Agro-Science Journal of Tropical Agriculture, Food, Environment and Extension
Volume 7 Number 1 January, 2008 pp. 58 - 65
ISSN 1119-7455

STUDIES ON YIELD AND YIELD COMPONENT RESPONSES OF *MUCUNA FLAGELLIPES* TO LIME AND PHOSPHORUS APPLICATIONS UNDER FIELD CULTURE IN A TROPICAL ULTISOL.

Asiegbu, J.E.[1] and Agba[2], O.A
[1]Department of Crop Science, University of Nigeria, Nsukka, Nigeria
[2]Department of Crop/Soil Science, Cross-River University of Technology Obubra Campus, Obubura

ABSTRACT
Mucuna flagellipes* was subjected to field scale culture over 1999 and 2000 growth seasons. Yield and yield component responses were evaluated using 4 x 3 factorial treatment combinations of phosphorus at 0, 20, 40, and 60kg P ha^{-1} and lime at 0, 1 and 2 t $CaCO_3$ ha^{-1}. The experiment was laid out in a randomized complete block design and there were three replications. Liming and P-fertiliser, whether individually or in combination, significantly shortened the period to anthesis and to pod-set, increased the number of inflorescences, flowers and pods produced, and consequently increased seed yield. Percentage pod-set was improved by lime or P treatment but was still considered low at 43-45% on average. Combined application of 2 t ha^{-1} of $CaCO_3$ and 40kg P ha^{-1} proved most satisfactory for use.

Key words: *Mucuna flagellipes*, Lime, P-fertiliser, Soil pH, Pod set. ***Running title: Mucuna*** *flagellipes* yield responses to lime and P

INTRODUCTION

Mucuna flagellipes (Vogel ex Hook) of the family Leguminosae, sub-family Papilioniodeae (Polhill and Raven, 1981) is a climbing perennial indigenous to Nigeria. It is one of the lesser known, neglected and under-exploited legumes of Nigeria (Anonymous, 1979; Okigbo, 1980). Currently, there is a growing awareness on its potential importance as food, pharmaceutical and other commercial importance (Okigbo, 1980; Ene-Obong and Carnovale, 1992; Eyiuche, 1988). Both the seed and the leaf have high economic, pharmaceutical and domestic uses. The seed is rich in protein, fats, carbohydrate and minerals, and is consumed in soup as condiment and thickner (Odelele, 1983; Okoro, 1989), while the leaf was reported as being used to formulate local hair dye (Okoro, 1989). The gum has potential for use as binder in ephedrine tablets (Chukwu, 1986; Eyiuche, 1988). Despite the acknowledged potentials, *Mucuna flagellipes* is commonly grown by the traditional farmers on subsistence level in solitary stands (Oyenuga, 1986; Okigbo, 1980). It exists in solitary stands trained to climb live stakes in farm fringes and does not enjoy full scale field culture. For realization of its potentials, it must be produced in commercial quantities through regular culture. There is no literature report on its cultivation, growth and yield on a field scale. There is a current interest to wean *Mucuna flagellipes* from the subsistence production level and integrate it into a commercial field scale of production.

Lime and P treatments were incorporated to gain more information on the field performance of the crop. Literature shows that P-fertiliser enhances growth and yield in legumes such as soybean, (Chien and Menon, 1995; Abdel *et. al.*, 1986; Aranjo, *et al* 1997), especially in soils deficient in phosphorus. Experience at the low altitude of the humid tropical agricultural zone of Nsukka shows that the soils are predominantly sandy loam, highly leached and acidic. Phosphorus under such acid conditions tends to be fixed leading to poor availability, hence the need for liming. The present study was part of the initiative to advance domestication of the crop and to fill information gap on the liming and phosphorus application responses, and to provide data on aspects of yield and yield attributes under field conditions in a tropical ultisol.

