop production due to fixation leading to low availability.

There is paucity of literature on the use of phosphorus fertilizer for the regular cultivation of *Mucuna flagellipes.* Therefore, this work aimed to investigate the effects of single super phosphate fertilizer rates on the growth and yield of *Mucuna flagellipes.*

2. MATERIALS AND METHODS

2.1 Description of the Experimental Site

Field trials were conducted at the Teaching and Research Farm of the Department of Agronomy, Cross River State University of Science and Technology, Obubra, Cross River State in 2010 and 2011 cropping season, respectively. Obubra is located at latitude 05º 59' N and longitude 8º 15' E. [13]. Rainfall distribution pattern in this region is bimodal with peaks in July and September and a short dry spell around mid August. The mean rainfall amount is 2000 mm per annum and the mean annual temperature is 27º Celsius with a mean monthly relative humidity of 79%. The experimental site was under two years grass fallow which was cleared and the land ploughed and harrowed in April, 2011.

2.2 Experimental Design and Field Operations

The experiment consisted of five rates of single super phosphate fertilizer namely 0 kg P ha^{-1}, 30 kg P ha^{-1}, 40 kg P ha^{-1}, 50 kg P ha^{-1} and 70 kg P ha^{-1} laid out in a randomized complete block design and replicated four times in 2010 and 2011 cropping season respectively. A total of 20 beds were made, each measured 4 m by 4 m (16 m^2). Each of the beds was separated from one another by a spacing of 1 m and 1 m pathway between replications. *Mucuna flagellipes* seeds were pre-soaked in water at room temperature for 24 hours. Those seed that floated on the water were removed while those seeds that sank in water were selected for sowing. Planting was done on 21st April in 2010 and 2011 cropping season respectively at a depth of 0 - 10 cm and at the rate of two seeds per hole at a plant spacing of 1.0 m by 0.6 m (inter and intra row spacing respectively). Seedlings were thinned to one plant per stand after two weeks of field emergence. Single super phosphate fertilizer rates (0 kg P ha^{-1}, 30 kg P ha^{-1}, 40 kg P ha^{-1}, 50 kg P ha^{-1} and 70 kg P ha^{-1}) were randomly applied to the experimental plots by side banding (5 cm distance from the seedling) at 60 days after planting. Vertical staking of the seedlings was done at three weeks after planting using bamboo stakes. Weeding was done manually by the use of traditional hoe. Basal dressing with 100 kg K ha^{-1} of potassium was applied to all the experimental plots.

2.3 Soil Sample Collection and Analysis

Soil samples were collected with steel auger from the top soil to a depth of 0 to 20 cm before planting. Three representative soil samples were randomly collected per plot and bulked to form a composite soil sample for each plot. A total of 20 composite soil samples were collected. Samples were air dried, ground and passed through a sieve with 2mm standard mesh size. The soil pH was determined with a pH meter using 1:2.5 soil to water ratio and 1: 2.5 soil to 0.1 N KCl (potassium chloride) suspension according to [14]. Organic carbon was determined using the Walkley and Black wet digestion method [15]. Soil organic matter content was obtained by multiplying the value of organic carbon by 1.724 (Van Bemmeler factor). Total nitrogen was determined by micro-kjeldahl procedure [14]. Available phosphorus was extracted with Bray II extractant as described by [16] and determined colorimeterically using ascorbic acid method [17]. Exchangeable potassium was extracted using 1 Nammonium acetate (NH_4OAC) solution and determined by the flame emission spectroscopy as outlined by [18]. Aluminum and Hydrogen content (exchangeable acidity) were determined by titrimetric method after extraction with 1.0 N KCl [19]. The cation exchange capacity was determined by NH_4OAC displacement method [20]. Calcium and magnesium were determined by the complexiometeric titration method as described by [21]. Particle size distribution analysis was done by the hydrometer method [22] and the corresponding textural class determined from the United States Department of Agriculture Soil Textural Triangle. Base saturation was determined by the method outline by [14].

