Effects of seeding rate, row spacing and nitrogen and phosphorus fertiliser on forage yield and quality of *Stylosanthes scabra* cvv. Seca and Fitzroy in south-western Nigeria

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Abstract

Two experiments were conducted in south-western Nigeria to determine the responses of S*tylosanthes* scabra cvv. Seca and Fitzroy to seeding rate (1.7, 3.4, 5.1 and 6.8 kg/ha), row spacing (30, 45 and 60 cm), nitrogen (0, 5.75, 11.5 and 23 kg/ha N) and phosphorus (0, 20 and 40 kg/ha P) rates on a soil containing 2.70 ppm available P over a 2-year period. There was an interaction between sowing rate and row spacing for DM production with closer row spacing increasing yields at low sowing rates but the reverse occurring at high sowing rates. Yields of leaf ranged from 3.1 to 8.7 t/ha in Year 1 and from 3.2 to 8.4 t/ha in Year 2, while corresponding values for stem were 8.4–19.4 t/ha and 9.6–19.5 t/ha. There were very few differences between cultivars. While application of N fertiliser had minimal effect on growth overall, application of P fertiliser increased both DM yields and P concentrations in both leaf and stem. In the absence of added N, P application increased DM yield by more than 60%.

Crude protein (CP) concentrations in leaf ranged from 15.5 to 21% in Year 1 and 14.6 to 19.7% in Year 2, while corresponding values for stem were 5.6 to 8.8% and 5.3 to 8.2%. Application of P fertiliser increased P concentrations in leaf from 0.13–0.17% to 0.16–0.24% and in stems from 0.06–0.08% to 0.08–0.13%. The concentrations of CP and P were higher ($P<0.05$) in Fitzroy than in Seca in both years. Sowing Seca or Fitzroy at 3.5–4 kg/ha in rows 45 cm apart into a prepared seedbed on these soils and applying 20 kg/ha P should give satisfactory establishment and yields of forage for feeding to stock during the dry season.

Introduction

Profitable ruminant livestock production in sub-Saharan Africa is constrained largely by an inadequate plane of nutrition. Natural grazing lands provide most forage for most animals but pastures are grossly deficient in energy, crude protein (CP) and minerals, particularly during the dry season, and so cannot meet the requirements for meat and milk production. Methods of providing effective year-round nutrition include: supplementary feeding; strategic nitrogen fertilisation of improved grass pastures; establishment of legume-grass mixtures; undersowing legumes into cereals to complement dry season grazing; growing legumes for green chop, silage or hay; and exploitation of shrubby or tree legumes and non-legumes as browse (Bogdan 1977; Crowder and Chheda 1982; Humphreys 1995). Of these, those involving legume use would be the least expensive for the smallholder farmers, with growing legumes in pure stands, cutting at the end of the wet season and conserving as dried forage being the easiest to manage.

The genus *Stylosanthes* has been found to have good potential in Nigeria, with *S. hamata* cv. Verano being probably the most widely studied. Although *S. scabra* has received very little research attention, observations over 2 decades have demonstrated its adaptation to humid, subhumid and semi-arid climatic conditions. Unlike other species, *S. scabra* has demonstrated resistance to anthracnose disease. It has recorded higher yields (Tarawali 1994) and greater drought tolerance and persistence than Verano stylo.

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Investigations are yet to be conducted on the edible forage yield and nutrient responses of *S. scabra* to different agronomic procedures in the nutrient-deficient soils of Nigeria. In Australia, *S. scabra* grows well on infertile soils, displaying good CP concentrations but often inadequate P levels (Humphreys 1995), because soil available P levels are often less than 5 ppm.

This study examined the effects of seeding rates, row spacings and N and P fertiliser application rates on herbage production and N and P concentrations of *S. scabra* cvv. Seca and Fitzroy on an infertile soil in Nigeria.

Materials and methods

Site

The trials were conducted at the Teaching and Research Farm, Ladoke Akintola University of Technology, Ogbomoso, in the derived savanna zone of south-west Nigeria. There is no meteorological station at Ogbomoso but Ilorin (8^o 26'N, 4^o 29'E), 50 km north of the study site, has a medium-term (1980–2001) mean annual rainfall of 1094 mm (697–1676 mm), over 73% of which is received between June and October. Below average rainfall figures, 998 and 649 mm, were observed during 2000 and 2001, respectively. Prior to clearing, the site was dominated by spear grass (*Imperata cylindrica*), with local guinea grass (*Panicum maximum*) and signal grass (*Brachiaria decumbens*) occurring in patches. It was ploughed twice, harrowed once, cleaned of trash and leveled with hoes to produce a fine seedbed. Analysis of the top soil (0–15 cm) indicated 79.3% sand, 8.5% silt, 12.2% clay, 0.72% organic carbon, 0.07% total N, 2.70 ppm (Bray 1) available P and a pH (in H_20) of 5.3.