MATERIALS AND METHODS

Field studies were conducted in the Department of Crop Science, University of Nigeria, Nsukka, Research Farm between 1999 and 2000, to investigate *Mucuna flagellipes* responses to lime and P-fertiliser treatments. Nsukka is located at latitude 06° 25′ N and longitude 07° 24′ E and at altitude 447 m above sea level. The experimental site was under two years grass fallow which was cleared, and the land ploughed in May 1999. Initial soil sample for site characterization was got by bulking samples obtained with auger to a depth of 0-20 cm from fifteen representative locations and sub-sampled for subsequent analysis. The experiment was a 4 x 3 factorial laid out in a randomized complete block design. Treatments comprised four phosphorus rates of 0, 20 40 and 60 kg P ha^{-1} and three lime rates of 0.0, 1.0 and 2.0 t ha^{-1} of $CaCO_3$, which were randomly laid our in the field within each block. There were three replicates. Each of the 12 plots within block measured 4 x 3 metres. Lime was incorporated into the appropriate plots according to the rate schedule on May 17, 1999, two weeks before finally pulverizing the soil and sowing the seeds (on May 31) at the spacing of 1 m between row and 60 cm within row. To ensure good field emergence, healthy seeds were pre-soaked in water for 24 hours. Those that floated on the water were removed as bad while the good ones were selected for sowing. Phosphorus was applied as single super-phosphate to the appropriate plots according to schedule on June 26 by ring banding. Weeding by hoeing was done three times in each year (1999 and 2000) to keep the plots as weed-free as possible. Basal dressing with 100 kg K ha^{-1} was applied to all plots.

In both the main-crop year (1999) and the ratoon-crop year (2000), records were taken on number of inflorescences, number of flowers, days to anthesis, pod-set and on seed yields. Records were also taken on such concomitant observations as pest and disease incidents and on weather. Data were subjected to analysis of variance according to the procedure for a randomised complete block design as outlined by Gomez and Gomez (1984).

RESULTS

The experimental site was characterized as a sandy loam soil with rather low nutrient contents of nitrogen, organic matter, magnesium and base saturation but high in aluminum content (Table 1). The soil was acidic.

Table 1: Physical and chemical characteristics of the experimental site before planting

Mechanical properties:	
Coarse sand (%)	46
Fine sand (%)	28
Clay (%)	24
Silt (%0	2
Textural class	sandy loam
Chemical properties:	
pH in water	4.3
pH in KCl	3.7
Organic carbon (%)	0.72
Organic matter (%)	1.24
Total nitrogen (%)	0.0064
Total phosphorus (ppm)	8.8
Base saturation (%)	43
Exchangeable cation (meq/100 g soil)	
Potassium	0.16
Magnesium	0.9
Calcium	1.0
Sodium	0.8
Hydrogen	2.4
Aluminium	3.6
C.E.C.	7.0

Rainfall was always high from May to October with the characteristic bimodal pattern peaks in June or July and August or September(Table 2). Solar radiation and soil and air temperatures were high all through the year, except for the slight depressions between July and August following from the high rainfall and rain-day trends during those months.

The first 1.0 t ha^{-1}incremental application produced marked increases in pH values, by 0.82 in water and 0.63 in salt solution at 4 weeks after liming, or 1.02 in water and 1.04 in salt solution at 8 weeks after liming (Table 3). The second 1.0 ton incremental application of lime produced rather modest pH increases.