2.4 Growth and Yield Data Collection

Morphological and physiological growth parameters were collected at 45, 60, 75, 90 and 164 days after planting. Number of leaves per plant and number of branches per plant were determined by taking a visual count of the green leaves and the branches, plant height was determined by measuring the length of the plant from the soil level to the tip of the topmost leaf using a measuring tape, Leaf area per plant was obtained by destructive sampling of the leaves per plant taken to the laboratory for leaf area determination using leaf area meter (model Mk – 2). Leaf area index was determined as total leaf area per plant divided by the feeding area available for the plant (inter row spacing multiplied by intra row spacing of each plant) according to [23]. The destructively sampled plants were separated into fractions (leaves, stems, nodules and roots) and put in a paper envelope and oven dried at 80º Celsius to a constant weight for three days for the dry matter determination of, nodules and root. Crop growth rates (nodule growth rate and root growth rate) were determined by the equation stated below.

Crop growth rate (CGR)

$$CGR = \frac{W_2 - W_1}{SA\ (t_2 - t_1)}\ g/m^2/\ day.$$

Where:

CGR = crop growth rate
W_1 and W_2 = dry weight at beginning and end of the interval of growth period
t_1 and t_2 = sampling time 1 and 2.
SA = the area occupied by the plant at sampling.

Yield data were collected after harvest (full maturity). Each plant was harvested separately. Number of pods per plant was obtained by visual counting of pods per plant, number of seeds per plant was determined by visual counting of the seeds in the pod per plant and number of pods without seeds was determined by visual counting pods without seeds. Pod yield per plant, seed yield per plant and seed yield per hectare were recorded at harvest.

Using electronic weighing balance. Days to first and 50% anthesis and pod formation (days to first pod set and 50% pod set)was calculated by counting the number days starting from the day of planting to anthesis and pod formation respectively. Number of inflorescences per plant, number of flowers per plant and number of flowers aborted per inflorescence were computed by visual counting of the inflorescences, flower and flower abortion.

2.5 Statistical Analysis

Data collected were subjected to analysis of variance (ANOVA) as outlined by [24]. Significant means were separated using Fishers least significant difference (F-LSD) at 5% probability level. Statistical analysis was executed using GENSTAT Release 7.2DE Discovery Edition 3 [25] statistical software.

3. RESULTS

The data shown in Table 1 indicated that the soil of the study area before planting was acidic (pH 4.5 and 3.4 in water and potassium chloride respectively in 2010 and 4.3 and 3.2 in water and potassium chloride, respectively in 2011). The soil textural class was sandy loam in 2010 and 2011 planting season, which contained 45% (2010) and 46% (2011) coarse sand, 26% (2010) and 28% (2011) fine sand,26% (2010) and 24% (2011) clay and 2% (2010) and 2% (2011) silt. The organic carbon content was found to be 0.73% (2010) and 0.72% (2011), organic matter content was 1.31% (2010) and 1.24% (2011) and total nitrogen contents were 0.0058% (2010) and 0.0064% (2011). The exchangeable base [sodium 0.8 meg/100 g soil (2010) and 0.8 meg/100 g soil (2011), potassium 0.18 meg/100 g soil (2010) and 0.16 meg/100 g soil (2011) calcium 1.2 meg/100 g soil (2010) and 1.0 meg/100 g soil (2011) and magnesium 0.7 meg/100 g soil (2010) and 0.9 meg/100 g soil (2011).] The cation exchange capacity of the soil was 6.8 meg/100 g soil (2010) and 7.0 meg/100 g soil (2011) for the base saturation 45% (2010) and 43% (2011). The hydrogen 2.6 meg/100 g soil (2010) and 2.4 meg/100 g soil (2011) and aluminum content was found to be 3.4 meg/100 g soil (2010) and 3.6 meg/100 g soil (2011) and available phosphorus (Bray 11) was found to be 8.6 parts per million (2010) and 8.8 parts per million (2011).

