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Effect of Plant Population on the Growth and Yield of *Mucuna Flagellipes* (Vogel ex Hook) in an Ultisol, South Nigeria

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ABSTACT

The effect of plant population on the growth and yield *Mucuna flagellipes* (Vogel ex Hook) was conducted for two cropping seasons (2013 and 2014) in the Teaching and Research farm, Department of Agronomy, Cross River University of Technology Obubra, Cross River State. The experimentwas laid out in a randomized complete block design (RCBD). Treatments comprised four plant populations of 33,333, 16,666, 10,000 and 8,333 plants/ha and there were three replications. Data collected were statistically analyzed using Analysis of Variance (ANOVA) procedure for a randomized complete block design. Close spacing with high plant population significantly ($p < 0.05$) reduced the number of leaves, branches and dry matter of plant fractions per plant. The longest vine of 594.1 and 651.3cm and leaf area index of 7.462 and 7.609 were produced in plant population of 33,333 plants/ha at 24 WAP in 2013 and 2014 cropping seasons respectively. Pod and seed yield per plant were higher in plots with the least plant population of 8,333 plants/ha as compared with other higher plant population of 33,333 and 16,666 plants/ha. The highest *Mucuna flagellipes* seed yield of 2.85 and 2.91 tons/ha were produced from plots with 33,333 plants/ha in 2013 and 2014 cropping seasons.

***Keywords*:** *Mucuna flagellipes*; plant population; growth and yield

1. INTRODUCTION

Mucuna flagellipes belongs to the fabaceae family, sub family papilioniodeae (polhill and Raven 1981). It has been described as a climbing perennial herb with compound trifoliate leaves and indigenous to Nigeria (Anonymous, 1979). *Mucuna flagellipe*s is one of the lesser known legume but has high nutritional value. It is variously called 'Ukpo' in Igbo, '*Karangiwa'* in Housa, '*agbarin'* in Yoruba and '*Ibaba'* in Efik (Oyenuga, 1989). The seed is rich in edible oils, fats and minerals (Odedele, 1983). It is widely consumed among the Igbo – speaking people in soup as thickener and condiment (Oyenuga, 1986; Okigbo, 1980).

Both the seed and leaf of *Mucuna flagellipes* have high economic importance in pharmaceutical industry and other domestic uses. In pharmaceutical industry, the gum produced from the seed could be used as a binder in the formulation of ephedrine hydrochloric tablet (Chukwu, 1986; Eyiuche, 1988). The leaves are used to formulate local hair dye (Okoro, 1989).

Despite the economic importance of this crop, it is grown on a sub-subsistence level mostly as a compound crop by the Igbos of South East Nigeria (Okigbo, 1980; Oyenuga, 1986). There is scanty literature in the cultivation, growth and yield of *Mucuna flagellipes* on a commercial scale. There is need to integrate *Mucuna flagellipes* into a regular farms culture. Literature showed that the use of optimum plant population increase total crop yield per unit area of land (Oseni and Fawusi, 1987; Muoneke and Asiegbu, 1997). Muoneke and Asiegbu, (1997) reported higher fresh fruit yield of okra planted at a population of 111, 111 plants per hectare when compared with others plant populations.

Documented information on the effects of plant population on the growth and yield of *Mucuna flagellipes* is lacking. The present study aimed at investigating the influenced of various plant populations on the growth and yield of *Mucuna flagellipes* to provide information to assist in the domestication and cultivation of the crop in commercial scale.

2. MATERIALS AND METHODS

Two experiments were conducted in the Department of Agronomy, Cross River University of Technology, Obubra Teaching, and Research Farm in 2013 and 2014 cropping seasons to investigate effects of plant population on the growth and yield of *Mucuna flagellipes*. Gographically, Obubra is located on latitude 05° 59' N and longitude 08° 15' E (CRADP, 1992).

The experimental site was under two years grass fallow when it was cleared, packed, and the land ploughed in April, 2013. Soil sample was collected from fifteen representative locations with steel auger to a depth of 0-20cm. The soil sample were bulked together to form a composite sample from where a sub-sample was obtained for laboratory analysis to determine the physical and chemical properties of the site.

The experimental design was a randomized complete block design (RCBD). Treatments were four spacing (plant populations) of *Mucuna flagelipes;* 33,333 *Mucuna flagellipes* /ha corresponding to the spacing of 1.0 m x 0.3 m inter and intra spacing:

16, 666 plants / ha = 1.0 m x 0. 6 m
10,000 plants /ha = 1.0 m x 1.0 m

8, 333 plants / ha = 1.0 m x 1.2 m

The four plant populations were allocated at random to each of the four blocks using the table of random numbers. Each plot measured 4 x 6m with area of 24 m^2.

