Effects of Seeding Rates and Phosphorus Levels on the Productivity of *Atylosia scarabeoides* (Benth.)

P. A. Iji[1], O. A. Kolawole and G. S. Bawa
Department of Animal Science, Ahmadu Bello University, P. M. B. 1044, Zaria, Nigeria

ABSTRACT : Glasshouse investigations were carried out to investigate the development and yield of *Atylosia scarabeoides* on soils of the northern guinea savanah zone of Nigeria. Seeds were sown at four rates 50, 75, 100 and 125 kg/ha. Single superphosphate (SSP) fertilizer was applied at sowing at four rates 0, 60, 90 and 120 kg/ha. Seedling (plant) population at one month and at harvest was significantly ($p < 0.01$) influenced by seeding rate but not fertilizer level. Fresh herbage yield was strongly ($p < 0.01$) dependent on fertilizer level, with the highest (not significant) dry matter yield at 90 kg SSP/ha. Seeding rate had no significant effects on herbage yield. The crude protein content of herbage rose with increase in fertilizer level although there were no significant differences between the various seeding and phosphorus rates. No significant interactions were observed between seeding rate and phosphorus level.

The yields were generally high, indicating good prospects for pasture development with *A. scarabeoides* in the zone, although field trials would be of benefit.
(**Key Words** : *Atylosia*, Fertilizer, Phosphorus, Savanah, Seeding Rate, Yield)

INTRODUCTION

Poor nutrition has been identified as the major limitation to increase in animal productivity in most areas of the tropics. Improvement can be rapidly made through pasture development (Otchere and Nuru, 1988). The options available for pasture improvement include the use of synthetic fertilizers/manures; irrigation or the sowing of improved species. Legumes are especially important in the improvement of natural grasslands. Apart from the low cost of this option, legumes fit well into the farming systems of several tropical regions (Mohamed-Saleem, 1984; Tarawali and Pamo, 1992).

The potential and actual impact of low-cost pasture improvement can be far-reaching. In Ivory Coast, *Stylosanthes hamata* oversown into natural grassland at 4 kg/ha supported yields of 5.45 and 5.15 t DM/ha in the first and second years, respectively (Dulieu, 1987). In association with *Panicum maximum*, yields were about 10 t DM/ha and the effects of stylosanthes hamata were similar to the application of 45 kg urea/ha. Liveweight gains and wool production of sheep have been found to closely reflect the clover content of the sward (Curll et al., 1985). de Oliviera et al. (1985) estimated nitrogen supply from *S. hamata*, *Galactia striata* and *Macroptilium atropupureum* to pasture of *Setaria anceps* at 82, 111 and 138 kg/ha/annum, respectively. Similarly, Dwivedi et al. (1988) reported that the N content of mixed herbage was higher than that of the pure grass alone.

Since most of the improved legumes are introduced from other environments into the developing areas of the tropics, there is a need to screen them prior to use in large scale pasture development schemes.

Atylosia scarabeoides is one of the improved legume species introduced into the northern savanah zone of Nigeria, a region that holds a large number of grazing livestock. Initial screening has shown high viability although the seeds require scarification prior to sowing. Seeding rates and fertilizer requirements have not been determined. Successful pasture development involving legumes in the Nigerian savanah and similar environments may require fertilization with phosphorus.

The objectives of the current study were to assess some of the primary characteristics of *A. scarabeoides* and its productivity when sown at different seeding rates and supplied with different levels of phosphorus on savanah (grassland) soils.

MATERIALS AND METHODS

The study was conducted in a glasshouse at the

[1] Address reprint requests to P. A. Iji, Department of Animal Science, The University of Adelaide, Waite Campus, Glen Osmond 5064, Australia.
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Institute of Agricultural Research, Ahmadu Bello University, Samaru, Nigeria (11°7'38' E). Samaru receives an annual rainfall of about 1,100 mm, between May and September. The ambient temperature ranges between 12℃ (January) and 38.5℃ (April). Soils within the area have been described as sandy loam (Klinkinberg and Higgins, 1968). The seeds were obtained from the demonstration plots of the University Farm and had been stored in cloth bags for two years at room temperature (about 25℃). The 100-seed weight was 1.84 g and the dry matter content was 93.1%. The pots were filled with local soil and watered to settle for two days prior to sowing of seeds. Some properties of the soil used are shown in table 1. The seeds were scarified in hot water (80℃) for ten minutes and sown by drilling to about 2 cm, a depth that was identified in a preliminary study as ideal for emergence of *A. scarabeiodes* seedlings. Preliminary petri-dish tests gave over 90% germination rate of scarified seeds.