Table 2: Meteorological data for 1999 and 2000.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1999 records												
Total rainfall (cm)	23.1	0.0	28.2	260.6	151.9	177.3	182.6	232.2	333.0	144.2	11.2	0.0
Rain days	4	0	2	8	13	15	19	17	22	18	3	0
Max. air temp. (°C)	29.9	32.3	3.1	31.2	29.7	29.5	26.6	26.6	27.6	28.6	28.0	27.9
Min. air temp.(°C)	21.0	23.1	23.3	22.3	21.6	22.2	20.7	20.5	20.6	22.9	22.9	22.9
Soil temp. (°C)	26.4	30.1	30.3	28.3	25.9	25.1	26.6	27.6	25.9	26.2	26.7	24.5
Solar rad. (cal/cm^2/day)	666.7	821.8	648.8	706.2	644.7	522.9	463.5	416.6	510.8	569.3	578.5	760.1
Rel.humidity (%)	66.7	62.3	71.6	72.4	75.7	76.6	77.6	77.4	79.1	79.0	70.2	66.2
Day length (hours)	11.46	11.54	12.04	12.12	12.25	12.30	12.29	12.20	12.11	12.00	11.49	11.45
Sunshine (hours/day)	5.2	5.3	6.0	5.8	6.2	3.9	3.3	3.6	3.7	5.4	6.2	4.4
2000 records												
Total rainfall (cm)	1.3	0.0	21.2	136.4	161.3	413.0	253.3	314.2	235.7	172.2	3.0	0.0
Rain days	1	0	2	7	9	16	17	22	20	15	1	0
Max. air temp. (°C)	3.0	34.3	33.5	31.5	29.4	29.8	27.7	28.2	26.9	27.3	31.5	29.8
Min. air temp.(°C)	21.2	24.3	23.3	22.4	21.6	21.3	20.8	20.5	21.5	20.9	24.0	22.1
Soil temp. (°C)	26.7	27.5	30.6	9.5	27.4	26.5	25.7	26.4	26.5	26.1	27.5	23.4
Solar rad . (cal/cm^2/day)	667.8	821.8	658.5	706.2	633.8	523.4	479.5	417.5	513.7	570.1	578.5	760.1
Rel.humidity (%)	65.1	54.8	67.7	74.9	78.1	79.5	79.6	76.8	80.1	79.1	70.3	65.5
Day length (hours)	11.46	11.54	12.04	12.12	12.25	12.30	12.29	12.20	12.11	12.00	11.49	11.45
Sunshine (hours/day)	5.2	5.3	6.0	5.8	6.2	3.9	3.3	3.6	3.7	5.4	6.2	4.4

Table 3: Effects of liming on soil pH# in water at 4 and 8 weeks after liming.

	Lime rate (t $CaCO_3$ / ha^{-1})			
	0.0	1.0	2.0	Mean
At 4 weeks after application				
pH in water	4.32	5.14	5.52	5.00
pH value increase per t of lime	-	0.82	0.48	-
pH in KCl	3.73	4.36	4.52	4.20
pH value increase per ton of lime	-	0.63	0.16	-
At 8 weeks after application				
pH in water	4.91	5.93	6.05	5.63
pH value increase per ton of lime	-	1.02	0.12	-
pH in kCl	3.89	4.93	5.02	4.61
pH value increase per t of lime	-	1.04	0.09	-

Days to anthesis were calculated from planting (May 31) for the main crop (1999) and from start of rationing (March 20) for the ratoon crop.

Lime and P-fertilizer applications significantly decreased the number of days to anthesis, thereby hastening pod-set, whether in the main or ratoon crop. (Table 4). Further depressant effects were not clearly evident at 60kg P ha^{-1} or 2 t $CaCO_3$ ha^{-1}. Delay in anthesis was most pronounced when both lime and P were not applied, while in combination, they jointly hastened anthesis, especially when P at 40 kg was combined with lime at 2 t ha^{-1}. Anthesis was on average attained at 146 days after planting in the main, and 156 days from ratooning in the ratoon crop.

Table 4: Days# to 50% anthesis in *Mucuna flagellipes* as affected by lime and P

Phosphorus (kg P ha^{-1}) rate	Lime rate (t $CaCO_3$ ha^{-1}) 0.0	1.0	2.0	Mean
In main crop in 1999				
0	167.0	152.3	151.0	156.8
20	147.7	144.7	146.0	146.1
40	138.3	139.0	134.7	137.3
60	141.0	143.0	141.7	141.9
Mean	148.5	144.8	143.3	145.5
In ratoon crop in 2000				
0	178.0	165.4	168.2	170.5
20	163.4	157.4	152.5	157.4
40	156.2	149.5	145.4	150.4
60	153.1	143.2	142.3	146.2
Mean	162.7	153.8	151.9	156.1
	Main crop		Ratoon crop	
LSD $_{(0.05)}$ for 2 P means	1.1		1.3	
LSD $_{(0.05)}$ for 2 lime means	2.0		1.0	
LSD $_{(0.05)}$ for 2 P X lime means	2.6		2.1	

= pH data represents mean of 12 values

Table 5: Effects of lime and P on inflorescence and flower production in *Mucuna flagellipes* in main and ratoon crops.