2. 1. Planting

Mature health seeds of *Mucuna flageelipes* were collected from Ikom market, Cross River State, Nigeria. as there is yet no source for improved seed materials. The seeds were soaked in water for 24 hours before planting at the rate of two seeds per hole according to schedule spacing above. The same procedure was repeated for the 2013 experiment as was done in 2014. In both 2013 and 2014 cropping seasons, data were collected on number of leaves, branches and nodules per plant. Leaf area and leaf are index (LAI), Days to First and 50% anthesis and pod formation.

2. 2. Growth Analysis

Growth analyses were evaluated at four stages of 50-100 days after planting (DAP), 50 – 80 DAP, 80-110 DAP, 110-140 DAP through destructive sampling of one plant per plot. The leaves of the destructively sampled plants were taken to the laboratory for leaf area determination using leaf area meter model (Mk – 2). Growth analysis techniques described by Radford and Brown (1984) was applied to the biological measurements as follows;

2. 3. Leaf area index (LAI)

LAI = La x $(p)^{-1}$
Where
LAI = leaf area index
La = total leaf area per plant
P = feeding area available (ground supporting it).

2. 4. Crop Growth Rate (CGR)

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

where:
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.

2. 5. Dry matter Fraction

The destructively sampled plants were separated into fractions of leaf, stem nodules, and roots and then dried to constant weight and recorded. Records were taken on number of inflorescences, number of pod per plant, pod and seed yield per hectare.

2. 6. Statistical Analysis

All data collected were subjected to analysis of variance according to the procedure for randomized complete block design by Gomez and Gomez (1984). Separation of treatments means for statistical significant difference was done using F-LSD at 5 % probability level as described by Obi (2002).

3. RESULTS AND DISCUSSION

The soils of the experimental sites were sandy loam with low pH, 5.05 in water and 4.90 in KCl, (Table 1). Nitrogen, organic mater, potassium, magnesium and calcium were equally low. *Mucuna flagellipes* leaf number per plant progressively significantly decreased with increasing plant population either at 12, 16, 20 and 24 weeks after planting in both 2013 and 2014 cropping seasons (Table 2). At 20 to 24 weeks after planting, the number of leaves per plant almost double with the lower plant populations of 10, 000 to 8,333 plants per hectare producing more number of leaves per plant than higher populations of 33,333 plants / ha. The plots with 8,333 plants / ha gave the highest number of leaves per plant in both 2013 and 2014 cropping seasons.

Leaf area per plant increase significantly with decreased in plant population. At all periods of measurement, leaf area per plant was higher in lower plant population densities than the higher densities. The least plant population of 8,333 plants / ha produced higher leaf area per plant than the other populations. On the other hand, leaf area index increased significantly with increased in plant population (Table 2). *Mucuna flagellipes* plots with 16,666 and 33,333 plants / ha gave higher values of leaf area index then the other plant populations. The highest leaf area index value of 7.462 and 7. 609 were obtained in plots with 33,333 plants / ha at 24 weeks after planting (WAP) in 2013 and 2014 cropping seasons respectively.

Table 1. Soil physical and chemical properties of the experimental sites in 2008 and 2009 cropping seasons.

Soil properties	2013	2014
Mechanical properties		
Coarse sand %	15.3	16.2
Fine sand %	67.0	69.4
Clay (%)	4.9	5.4
Silt (%)	19.0	18.3
Textural class	Sandy loam	Sandy loam

Chemical properties		
pH in water	5.06	5.04
pH in kcl	4.91	4.94
Organic carbon (%)	0.82	0.79
Organic matter(%)	1.33	1.28
Nitrogen (%)	0.08	0.09
Total Phosphorus (ppm)	7.0	6.2
Base saturation (%)	58.6	57.4
Exchangeable Cation (Meg/100 soil)		
Potassium (k) meg/100 soil	0.13	0.15
Magnesium (mg)	1.9	1.6
Calcium (ca)	2.6	2.5
Sodium (Na)	0.07	0.09
Aluminum (Al)	1.5	1.8
Hydrogen (H)	2.4	2.5
Cation Exchange Capacity	8.41	8.29

Table 2. Effects of plant population on the vegetative growth (number of leaves, branches per plant and plant height) at different periods in 2013 and 2014 cropping seasons:

Plant population (No of plants/ha)	Number of leaves per plant				Leaf Area (cm^2) per plant				Leaf Area Index (LAI)				Number of branches per plant			Plant height (Vine length) (cm)				
	12 WAP	16 WAP	20 WAP	24 WAP	12 WAP	16 WAP	20 WAP	24 WAP	12 WAP	16 WAP	20 WAP	24 WAP	12 WAP	16 WAP	20 WAP	24 WA P	12 WAP	16 WAP	20 WAP	24 WAP
2013 Cropping season																				
33,333	20.5	25.7	39.4	63.8	47.06	63.21	84.34	103.86	0.103	1.444	4.168	7.462	2.4	3.7	5.3	10.4	183.4	238.4	452.4	594.1

16,666	22.2	27.8	45.2	71.0	49.54	65.73	87.83	110.36	0.083	1.267	3.891	5.977	3.0	3.9	6.1	13.1	177.8	232.2	440.4	584.9
10,000	23.4	29.8	49.7	83.4	51.82	67.28	94.67	115.41	0.081	1.074	3.626	4.410	3.5	4.3	7.1	15.5	173.4	223.7	432.0	559.9
8,333	25.7	32.2	54.2	111.6	54.70	70.01	100.91	125.10	0.075	0.843	3.247	4.254	3.5	5.0	8.2	16.1	170.2	219.2	416.9	554.4
2014 Cropping season																				
33,333	22.5	27.5	42.0	67.0	47.89	63.60	84.66	102.69	0.105	1.451	4.315	7.609	2.4	3.7	5.3	10.4	188.5	256.0	473.9	651.3
16,666	24.7	30.0	45.9	74.3	50.12	65.29	88.39	111.05	0.088	1.278	3.918	6.027	3.0	3.9	6.1	13.1	180.3	244.3	462.3	639.7
10,000	26.8	32.1	52.4	88.8	52.80	68.04	96.07	116.61	0.080	1.088	3.608	4.679	3.5	4.2	7.1	15.5	176.2	235.4	453.2	629.3
8,333	29.0	35.2	57.0	118.7	55.19	70.47	102.00	125.69	0.074	1.864	3.186	4.064	3.5	5.0	8.2	16.1	171.1	230.0	443.0	619.4
LSD(0.05)	1.1	1.5	2.3	3.3	0.12	0.3	2.1	5.3	0.001	0.01	0.10	0.30	NS	0.01	0.3	1.0	1.4	3.1	8.1	10.2

Leaf dry matter per plant decreased significantly with increasing plant population (Table 3). Leaf dry matter weight per plant almost doubled at 24 WAP especially in lower plant populations. The highest leaf dry weight per plant was obtained in plots with 8, 333 plants / ha in the two cropping seasons. *Mucuna flagellipes* branching significantly decreased with increasing plant population in all stages of growth at 16, 20 and 24 WAP in 2013 and 2014 seasons (Table 3). The lower plant populations of 10,000 to 8, 333 plants / ha gave more number of branches per plant than the higher plant populations.

Table 3. Effects of plant population on dry matter weight of plant fractions (leaf, Vine and root dry weight (g) per plant of *Mucua flagellipes* at different periods in 2013 and 2014 cropping seasons.

Plant population (No of plants/ha)	Leaf dry weight per plant (g)			Vine dry weight per plant (g)			Root dry weight per plant (g)			Nodule dry weight per plant (g).		
	16 WAP	20 WAP	24 WAP	16 WAP	20 WAP	24 WAP	16 WAP	20 WAP	24 WAP	16 WAP	20 WAP	24 WAP
2013 Cropping season												
33,333	12.14	23.14	43.41	2.13	15.43	35.72	1.42	3.54	15.05	0.01	0.05	0.49
1 6,666	17.16	26.16	53.73	3.07	18.17	43.16	1.54	4.94	16.77	0.01	0.12	0.51
10,000	21.20	29.20	62.66	3.65	21.34	46.37	1.74	5.44	18.28	0.01	0.17	0.53
8,333	26.36	33.36	74.53	3.97	27.56	51.68	1.87	5.80	20.24	0.01	0.33	0.55
LSD (0.05)	0.52	2.1	5.6	0.51	1.34	2.1	0.01	0.1	1.1	NS	0.01	0.02
2014 Cropping season												
33,333	13.11	25.61	52.21	2.41	16.31	36.00	1.44	3.57	15.18	0.01	0.03	0.49
16,666	18.23	30.27	62.65	3.39	18.58	43.46	1.61	5.00	16.98	0.01	0.05	0.52
10,000	22.15	33.66	74.63	3.76	22.44	47.91	1.76	5.48	18.55	0.01	0.17	0.55
8,333	27.32	39.02	87.28	4.05	28.36	54.22	1,76	6.01	20.36	0.01	0.33	0.58
LSD (0.05)	0.54	2.5	5.8	0.53	1.35	2.1	1.1	0.1	1.1	NS	0.01	0.02