Table 1. Characteristics of soil used

Sand (%)	40.0
Silt (%)	42.0
Clay (%)	18.0
pH (in water)	5.1
Organic carbon (%)	0.40
Textural class	Silty loam
Total nitrogen (%)	0.056
Available P (ppm)	4.48
Exchangeable bases (meq/100 g soil)	
Calcium	3.12
Magnesium	1.05
Potassium	0.41
Sodium	0.18
Hydrogen + Aluminium	0.60
Cation exchange capacity (cmol/kg)	7.20

The four seeding rates chosen were 50, 75, 100 and 125 kg/ha, calculated to yield about 272, 408, 543 and 579 seedlings/m^2, assuming a 100% seed viability. Seeding and fertilizer rates were estimated from the top surface area of the pots rather than through the conventional method of soil weight and density. The pots used were about 25 cm deep with top diameter and surface area of about 20 cm and 314 cm^3 respectively. Single superphosphate (SSP) ferilizer (18% P_2O_5) was applied at sowing at the rate of 0, 60, 90 or 120 kg/ha as a single dose. This was followed by the application of nitrogen (urea) and potassium (muriate of potash) at a uniform rate of 30 kg/ha each, 37 days post-sowing. There were four replicates of each seeding rate and fertilizer level, with the pots set out in a completely randomized block design.

The study lasted for 105 days between January and May. The pots were watered every two days. No supplemental light was provided, natural sunlight was about 12 hours/day. Environmental temperature at Samaru during the period of study ranged from 19 to 30℃. Seedling count and plant height were undertaken at one month post-sowing and at harvest. Stakes were installed after two months to prevent entanglement of plants from different plots.

At the end of the trial, plants in each pot were cut at the cotyledonary node and manually sorted into leaves and stems. The fresh weight of the components was obtained. The entire biomass was dried to a constant weight in a draught-type oven at 80℃ for 24 hours. The material (stems and leaves) was then ground in a hammermill to pass through a 1 mm screen. Organic matter and total mineral contents were determined by ashing in a furnace at 550℃. Further analysis was done for crude protein, using the Kjeldahl technique as set out by the AOAC (1984).

Data obtained were subjected to analysis of variance and mean values compared by the method of least significant difference as described by Snedecor and Cochran (1980).

RESULTS

Seedling populations at one month post-sowing and at harvest increased with increase in seeding rate (table 2). These differences were highly significant ($p < 0.01$). There was no significant effect of fertilizer level on seedling population at the two periods considered although 90 kg SSP/ha supported the highest population. Seedling population at harvest was lower than at the intial count at one month. Plants obtained from a seeding rate of 100 kg/ha or supplied with 90 kg SSP/ha grew most rapidly and were taller than plants at other seeding rates or given other phosphorus doses (table 3). However, there were no significant differences between the seeding rates and fertilizer rates. Fresh yield of components and in total was highest, although not significantly at a seeding rate of 100 kg/ha (table 4). Similarly, yields were significantly ($p < 0.01$) higher at a fertilizer level of 120 kg/ha. Most of the fresh weight was attributable to leaf. Leaf weight was highest at a seeding rate of 75 kg/ha and lowest at 100 kg/ha (table 5). Application of 120 kg SSP/ha supported the highest leaf:stem ratio while the lowest value was observed in plants maintained with 90 kg SSP/ha. There were no significant differences between the treatments (seeding rate or phosphorus level) as regards leaf: stem ratio. The lowest seeding rate promoted the production of the highest total dry matter (table 5). Dry matter yield generally declined with increase in seeding rate although no significant differences were observed. The application of 90 kg SSP/ha also yielded the highest (not significantly) amounts of dry matter while the lowest amounts were produced without phosphorus application.

The crude protein content of herbage was highest at a seeding rate of 75 kg/ha and lowest at the highest seeding rate (table 6). Crude protein content rose with increase in phosphorus level but no significant differences exist between the groups. Plants obtained from sowing at 100 kg seeds/ha or maintained with 60 kg SSP/ha ensured the highest concentration of ash.