Lime rate	Lime rate (t $CACO_3$ ha^{-1})							
Phosphorus (Kg P ha^{-1})	0.0	1.0	2.0	Mean	0.0	1.0	2.0	Mean
	Mean crop				Ratoon crop			
Number of inflorescences plant^{1}								
0	21.3	22.3	28.3	3.9	22.1	24.5	27.4	24.6
20	31.3	27.0	36.3	31.6	27.3	25.0	34.5	28.9
40	40.7	36.0	49.0	41.9	38.7	33.0	43.6	38.4
60	38.0	41.3	46.7	42.0	32.4	40.1	45.2	39.7
Mean	32.8	31.6	40.1	34.8	30.1	30.7	37.7	32.8
Number of flowers inflorescence $^{-1}$								
0	8.7	8.0	8.0	8.2	8.3	9.1	8.0	8.5
20	8.3	8.3	8.7	8.6	8.4	8.0	8.5	8.3
40	8.3	8.7	9.0	8.7	8.2	8.4	9.1	8.6
60	8.3	8.3	9.0	8.4	8.5	8.1	8.3	8.3
Mean	8.4	8.3	8.7	8.5	8.4	8.4	8.5	8.4
Percentage pod-set plant^{-1}								
0	19.0	25.0	25.0	23.0	20.2	23.0	26.1	23.1
20	32.0	27.7	48.0	35.9	35.3	45.8	52.3	44.5
40	56.3	42.7	56.0	51.7	43.3	59.6	63.4	55.4
60	62.0	52.3	64.7	59.7	50.9	54.4	67.6	57.7
Mean	43.0	36.9	47.8	42.6	37.4	45.7	52.4	45.2
		No of infl. plant^{-1}		Flowers infl.$^{-1}$		% pod-set lant^{-1}		
		Main	*Ratoon*	*Main*	*Ratoon*	*Main*	*Ratoon*	
LSD $_{(0.05)}$ for 2 P mean		3.4	2.9	ns	Ns	7.9	5.8	
LSD $_{(0.05)}$ for 2 lime means		2.9	2.0	Ns	Ns	6.8	4.8	
LSD $_{(0.05)}$ for 2 P X Lime means		5.9	5.2	Ns	ns	13.6	10.7	

Table 6: Effects of lime and P on aspect of yield components in Mucuna flagellipes in the main and ratoon crops.

	Lime treatment (t $CaCO_3$ ha^{-1})							
Phosphorus (Kg P ha-1)	0.0	1.0	2.0	Mean	0.0	1.0	2.0	Mean
	Main crop					Ratoon crop		
Number of pods per plant								
0	16.0	17.3	20.3	16.3	14.5	15.6	18.7	16.3
20	26.7	21.7	28.7	25.7	20.8	22.1	24.5	22.5
40	28.3	28.3	38.7	34.6	23.3	26.0	29.7	26.3
60	26.7	26.7	32.3	29.6	25.7	27.4	30.9	28.0
Mean	23.3	26.1	30.0	26.4	21.1	22.8	26.0	23.3
% no of pods without seed								
0	49.0	37.6	28.6	41.1	53.0	42.1	30.9	42.1
20	21.7	26.3	15.7	20.6	34.5	31.4	19.7	28.5
40	24.4	15.9	11.1	15.0	31.2	27.7	16.1	25.0
60	20.2	16.5	11.8	15.2	29.4	17.8	14.8	20.7
Mean	28.0	20.4	15.5	20.8	37.1	29.8	20.4	29.1
Number of seeds per pod								
0	3..3	3.3	3.2	3.3	3.0	3.1	2.8	3.0
20	2.7	3.3	2.3	2.7	2.6	3.2	3.1	3.0
40	3.3	3.3	3.0	3.2	3.3	2.9	3.0	3.1
60	3.2	2.3	2.3	2.6	3.2	3.2	3.1	3.0
Mean	3.2	3.1	2.7	3.0	3.0	3.1	3.0	3.0