At all periods of sampling, plant population did not significantly influenced the number of nodules per plant in *Mucuna flagellipes* both in 2013 and 2014 seasons. The effects of plant population on vine dry matter closely followed the same trend as their effects on leaf dry weight per plant. The plant population of 8,333 plants / ha produced greater vine dry weight per plant as compared with the other plant populations. Flower production was significantly earlier in lower plant population plots than the higher populated ones (Table 4). Days to first and 50% anthesis were significantly reduced in plots with 8, 333 plants / ha which gave the earliest (less number of days) to first and 50% anthesis in 2008 and 2009 seasons. The effects of plant population on days to first and 50% pod formation closely follows similar trend as their effects on days to first and 50% anthesis. *Mucuna flagellipes* pod and seed yields per hectare increased significantly with increasing plant population (Table 5). On per plant bases, the number of pods per plant, seed weight per plant decreased with increased in plant population. Lower plant population gave higher number of pods and seed per plant than higher plant population. The highest seed yield per hectare was obtained in plots with 33,333 plants / ha in the two cropping seasons of 2008 and 2009.

Table 4(a). Effects of plant population on the *Mucuna flagellipes* leaf, vine and nodules growth rate (g/m^2 /day) at different periods in 2013 and 2014 cropping seasons

Plant population (No of plants/ha)	Leaf growth rate (g/m^2 /day)				Vine growth rate (g/m^2 /day)					Nodule growyh rate (g/m^2 /day)				Nodule growyh rate (g/m^2 /day)
	50-80 DAP	80-110 DAP	110-140 DAP	140-170 DAP	50-80 DAP	80-110 DAP	110-140 DAP	140-170 DAP	140-170 DAP	50-110 DAP		110-140 DAP	110-140 DAP	
2013 cropping season														
33,333	0.3541	0.8126	0.9631	2.0134	0.3486	0.7812	1.021	1.8761		0.001	0.003	0.023	0.057	594.1
16,666	0.4132	0.932	1.1551	2.3568	0.5681	1.323	2.434	3.0104		0.002	0.004	0.035	1.034	584.9
10,000	0.5241	1.014	1.2052	3.2031	0.8214	1.745	2.8143	3.6341		0.001	0.006	0.042	1.065	559.9
8,333	0.7132	1.172	1.5121	3.6214	0.9983	1.984	3.1105	3.9756		0.001	0.009	0.064	2.324	554.4
LSD(0.05)	0.01	0.02	0.04	0.12	0.03	0.21	0.14	0.23		NS	0.001	0.003	0.01	8.2
2014 cropping season														
33,333	0.2931	0.8201	0.9812	2.0216	0.3510	0.7651	1.032	1.7682	0.105	0.001	0.003	0.24	0.053	651.3
16,666	0.4251	0.987	1.1743	2.3010	0.5813	1.4121	2.372	3.0201	0.088	0.001	0.005	0.27	1.051	639.7
10,000	0.5187	1..012	1.2613	3.1431	0.9010	1.7615	2.9012	3.5431	0.080	0.001	0.008	0.044	1.068	629.3
8,333	0.8022	1.216	1.6743	3.7124	0.9989	2.0312	3.2201	4.1263	0.074	0.002	0.012	0.063	2.361	619.4
LSD(0.05)	0.01	0.02	0.03	0.13	0.03	0.24	2.1	5.3	0.001	NS	0.001	0.003	0.02	10.2

Table 4(b). Effects of plant population on flower production in *Mucuna flagellipes* in 2013 and 2014 cropping seasons.