It was observed that the interactions between the two factors were not significant with any of the variables considered. Flowering commenced by day 79 in plots sown at 75, 100 and 125 kg seeds/ha without supplemental phosphorus. Further observations up to 2 weeks after harvest indicated that regeneration occured in 14% of the plots although the distribution of this did not reveal any definite treatment effects.

Table 2. Seedling population (plant/m^2) after one month and at harvest

Seeding rate (kg/ha)	SSP Levels (kg/ha)				
	0	60	90	120	Mean
One month					
50	235.0	181.0	235.0	244.0	224.0^c
75	361.0	262.0	379.0	271.0	318.0^{bc}
100	388.0	433.0	299.0	379.0	379.0^{ab}
125	533.0	424.0	515.0	325.0	449.0^a
Mean	379.0	325.0	357.0	309.0	
S. E. for P and seeding rate = 29.8; for interaction = 59.6.					
At harvest					
50	130.8	135.3	189.8	180.5	172.0^b
75	235.0	207.8	198.8	180.5	206.0^b
100	327.0	334.0	271.0	307.5	305.0^a
125	424.0	325.0	505.5	261.5	379.0^a
Mean	287.0	251.0	291.0	232.0	

S.E. for P level and seeding rate = 25.98; for interaction = 51.95.

Mean values on column with different superscripts vary significantly ($p < 0.01$).

Table 3. Effect of phosphorus and seeding rate on plant height (cm) at one month

Seeding rate (kg/ha)	SSP Levels (kg/ha)				
	0	60	90	120	Mean
50	5.9	5.2	5.1	5.5	5.4
75	5.1	5.3	5.6	5.1	5.3
100	5.3	5.6	6.2	6.6	5.7
125	5.9	5.3	6.1	5.9	5.1
Mean	5.3	5.3	5.8	5.5	

S.E. for P level and seeding rate = 0.23; for interaction = 0.46.

Table 4. Component and total fresh matter yields (kg/ha)

Seeding rate (kg/ha)	SSP levels (kg/ha)				
	0	60	90	120	Mean
Stem					
50	1,083.0	1,264.0	1,805.0	1,805.0	1,489.0
75	1,264.0	903.0	1,625.0	1,805.0	1,399.0
100	1,625.0	1,625.0	1,625.0	1,534.0	1,602.0
125	1,444.0	1,444.0	1,625.0	1,444.0	1,489.0
Mean	1,354.8^a	1,309.6^b	1,670.0^a	1,647.0^a	
S.E. for P level and seeding rate = 125.4; interaction = 250.9^{NS}.					
Leaf					
50	1,986.0	2,527.0	2,888.0	3,430.0	2,708.0
75	2,527.0	3,166.0	3,069.0	3,430.0	2,797.0
100	2,888.0	2,708.0	2,708.0	3,430.0	2,933.0
125	3,069.0	2,888.0	2,527.0	3,069.0	2,888.0
Mean	2,617.0^b	2,572.0^b	2,798.0^b	3,339.0^a	
SE for P level and seeding rate = 219.3; interaction = 438.5^{NS}					
Total					
50	3,069.0	3,791.0	4,693.0	4,874.0	4,107.0
75	3,791.0	3,069.0	4,693.0	5,235.0	4,197.0
100	4,513.0	4,332.0	4,332.0	4,964.0	4,535.0
125	4,513.0	4,332.0	4,152.0	4,513.0	4,377.0
Mean	3,971.0^c	3,881.0^{bc}	4,468.0^{ab}	4,896.0^a	
S.E. for P level and seeding rate = 301.8; interaction = 603.6^{NS}.					

Mean values on rows with different superscripts vary significantly ($p < 0.01$).
NS - not significant.

Table 5. Leaf to stem ratio (on fresh weight basis) and total dry matter yield (kg/ha)

Seeding rate (kg/ha)	SSP levels (kg/ha)				
	0	60	90	120	Mean
Leaf : stem					
50	2.0	2.0	1.6	1.7	2.0
75	2.1	2.5	2.0	2.0	2.2
100	1.8	1.7	1.7	2.3	1.9
125	2.0	2.1	1.6	2.2	2.0
Mean	2.0	2.1	1.6	2.2	
S.E. for P level and seeding rate = 0.21; interaction = 0.41.					
Total dry matter					
50	1,083.0	1,264.0	1,289.0	1,444.0	1,670.0
75	1,083.0	1,625.0	1,083.0	1,444.0	1,309.0
100	902.0	1,264.0	1,083.0	1,444.0	1,173.0
125	1,264.0	1,444.0	1,264.0	1,264.0	1,309.0
Mean	1,083.0	1,399.0	1,560.0	1,264.0	
S.E. for P level and seeding rate = 310.3; for interaction = 620.6.					