Table 2 revealed that the effects of single super phosphate fertilizer treatment on the number of leaves per plant (410.4 in 2010 and 223.1 in 2011), leaf area index (9.16 in 2010 and 5.89 in 2011), number of branches per plant (41.1 in 2010 and 39.4 in 2011) and plant height (554.8 cm in 2010 and 532.4 cm in 2011) of *Mucuna flagellipes* were most significantly ($p < 0.05$) pronounced at 164 days after planting (DAP) than the other periods of observation (45, 60, 75, 90 DAP) at the highest application rate of 70 kg P ha^{-1}. The highest application rate of 70 kg P ha^{-1} at 164 DAP significantly ($p < 0.05$) gave the highest number of nodules per plant (34.2 in 2010 and 32.4 in 2011), nodule dry weight per plant (8.81 g plant^{-1} in 2010 and 6.91 g plant^{-1} in 2011), nodule growth rate (0.931 g/m^2/day in 2010 and 0.913 g/m^2/day in 2011) and root growth rate (1.24 g/m^2/day in 2010 and 1.19 g/m^2/day in 2011), than in the plot which received 0 kg P ha^{-1}single super phosphate fertilizer in 2010 and 2011 cropping season (Table 3).

In Table 4, the number of days to first anthesis (118.7 in 2010 and 125.0 in 2011) and number of days to 50 percent anthesis (135.2 in 2010 and 146.2 in 2011) were significantly ($p < 0.05$) reduced at 50 kg P ha^{-1}as compared with 0 kg P ha^{-1}. The effects of single super phosphate fertilizer rates on number of days to first pod formation (149.9 in 2010 and 160.4.0 in 2011) and number of days to 50 percent pod formation (163.4 in 2010 and 172.6 in 2011) were significantly ($p < 0.05$) reduced at 50 kg P ha^{-1}as compared with 0 kg P ha^{-1}. Application of 50 kg P ha^{-1} of single super phosphate fertilizer rate significantly ($p < 0.05$) enhanced number of inflorescence per plant in 2010 (45.1) and in 2011 cropping season 40 kg P ha^{-1} of single super phosphate fertilizer rate significantly ($p < 0.05$) increased the number of inflorescence per plant (47.3) as compared with 0 kg P ha^{-1}. More so, in Table 4 50 kg P ha^{-1} of single super phosphate fertilizer rate significantly ($p < 0.05$) reduced the number of flowers aborted per plant in *Mucuna flagellipes*in 2010 (3.1) and 2011 (3.0) cropping season respectively as compared with 0 kg P ha^{-1}.

The results in Table 5 indicated, that the number of pods without seeds per plant (4.5 in 2010 and 4.2 in 2011) was significantly ($p < 0.05$) reduced at 50 kg P ha^{-1}of single super phosphate fertilizer rate in comparison with 0 kg P ha^{-1}. Furthermore, the number of pods per plant was significantly ($p < 0.05$) the highest (34.6) in plot amended with 40 kg P ha^{-1} as compared with 0 kg P ha^{-1} in 2010 but in 2011, 70 kg P ha^{-1} of single super phosphate fertilizer rate significantly ($p < 0.05$) gave the highest (31.4) number of pods per plant than the other rates. The number of seeds per plant was significantly ($p < 0.05$) the highest (4.6) in plot treated with 50 kg P ha^{-1} as compared with 0 kg P ha^{-1} in 2010 both in 2011, 70 kg P ha^{-1} of single super phosphate fertilizer rate significantly ($p < 0.05$) gave more number of seeds per plant than the control treatment. Pod yield per plant (372.2 g plant^{-1} in 2010 and 368.0 g plant^{-1} in 2011), seed yield per plant (283.5 g plant^{-1} in 2010 and 287.3 g plant^{-1} in 2011), seed yield per hectare of *Mucuna flagellipes* (3.20t ha^{-1} in 2010 and 3.25 t ha^{-1} in 2011), were significantly ($p < 0.05$) the highest at 50 kg P ha^{-1}as compared with 0 kg P ha^{-1}.