Plant population (No of plants/ha)	Days to first anthesis	Days to 50% anthesis	Days to first pod set	Days 50% pod set	No of inflorescence per plant	No of flowers per inflorescence	No of flowers aborted per inflorescence	Percentage of flowers aborted per plant (0%)	Percentage pod set per plant (0%)
2013 Cropping Season									
33,333	146.3	171.9	172.5	187.4	30.2	8.2	6.5	79.27	20.73
16,666	140.3	170.0	169.6	185.0	32.3	8.3	5.2	62.65	37.35
10,000	137.8	169.0	168.0	183.3	35.2	8.1	4.3	53.09	46.91
8,333	136.3	168.3	167.0	181.6	39.4	8.0	4.0	50.00	50.00
LSD (0.05)	1.3	1.5	1.5	2.1	0.4	NS	0.3	1.4	2.3
2014 Cropping Season									
33,333	146.1	174.5	172.1	187.1	31.1	8.3	6.6	79.52	20.48
16,666	141.7	171.7	170.8	185.6	32.4	8.2	5.1	62.20	37.81
10,000	140.1	169.3	169.0	184.1	36.1	8.1	4.2	51.85	48.15
8,333	137.8	167.8	167.4	181.1	39.3	8.3	4.0	40.82	59.18
LSD (0.05)	1.2	1.5	1.5	2.1	0.4	NS	0.3	1.3	2.4

Table 5. Effects of plant population on the yield and yield component of *Mucuna flagellipes* in 2013 and 2014 cropping seasons.

Plant population (No of plants/ha)	No of pods per plant	No of pods without seed per plant	Percentage of pods without seeds per plant (0%)	No of seeds per pod	Average No of seeds per plant	Pod yield per plant (g)	Seed yield per plant	Seed yield per hectare (t/ha)
2013 Cropping Season								
33,333	14.01	6.2	44.29	2.7	33.5	223.1	170.6	2.85
16,666	17.8	7.4	41.57	2.9	44.3	259.3	186.0	2.51
10,000	20.0	7.1	37.50	3.1	53.1	277.1	198.4	2.42
8,333	23.3	8.3	35.62	3.3	58.4	300.8	666.2	2.33
LSD (0.05)	1.0	0.3	10.5	0.1	2.1	15.3	10.2	0.01
2014 Cropping Season								
33,333	14.6	6.4	45.71	2.8	35.1	235.4	228.5	2.91
16,666	18.0	7.5	411.67	3.0	45.2	258.3	241.6	2.57
10,000	20.4	7.6	37.25	3.3	55.6	271.0	252.4	2.45
8,333	24.1	8.5	35.27	3.1	60.1	302.7	268.1	2.35
LSD (0.05)	1.0	0.3	0.6	0.1	2.1	15.3	10.2	0.01

Close spacing due to high plant population of *Mucuna flagellipes* resulted in plants with longer vine length, with less branches, less number of leaves and lower leaf area per plant as compared with low plant population associated with wider spacing obtained in this study was also reported by Nwofia *et al.*, (2005). Whereas leaf area per plant decreased as plant population increased, leaf area index increased with increasing population. This increase in leaf area index as plant population increased corroborated the findings by Agbo *et al.*, (2008); and Muoneke and Asiegbu, (1997).

Leaf and stem dry matter weight per plant was greater in low plant populations than in higher plant population densities. The least plant population of 8, 333 plants / ha gave the highest leaf and stem dry weight per plant. Dry matter weight reduction in plant parts associated with higher plant population densities have been reported by other workers. (Okpara, 2000; Muoneke and Asiegbu, 2005).

Plant population influenced flowering in *Mucuna flagellipes*. Low plant population of 8, 333 plants /ha gave earlier flowers than the other higher plant population of 16, 666 or 33, 333 plants / ha. This earlier flowering obtained in lower plant population densities could probably be due to wide spacing that might have provided better air and light interception into the canopy resulted to enhance flower production. Schipper (2000) also observed earlier flowering in low soybeans plant population as compare with higher plant population.

Mucuna flagellipes yield and yield components such as number of pods per plant, pod weight and seed weight per plant decreased with increased in plant population. This could be due to intra-specific competition. Similar decreased in yield per plant was obtained by earlier researchers (Muoneke *et al.*, 1997; Muoneke and Asiegbu, 1997 and Okpara, 2000). They attributed such depressant effects on yield to intra specific competition for nutrients, moisture and or space due to close spacing of the plants. On per hectare basis, the seed yield per hectare increased as plant population increased. The plant population of 16,666 and 33,333 plants / ha produced higher seed yield per hectare than the other plant populations. Similarly Nwofia and Ekeleme, (2005) have observed higher yield per hectare in higher populated plots than in low plant population plots.

4. CONCLUSION

Based on the result of this investigation, *Mucuna flagellipes* could be cultivated at a spacing of 1. 0 x 0. 6 m or 1.0 x 1.0 m in an ultisol, South-south Nigeria for optimum growth and yield.

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