Table 6. Effect of phosphorus and seeding rate on crude protein and ash contents (%) of herbage

Seeding rate (kg/ha)	SSP Levels (kg/ha)				
	0	60	90	120	Mean
Crude protein					
50	19.4	15.6	20.3	21.5	19.2
75	17.9	19.5	18.4	21.9	19.4
100	17.7	19.1	20.4	17.4	17.4
125	15.8	16.0	20.3	20.1	18.1
Mean	15.8	16.0	19.9	20.2	
Ash					
50	6.9	7.5	6.6	7.7	7.2
75	7.0	7.2	7.0	6.3	6.9
100	8.7	9.1	6.2	7.5	7.9
125	6.4	6.5	8.6	5.9	6.9
Mean	7.3	7.6	7.1	6.9	
S.E. for crude protein = 1.28 and for ash = 0.65.					

DISCUSSION

The increase in seedling population with rise in seeding rate is expected of seeds with high viability. The seedling populations observed at one month are close to the expected values and might have actually been higher at earlier periods. This is an indication that *A. scarabeoides* seeds maintain a high viability, to the second year of storage. On rangeland, seeds of *A. scarabeiodes* that fell to the ground lost their viability within the season (Naugraiya and Pathak, 1989). Such early loss of viability may be due to pest destruction. The viability of seeds of the species has been observed to increase from about 6 months in storage, to a maximum at one year (Naugraiya and Pathak, 1987). The 1,000-seed weight of the trial seeds varied between 17.6 and 21.0 g, which is comparable to the weight of seeds used in the current study. Seeds of *A. scarabeoides* appear to be heavy and this tends to portray a high seeding rate. Seeds of *S. hamata* which are sown at about 10 kg/ha are about 14 times lighter than those of *A. scarabeoides*. Most legume species, notably the stylos are able to maintain their initial population or even increase in density through continuous seeding (Gardener, 1982). *A. scarabeoides* may be able to maintain its population through similar processes. The fact that some regeneration occured after harvest may also indicate some ability to perennate through old stock. Naugraiya and Pathak (1989) reported that *A. scarabeoides* is a weak perennial but possesses good seed production potentials. The seed production potential of *A. scarabeoides* was reported to be comparable with that of *S. hamata*, in trials involving six other legumes (Rai, 1988).

The high fresh yields obtained with high phosphorus application are expected. Mengel and Kirby (1979) reported that an adequate supply of phosphorus usually results in good crop (legume) growth and consequent yield. *Desmodium* and *Centrosema* have been observed to respond in similar manner to the application of phosphorus (Trigoso and Fassbende, 1973). High seeding rates, however, may limit the availability of phosphorus to the plants, resulting in reduced growth and yield.

The yields are generally encouraging for a growth period of only about 3 months. This is in consonance with reports on the performance of the legume in other environments. In trials with eight herbaceous legume species, *A. scarabeoides* promoted the yield of the grass, *Chrysopogon fulvus* better than the rest (Dwivedi et al., 1988). The grass yielded 11.4 tonnes/ha while *A. scarabeoides* contributed 90 kg nitrogen/ha to the soil, higher than the contribution of any of the seven other legumes. A mixed pasture of *A. scarabeoides* and *Dicanthium annulatum* yielded 5.2 tonnes dry matter per hectare, with the legume providing 201.7 kg crude protein per hectare. The crude protein contents observed in this study are higher than the range of 8.6-12.9% reported by

Singh (1962).

CONCLUSION

The species responds strongly to seeding rate and may benefit from supplemental levels of phosphorus. Although yields appear to be excellent under controlled environment, there is a need to conduct extensive trials in the field before any recommendations could be made as to the use of *A. scarabeoides* in pasture development in the northern guinea savanah zone of Nigeria and similar regions of the world.

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