	No of pods Plant^{-1}		% pods non –seed		No of seeds pod^{-1}	
	Main	*Ratoon*	*Main*	*Ratoon*	*Main*	*Ratoon*
LSD $_{(0.05)}$ for 2 P means	3.2	3.1	3.5	2.9	Ns	Ns
LSD $_{(0.05)}$ for 2 lime means	2.7	2.6	2.0	2.0	Ns	Ns
LSD $_{(0.05)}$ for 2 P X Lime means	5.5	5.2	4.3	4.6	ns	Ns

ns= not significant

The number of inflorescences produced per plant was increased with incremental P application up to the P rate of 40 kg P ha^{-1} in the main or ratoon crop, while with lime, significant increases also occurred at the highest level of 2 t $CaCO_3$ ha^{-1} in both the main and ratoon crops (Table 5). The number of flowers produced per inflorescence was constant at 8-9 and did not vary due to lime or fertilizer P application, but pod-set, which was considered low at the average of 42-52%, benefited significantly from P application and from liming. Pod-set was considerably improved by a combined application of 60 kg P ha^{-1} and lime of 2 t ha^{-1} to give 40-45 and 42-47% pod set in the main and ratoon crops, respectively.

The number of pods set per plant followed the same general trend as inflorescence production (Table 6). The percentage number of empty pods (without seeds) was considered undesirably high at an average of 29% and rather very high at 49-53% when both lime and P were not applied. The number of seeds per pod was not affected by lime or P treatment and a general average of 3 seeds per pod was maintained.

Seed yield, similar to pod yield, was progressively improved with liming and with increased P application (Table 7). The high P rate of 60 kg P ha $^{-1}$ did not evince any advantage over the rate of 40 kg P ha,$^{-1}$ except in the ratoon crop in the following year. The combined use of lime at 2 t ha^{-1} and P at 40 kg P ha^{-1} always gave satisfactory results. Seed yield was markedly higher in the main than in the ratoon crop. Harvest index was depressed where P or lime was not applied, more so where both were not.

Seed yield was regressed against LAI, Leaf DM and Number of Branches as follows:

$$Y= a\ 0.549 - 0.0767X_1 - 0.0216X_2 + 0.114\ X_3$$

$$(R = 0.964;\ R^2 = 0.929)$$

Y= yield of seed; X_1 = LAI; X_2 Leaf DM; X_3 = number of branches. The seed yield parameters of number of pods per plant and number of seeds per pod correlated highly positively with the various growth parameters, especially the number of branches and number of nodules produced per plant. Over 92% of the seed yield variability (t/ha) (R^2= 0.929) was caused by the combined effects of number of branches, LAI and Leaf dry matter accumulation.

Table 7: Effects of lime and P on pod and seed yields in *Mucuna flagellipes* main and ratoon crops

	Lime treatment (t $CaCO_3$ ha^{-1})							
Phosphorus (Kg P ha-1)	0.0	1.0	2.0	Mean	0.0	1..0	2.0	Mean
	Main crop				Ratoon crop			
Pods yield (g $plant^{-1}$)								
0	123.5	153.5	182.6	153.2	115.6	126.4	187.8	143.3
20	124.3	264.0	274.2	257.9	184.5	197.6	209.4	197.2
40	128.8	287.2	307.7	281.2	195.3	203.5	233.4	210.7
60	279.7	297.6	299.2	292.2	207.2	210.6	251.3	223.0
Mean	194.1	250.6	265.9	246.1	175.7	184.6	220.4	193.6
Seed yield (t ha^{-1})								
0	0.67	1.07	1.21	0.98	0.48	0.85	0.93	0.75
20	1.87	2.14	2.41	2.17	0.75	0.95	1.30	1.00
40	1.89	2.66	3.58	2.71	0.89	1.56	1.75	1.50
60	1.85	2.28	2.48	2.20	1.03	1.86	2.03	1.55
Mean	1.59	2.04	2.42	2.02	0.79	1.31	1.50	1.20
# Harvest index (%)								
0	76.6	84.1	85.5	81.7	65.4	76.5	79.3	73.7
20	86.0	90.7	91.8	89.5	78.2	84.8	88.4	83.8
40	86.0	95.4	96.3	92.1	81.6	89.3	92.3	87.7
60	86.1	95.4	96.3	92.1	83.4	91.5	96.5	90.5
Mean	83.5	90.4	90.9	83.3	77.1	85.5	89.1	83.9

	Pod yield		Seed yield		Harvest index	
	Main	*Ratoon*	*Main*	*Ratoon*	*Main*	*Ratoon*
LSD $_{(0.05)}$ for 2 P means	6.8	7.3	0.05	0.04	1.3	1.2
LSD $_{(0.05)}$ for 2 lime means	5.6	6.2	0.04	0.03	1.2	1.0
LSD $_{(0.05)}$ for 2 P X Lime means	4.8	12.3	0.08	0.09	2.3	2.0

Harvest index = seed weight as % of pod (seed +husk) weight.