4. DISCUSSION

The results of this investigation revealed that *Mucuna flagellipes* benefited from the application of single super phosphate fertilizer in terms of increase in the number of leaves per plant, number of branches per plant, plant height and leaf area index. This finding is in tandem with the observations of [8], who reported an increase in the number of leaves per plant and branches per plant in cowpea as a result of increasing phosphorus fertilizer application rate. *Mucuna flagellipes* growth rate, dry matter accumulation and leaf area increased with successive increase in application rates of single super phosphate fertilizer. This finding is due to greater accumulation of photosynthates in *Mucuna flagellipes* sown in single super phosphate fertilizer treated soil than untreated soil [26].

Fertilization with single super phosphate fertilizer at the rate of 70 kg P/ha in 2010 and 2011, respectively produced the highest number of nodules per plant 34.2 (2010) and 32.4 (2011) and dry weight per plant 8.81 g plant^{-1} (2010) and 6.91 g plant^{-1} (2011) at 164 days after planting, respectively than in the untreated soil. [27], obtained higher number of nodules per plant and dry weights of nodules per plant in groundnut grown on sandy loam soil amended with 38 kg P ha^{-1} of single super phosphate fertilizer than unamended soil.

Amending the soil with single super phosphate fertilizer improved flower production in *Mucuna flagellipes.* Earlier attainment of 50% anthesis and pod initiation, higher percentages of pod set and low flower and pod abortion were observed in single super phosphate fertilizer treated soil than in the untreated soil. Such responses tallied with the results of [28], who reported increased flower production, retention of pods and reduction in the incidences of flower and pod abortion in cowpea with phosphorus fertilizer treatment.

Table 1. Initial soil characteristics before planting in 2010 and 2011 cropping season

Parameters	2010	2011
Particle size distribution (%)		
Coarse sand	45	46
Fine sand	26	28
Clay	26	24
Silt	2	2
Textural class	Sandy loam	Sandy loam
pH (water)	4.5	4.3
pH (KCl)	3.4	3.2
Organic carbon (%)	0.73	0.72
Organic matter (%)	1.31	1.24
Total nitrogen (%)	0.0058	0.0064
Available phosphorus (ppm)	8.6	8.8
Exchangeable bases (meg/100 g soil)		
Calcium	1.2	1.0
Magnesium	0.7	0.9
Potassium	0.18	0.16
Sodium	0.8	0.8
Exchangeable acidity (meg/100 g soil)		
Hydrogen	2.6	2.4
Aluminum	3.4	3.6
Cation exchangeable capacity (meg/100 g soil)	6.8	7.0
Base saturation (%)	45	43

Table 2. Effects of single super phosphate fertilizer rates on vegetative growth of *Mucuna flagellipes* in 2010 and 2011 cropping season