Experiment 1

The experiment was laid out in a split-split-plot arrangement in a randomised complete block design with cultivars as the main plots, the 4 seeding rates (1.7, 3.4, 5.1 and 6.8 kg/ha) as the sub-plots, and 3 inter-row spacings (30, 45 and 60 cm) as the sub-sub-plots with 3 replications. The main plots measured 15 m x 14.2 m. The replicates and the sub-sub-plots (2 m x 1.8 m) were demarcated by 1.2 m and 0.6 m paths, respectively. At sowing on June 8, 2000, compound N:P:K fertiliser (20 N:4.4 P:8.3 K) was hand-broadcast and raked into the soil. Seed of *Stylosanthes scabra* cvv. Seca and Fitzroy was treated with hot water (80°C for 5 min) and drilled into the soil. The plots were kept weed free by regular weeding with hoes.

When the first flowers had opened on about 50% of stands (November 14, 2000), plants within 1.44 m^2 of each sub-sub-plot were cut at 10 cm above the ground. Five of these were randomly picked for counts of primary branches. The harvested material was weighed and subsamples were separated into leaf and stem, oven-dried at 80°C for 48 h and weighed for dry matter yield estimation. On June 12, 2001, the little regrowth following the previous harvest was cut back preparatory to the commencement of growth in Year 2. Sampling for yield and quality was carried out on November 13, 2001, using the same procedure as for Year 1. However, no branch counting was conducted. Dried plant portions for each year were ground and analysed for crude protein (AOAC 1995) and phosphorus.

Statistical analysis

The data collected were subjected to a two-way analysis of variance and significant means were

Table 1. Monthly rainfall at Ilorin during the study and medium-term means.

Period	Month												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
						(mm)							
2000	35	0	20	46	106	194	81	185	288	43	0	0	998
2001	0	0	14	5	145	137	85	57	174	32	0	0	649
1980–2001	4	9	45	84	60	180	154	165	236	132	14	11	1094

separated using the Tukey test at P<0.05 (SAS 1999).

Experiment 2

The experimental layout, field and laboratory protocols were as described for Experiment 1. However, treatments were different. The main plots were the cultivars while the four N rates (0, 5.75, 11.5 and 23 kg/ha N) as urea constituted the sub-plots. Phosphorus, applied as triple superphosphate at the equivalent of 0, 20 and 40 kg/ha P, made up the sub-sub-plots. The 2 *S. scabra* cultivars were each drilled at 4.0 kg/ha in rows, 45 cm apart, and fertiliser was applied on June 10, 2000. Harvesting was performed 2 days after Experiment 1.

Results

Experiment 1

The number of primary branches was highest (P<0.05) (22) with cv. Fitzroy sown at 3.4 kg/ha at the closest row spacing and least (15) with cv. Seca sown at the highest seeding rate and closest spacing. There were no significant differences in the means between spacings, while Fitzroy had more (P<0.05) branches (19.4) than Seca (16.8).

There were interactions between seeding rate and row spacing in terms of leaf and stem yields. Overall, yields of leaf and stem increased (P<0.05) with seeding rate up to 3.4 kg/ha and declined at the highest rate of 6.8 kg/ha. However, yields were similar in the second year between 3.4 and 5.1 kg/ha seeding rates. Similarly, yields tended to increase with narrower row spacing up to a sowing rate of 5.1 kg/ha but narrower row spacing reduced yields at 6.8 kg/ha, although most differences were not significant (Tables 2 and 3). Leaf yields ranged from 3.1 to 6.5 t/ha in Year 1 and 3.2 to 7.1 t/ha in Year 2, with corresponding values for stem of 8.4–14.7 t/ha (Year 1) and 9.6–18.5 t/ha (Year 2). At the widest spacing, yields were significantly lower (P<0.05) than at the 30 and 45 cm spacings. Leaf:stem ratio was below 1:2 in both years. Differences in yields between cultivars were not significant except in the second year, when Fitzroy had more leaf and stem than Seca.

Crude protein concentrations in leaf varied from 16.1 to 19.5% in Year 1 and 14.6 to 18.4%

Table 2. Effects of cultivar, seeding rate and row spacing on dry matter yield and crude protein (CP) and phosphorus (P) concentrations in leaf and stem fractions in the first year of assessment (Experiment 1).