DISCUSSION

Typical of the tropical lowland environments, there were high rainfalls and high temperatures that evidently had, over time, led to high amounts of leaching and to the formation of soils low in nutrient reserves and organic matter contents. These were characteristics also similarly reported for the ultisol that make up over 70% of the soils of the zone (Enwezor, 1977; Unamba-Opara, 1985; Mbagwu, 1990, 1992). Except for about five months of no or low rainfalls which limited moisture supply and would require supplemental irrigation, temperatures seemed good and insolation high to support all-year-round cropping.

The dramatic increase in soil pH with application of 1 t $CaCO_3$ ha^{-1} and the low response following the second incremental application showed evidence of low buffering of the soil. In a similar Nsukka soil, Asiegbu (1989) also reported a marked increase in pH with application of 1.5 t $CaCO_3$ ha^{-1}, with liming efficiency dropping markedly beyond that rate. Liming with 1-2 t $CaCO_3$ ha^{-1} in the present study satisfactorily served to raise the pH to levels that would generally prevent excessive aluminium and iron solubility and consequent toxicity and apparently improved availability of plant nutrients. Fore and Okigbo (1979) also noted the great need to lime Nsukka soils to eliminate aluminium and iron toxicity, while Enwezor (1977) concluded that liming of Nsukka soils is desirable when pH in water is below 5.0, especially to prevent aluminium and iron toxicity. All these liming influences evidently formed part of the bases for the increased yield responses with lime treatment.

Great benefits from P-fertiliser application to legumes, especially in P-deficient soils, have been reported, and examples include improved root development and grain yield (Singh and Lamba, 1973; Kang and Fox, 1983), increased root development, nodulation and nitrogen fixation (Sharma and Garg, 1982; Khare and Rai, 1986; Sign *et al.,* 1986). Often yield increases were associated with increased flower production and retention of pod or reduced incidence of abortion (Faroda, 1973; Kurdikari *et.al.,* 1979).

In the present investigation, P and lime treatments increased the number of inflorescences and consequently the number of flowers produced, shortened the time to anthesis and to pod set, depressed abortion, increasing pod-set percentage and improved seed yields. Consideration of lime x P-fertiliser interaction favoured recommendation of combined application of 2 t $CaCO_3$ ha^{-1} and 40 kg P ha^{-1}. Although both lime and P benefited yields significantly, responses appeared greater with P treatment on average, probably indicating that P was more limiting under the circumstances. For instance, application of 2 t $CaCO_3$ ha^{-1} resulted in the seed yield increase of over 52% for the main and 90% in the ratoon crop over where lime was not applied, while application of 40 kg P ha^{-1} increased yield by 177% for the main and 100% for the ratoon crop compared with where P was not applied. Concomitant observations did not reveal serious pest and disease problems on the crop, although *Zonocerus variegatus* attacked the leaf.

CONCLUSION

Considering that no work based on a field scale study has been reported on this important crop, the data generated in this study will be useful as bench-mark information for a general crop improvement programme and for further agronomic studies needed for evolving suitable production technology. A good breeding programme is needed to solve the problems of high flower and pod abortion and to improve yields. It will also help to accelerate domestication to wean the crop from the perennial and wild growth habit, change the crop architecture to a smaller and more manageable stature that will obviate the use of long trellis that hampers large scale cultivation. Breeding will also help to improve product quality and nutritive value. The currently low level of research attention and use of unimproved provenances leave room for disappearance of important germplasms from the hands of the local farmers who grow it. There is a need for urgent redress.

REFERENCES

Abdel, S.M.A., Osman, A.Z. and Basiony, H. (1986). Interaction of the level and method of phosphorus fertilizer and cowpea production in newly reclaimed soils, *Isotopes* 1: 33-39.

Aranjo, A. P., Teixeira, M.G. and Almeida, D.I. (1997). Phosphorus efficiency of wild and cultivated genotypes of common beans (*Phaseolus vulgare* L.) under biological nitrogen fixation. *Soil Biochemistry,* 29: 951-957.