Rates (kg P ha^{-1})	Number of leaves per plant					Leaf area index					Number of branches per plant					Plant height (cm)				
	45	60	75	90	164	45	60	75	90	164	45	60	75	90	164	45	60	75	90	164
	DAP					DAP					DAP					DAP				
2010 cropping season																				
0	9.8	16.8	17.8	27.9	173.3	0.10	0.15	0.29	0.39	3.03	1.6	1.7	2.8	6.6	17.0	122.2	194.3	249.3	284.2	431.2
30	12.1	17.6	20.7	29.2	274.6	0.20	0.22	0.32	0.48	5.92	1.4	1.5	3.6	13.1	29.9	128.3	200.0	250.3	301.5	461.1
40	13.2	17.7	20.2	31.4	309.8	0.22	0.32	0.35	0.49	6.35	1.6	1.7	4.0	15.1	33.4	124.1	203.7	266.9	312.5	481.3
50	13.8	18.0	21.3	35.2	330.3	0.24	0.37	0.39	0.54	7.46	1.6	1.9	4.2	16.7	36.6	128.2	224.0	282.9	331.4	493.2
70	15.2	19.5	25.2	41.3	410.4	0.27	0.39	0.43	0.68	9.16	3.1	2.1	5.2	18.3	41.1	131.6	243.9	317.5	406.2	554.8
LSD $_{(0.05)}$ for 2 rates	1.8	NS	2.1	2.3	11.2	NS	0.02	0.10	0.04	0.2	NS	NS	NS	1.1	1.6	NS	NS	2.1	3.1	2.2
2011 cropping season																				
0	6.3	10.1	12.2	18.4	101.1	0.03	0.11	0.17	0.26	2.10	1.0	1.3	2.0	4.1	11.1	101.5	162.2	206.5	251.3	322.1
30	9.2	13.2	15.5	23.1	152.3	0.11	0.18	0.20	0.34	3.23	1.3	1.4	2.5	7.3	21.3	114.8	183.7	221.7	286.4	413.2
40	11.1	14.3	17.2	27.3	171.5	0.19	0.23	0.27	0.37	4.16	1.4	1.6	3.1	9.2	30.2	120.2	195.1	243.4	301.7	444.8
50	12.3	16.1	18.1	30.2	192.4	0.21	0.29	0.31	0.48	5.57	1.5	1.7	3.5	13.5	33.0	123.6	203.5	264.6	315.5	473.7
70	14.2	17.3	18.9	43.6	223.1	0.32	0.33	0.37	0.51	5.89	1.8	1.9	3.9	16.3	39.4	131.3	241.2	281.6	341.5	532.4
LSD $_{(0.05)}$ for 2 rates	1.1	1.2	1.0	1.5	4.1	NS	0.02	0.11	0.02	0.1	NS	NS	NS	1.1	1.2	NS	1.0	1.3	2.2	1.4

NS – Non significant at 0.05 probability level, DAP – days after planting

Table 3. Effects of single super phosphate fertilizer rates on nodulation of *Mucuna flagellipes* in 2010 and 2011 cropping season

Rates (kg P ha^{-1})	Number nodules per plant			Nodule dry weight (g $plant^{-1}$)			Nodule growth rate (g/m^2/day)		Root growth rate (g/m^2/day)	
	75	90	164	75	90	164	45-90	90-164	45-90	90-164
	DAP			DAP			DAP		DAP	
2010 cropping season										
0	2.7	3.2	11.1	0.02	0.52	2.02	0.004	0.404	0.63	0.40
30	2.7	3.2	27.3	0.02	0.61	3.61	0.006	0.698	0.65	0.69
40	3.3	4.3	34.3	0.17	0.65	7.75	0.007	0.882	0.82	0.88
50	3.0	6.5	32.3	0.31	0.69	8.39	0.008	0.905	0.91	0.98
70	3.4	7.1	34.2	0.37	0.75	8.81	0.009	0.931	0.97	1.24
$LSD_{(0.05)}$ for 2 rates	NS	0.02	0.4	NS	0.02	0.4	0.03	0.02	0.02	0.02
2011 cropping season										
0	1.2	2.2	8.4	0.01	0.24	1.43	0.803	0.213	0.35	0.49
30	1.8	2.7	15.2	0.02	0.41	2.26	0.004	0.432	0.517	0.48
40	2.4	3.6	21.5	0.12	0.53	5.11	0.005	0.671	0.73	0.10
50	2.8	4.9	29.7	0.23	0.59	6.78	0.006	0.814	0.84	0.88
70	3.2	5.3	32.4	0.31	0.64	6.91	0.009	0.913	0.93	1.19
$LSD_{(0.05)}$ for 2 rates	NS	0.01	0.2	0.01	0.03	0.2	0.03	0.01	0.03	0.01