Cultivar	Seeding rate	Row spacing	Yield		CP		P	
			Leaf	Stem	Leaf	Stem	Leaf	Stem
	(kg/ha)	(cm)	(t/ha)			(%)		
Fitzroy	1.7	60	4.08	8.43	19.5	8.8	0.24	0.13
		45	4.92	11.21	18.4	8.8	0.22	0.12
		30	6.08	12.95	17.8	8.5	0.19	0.11
	3.4	60	4.71	10.16	18.7	8.5	0.23	0.13
		45	5.94	14.04	18.1	8.2	0.21	0.12
		30	6.46	15.75	17.5	7.9	0.2	0.11
	5.1	60	4.29	10.41	17.8	8.2	0.22	0.13
		45	5.44	12.01	17.2	7.9	0.22	0.12
		30	5.35	12.32	17.2	8.2	0.20	0.11
	6.8	60	4.84	11.70	17.5	7.6	0.20	0.12
		45	3.79	9.91	17.2	7.9	0.20	0.11
		30	3.28	8.36	17.5	7.9	0.18	0.11
Seca	1.7	60	4.62	9.09	19.3	7.0	0.23	0.12
		45	5.46	11.63	18.1	7.6	0.20	0.12
		30	5.83	13.63	18.1	7.3	0.18	0.11
	3.4	60	4.51	9.52	18.1	7.0	0.21	0.12
		45	5.70	13.00	18.1	7.0	0.19	0.12
		30	6.05	14.72	17.2	6.7	0.19	0.10
	5.1	60	4.73	10.53	17.5	6.7	0.20	0.12
		45	4.62	11.08	16.9	6.7	0.18	0.11
		30	4.80	11.67	16.9	6.4	0.17	0.11
	6.8	60	4.53	10.78	16.9	6.7	0.19	0.12
		45	3.11	8.50	16.1	6.4	0.17	0.11
		30	3.22	9.15	16.6	6.1	0.17	0.10
	LSD (P<0.05)		1.39	2.99	1.99	1.06	0.017	0.011

in Year 2, with corresponding values for stem of 6.1–8.8% (Year 1) and 5.6–8.2% (Year 2) (Tables 2 and 3). Values declined (P<0.05) as sowing rate increased and row spacing declined. In both years, CP concentrations in stems of Seca were lower than in Fitzroy stems (P<0.05). Phosphorus concentrations in leaf varied from 0.17 to 0.24% in Year 1 and 0.14 to 0.21% in Year 2, with corresponding values for stem of 0.10–0.13% (Year 1) and 0.06–0.11% (Year 2). Values declined with higher sowing rates and closer row spacing (P<0.05) as for CP.

Experiment 2

The numbers of branches (17.4 and 17.8) for both cultivars in the first year were similar. However, the number of branches was influenced (P<0.05) by both N and P rates. The values for the control (17.1) and highest (16.8) N levels were lower than at 5.75 kg/ha (18.8). At the highest P rate, Fitzroy (22) had more branches than Seca (15). DM yields for both fractions increased (P<0.05) with increase in P fertiliser rate for both cultivars in both years (Tables 4 and 5). Yields increased (P<0.05) with increase in N application up to 5.75 and 11.5 kg/ha N in 2000 and 2001, respectively, with declines in yield above these levels. In both years, yields with application of N at 5.75 and 11.5 kg/ha and application of P at 40 kg/ha were similar but higher than the control without N and P. In addition, yields of leaf and stem fractions were consistently higher (6.3; 16.0 t/ha) (P<0.05) at the lowest N rate than for the control (5.9; 13.3 t/ha). Leaf:stem ratios were 1:2 or worse in both years. Performance of the two cultivars was similar in 2000. However, in 2001, yields (leaf and stem) favoured Fitzroy (6.6; 15.5 t/ha) over Seca (5.7; 13.9 t/ha).

Crude protein concentrations in leaf tended to increase with level of P applied but differences were not significant (Tables 4 and 5). Levels ranged from 15.5 to 21% in leaf and 5.6 to 8.2% in stem in Year 1 and from 15.2 to 19.7% in leaf and 5.3 to 8.2 % in stem in Year 2. Leaf and stem CP concentrations of both species in the two years were highest with applications of N and P at 11.5 and 40 kg/ha, respectively, while the lowest values were from the control plots. Differences in CP concentrations between plots with application of N were similar in 2001 but greater (P<0.05) than the control plot. The concentrations of CP and P in Fitzroy were higher (P<0.05) than

Table 3. Effects of cultivar, seeding rate and row spacing on dry matter yield and crude protein (CP) and phosphorus (P) concentrations of leaf and stem fractions in the second year of assessment (Experiment 1).