Anonymous (1979). Tropical legumes: Resources for the future. Report of an Adhoc Panel for Advisory Committee on Technology Innovation. National Academy of Science. Washington D.C. p. 214

Asiegbu, J. E. (1989). Response of onion to lime and fertilizer N in a tropical ultisol. *Tropical Agriculture (Trinidad)* 66 (2): 161-166.

Chien, S.H. and Menon, R.G. (1995). Factors affecting the agronomic phosphate rock for direct application. *Fertiliser Research,* 41 (3): 227-234.

Chukwu, A. (1986). Evaluation of *Mucuna flagellipes* gum as a tablet disinterant B. Pharm Thesis of University of Nigeria, Nsukka, Nigeria, p.56

Ene-Obong, H.N. and Carnovale, E. (1992). Nigeria soup and condiments. Traditional processing and potentials as dietary fibre sources. *Food Chemistry,* 43:29-44.

Enwezor, W.O. (1977). Soil testing for phosphorus in some Nigeria soils: 3 forms of phosphorus in soils of Eastern Nigeria and their relationship to plant available phosphorus. *Soil Science,* 124(1):27-33.

Eyiuche, P.I. (1988). Comparative evaluation of *Mucuna flagellipes* gum and other binders on dissolution of ascorbic acid and ephedrine hydrochloric tablets. B. Pharm Thesis, University of Nigeria, Nsukka, Nigeria. p. 58

Faroda, A.S.(1973). Notes on the effect of different levels of nitrogen, phosphorus and potash on fodder production of legumes. *Indian Journal of Agricultural Research,* 7(3-4):217-218.

Gomez, K.A. and Gomez, A.A. (1984) statistical Procedures for Agricultural Research, 2nd Edn., New York, John Wiley & Sons, p.680

Khare, N.K. and Rai, M. M. (1986). Effect of nitrogen, phosphorus and potassium on field of legumes. *Kereha Journal of Agricultural Research,* 17(2): 194 -199

Kurdikari, K.P., Sharma, A.K. and Thakur, T. A. (1979). Manuring cowpea: A study of the effects of different rates of phosphorus and molybdenum on the growth and yield of cowpea. *India Journal of Agronomy,* 15: 112-117.

Mbagwu, J.S.C.(1990). Maize (*Zea mays* L.) response to nitrogen fertilizer on an Ultisol on southern Nigeria under two tillage and mulch treatments. *Journal of Science of Food and Agriculture,* 52: 365-376.

Mbagwu, J. S. C. (1992). Improving the productivity of a degraded Ultisol in Nigeria using organic and inorganic amendments. Part 1: Chemical properties and maize yield. *Bioresource Technology,* 42: 149-154.

Odedele, I.O. (1983). Physiochemical Properties of *Mucuna flagellipes.* B.Sc. Thesis Department of Food Science and Technology, University of Nigeria, Nsukka, Nigeria, p.56

Okigbo, B.N. (1980). Utilization of indigenous plants. 1980 Ahajioku Lecture. Culture Division, Ministry of Information, Culture, Youth and Sports, p.32

Okoro, C. (1989). The Darkening material in *Mucuna flagellipes,* (Papilionaceae), its Prevention and Prospects of its Uses in Hair Colouring. B. Pharm Thesis, University of Nigeria, Nsukka, Nigeria p.. 63

Oyenuga, V. A. (1968). Nigeria Food and feeding Stuffs. Ibadan University Press 145pp.

Polhill, R.M. and Raven, P.H.(eds.) (1981). Advances in Legume Systematics, Part I, Royal Botanic Garden, p.256

Sharma, B.S. and Garg, K. (1982). Effects of soil phosphorus on yield of soybean. *Experimental Agriculture,* 21(2):34-39.

Singh, G.S., Adams, M. and Kaplan, L (1986). Variability of phosphorus intake translocation in *Phaseolus vulgaris*(L.). *Journal of American Society of Horticultural Science,* 102:74-79.

Unamba-Opara, I. (1985). The potassium status of the sandy soils of northern Imo State, Nigeria. *Soil Science,* 139: 437-445.