NS – Non significant at 0.05 probability level, DAP – days after planting

Table 4. Effects of single super phosphate fertilizer rates on flower and pod formation of *Mucuna flagellipes* in 2010 and 2011 cropping season

Rates (kg P ha^{-1})	Days to first anthesis	Days to 50% anthesis	Days to first pod set	Days to 50% pod set	Number of inflorescence per plant	Number of flower aborted per inflorescence
2010 cropping season						
0	140.7	156.8	163.0	178.0	32.3	5.3
30	124.3	146.1	156.7	170.2	37.4	4.2
40	123.3	141.9	153.2	168.6	40.3	4.1
50	118.7	137.3	149.9	163.4	45.1	3.1
70	120.2	135.2	150.3	170.1	38.1	3.5
$LSD_{(0.05)}$ for 2 rates	0.18	1.11	1.33	1.48	0.7	0.1
2011 cropping season						
0	147.7	170.5	171.2	185.5	32.2	5.4
30	135.3	157.4	165.8	180.3	38.1	4.3
40	131.5	150.4	163.2	176.4	47.3	3.4
50	125.0	146.2	160.4	172.6	41.2	3.0
70	129.3	152.4	166.1	174.2	39.3	3.4
$LSD_{(0.05)}$ for 2 rates	0.94	1.35	1.43	1.65	0.8	0.1

NS – Non significant at 0.05 probability level

Application of single super phosphate fertilizer gave higher seed yield and yield parameters in comparison with the unamended soil. This increase in yield and plant size parameters could be related to the greater production of nodules and consequently the higher nitrogen fixation in *Mucuna flagellipes* with single super phosphate fertilizer. This could also be attributed to the greater light interception and high photosynthetic capacity of the plant. [29] had concluded that nitrogen fixation by legumes gave high yields predominantly through its effects on enhancing the leaf area index and net assimilation rate.

Table 5. Effects of single super phosphate fertilizer rates on the yield of *Mucuna flagellipes* in 2010 and 2011 cropping season

Rates (kg P ha^{-1})	Number of pod per plant	Number of pods without seed per plant	Number of seeds per plant	Pod yield per plant (g $plant^{-1}$)	Seed yield per plant (g $plant^{-1}$)	Seed yield per hectare (t ha^{-1})
2010 cropping season						
0	16.3	6.7	3.3	153.2	106.3	0.98
30	25.7	5.3	2.7	257.9	201.3	2.17
40	34.6	5.2	3.2	281.2	236.9	2.71
50	29.4	4.5	4.6	372.2	283.5	3.20
70	27.1	4.6	3.1	243.6	221.5	2.1
$LSD_{(0.05)}$ for 2 rates	3.16	0.51	NS	6.8	11.1	0.05
2011 cropping season						
0	15.2	7.0	3.0	143.3	88.2	0.75
30	22.5	5.3	3.0	197.2	174.7	2.00
40	26.3	4.6	3.1	210.7	231.1	2.50
50	28.0	4.2	3.0	368.0	287.3	3.25
70	31.4	5.1	3.2	227.4	201.4	2.0
$LSD_{(0.05)}$ for 2 rates	2.1	0.30	NS	6.4	10.2	0.03

NS – Non significant at 0.05 probability level

5. CONCLUSION

The results of this study revealed that there was a consistent significant difference ($p < 0.05$) among the single super phosphate fertilizer rates (0 kg P ha^{-1}, 30 kg P ha^{-1}, 40 kg P ha^{-1}, 50 kg P ha^{-1} and 70 kg P ha^{-1}) on the growth and yield of *Mucuna flagellipes* grown in an utisol in south east Nigeria in 2010 and 2011 cropping season, respectively. For optimum crop growth and yield in the cultivation of *Mucuna flagellipes*, the application rate of 50 kg P ha^{-1} and 70 kg P ha^{-1} of single super phosphate fertilizer should be used.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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