Variety	Seed rate	Row spacing	Yield		CP		P	
			Leaf	Stem	Leaf	Stem	Leaf	Stem
	(kg/ha)	(cm)	(t/ha)			(%)		
Fitzroy	1.7	60	4.49	10.14	18.4	7.9	0.21	0.12
		45	4.01	12.36	18.1	7.9	0.19	0.11
		30	5.90	16.05	16.9	7.3	0.18	0.10
	3.4	60	5.36	12.45	18.1	8.2	0.21	0.11
		45	5.80	14.93	17.2	7.3	0.19	0.11
		30	6.63	16.29	16.9	7.3	0.18	0.11
	5.1	60	5.51	14.15	17.2	7.9	0.21	0.12
		45	6.59	16.60	17.2	7.9	0.18	0.10
		30	7.06	18.53	16.6	7.3	0.18	0.10
	6.8	60	4.94	12.49	16.9	7.3	0.18	0.11
		45	4.00	11.85	16.3	6.7	0.18	0.10
		30	3.68	11.49	16.3	6.7	0.14	0.10
Seca	1.7	60	4.61	9.83	18.1	6.7	0.19	0.10
		45	4.86	11.40	17.8	7.0	0.18	0.09
		30	5.20	12.69	17.2	6.4	0.17	0.09
	3.4	60	5.20	11.48	17.5	7.0	0.19	0.09
		45	5.40	12.87	17.8	6.1	0.17	0.09
		30	5.82	14.24	16.3	5.8	0.16	0.08
	5.1	60	4.72	11.71	17.2	6.7	0.18	0.08
		45	5.87	14.25	16.9	6.1	0.17	0.09
		30	5.96	15.85	16.4	5.8	0.16	0.07
	6.8	60	4.02	10.50	16.9	6.4	0.17	0.08
		45	3.74	11.18	15.2	6.1	0.17	0.07
		30	3.16	9.63	14.6	5.6	0.16	0.06
	LSD (P<0.05)		0.86	3.50	1.47	0.74	0.016	0.013

in Seca in both years. Phosphorus concentration in both leaf and stem increased with increasing P fertiliser rate (P<0.05) with values for leaf of 0.15–0.24% and 0.13–0.20% in Years 1 and 2, respectively. Corresponding values for stem were 0.07–0.13% and 0.06–0.11%.

Discussion

This study has demonstrated that high yields of forage can be obtained from pure stands of both *S. scabra* cultivars in the first season after planting, even in the absence of fertiliser in this environment on these soils. Quality of the material produced, in terms of N concentration, was also quite satisfactory and the CP concentrations of the leaf fraction, which is preferred by livestock, were above the 7% considered necessary for maintenance of livestock (Minson 1971). This fodder would be a valuable source of nutrients for supplementing animals during the dry season. A boost in production in the second year might have been expected, but the lower rainfall received in that year might have restricted growth during the second season.

The growth response to application of P in this study was similar to reports in northern Australia, where stylos are grown extensively. Soil P levels in those environments are commonly less than 10 ppm and responses in both DM yields and P concentration are obtained following application of P fertiliser. Legume yields in those situations respond asymptotically to soil P, with near maximum yields at 10 ppm soil available P (Probert and Williams 1985; Kerridge *et al*. 1990). Grof *et al*. (1979) showed that near maximum yields of forage could be obtained from *S. scabra* at soil P (Bray II) levels of 11 ppm. Growth responses to P fertiliser under Australian conditions on soils with low plant-available P levels have been reported in Verano stylo (Gilbert and Shaw 1987a), Seca (Gilbert and Shaw 1987b) and Graham, Verano and Seca stylos and Siratro mixed with a native grass (Shaw *et al*. 1994).

The response in P concentrations in forage with P fertiliser application was to be expected. Members of the *Stylosanthes* genus are very efficient in utilising soil P and have the ability to grow well at low soil P levels, but the P concentration in the forage produced can be very low (Jones 1990). Jones (1974) studied 30 accessions of *Stylosanthes* and found that P concentration in

Table 4. Effects of cultivar and nitrogen and phosphorus fertiliser application on dry matter yield and crude protein and phosphorus concentrations of leaf and stem fractions in the first year of assessment (Experiment 2).

Variety	N	P	Yield		CP		P	
	rate	rate	Leaf	Stem	Leaf	Stem	Leaf	Stem
	(kg/ha)		(t/ha)			(%)		
Fitzroy	0	0	4.72	8.87	16.9	5.8	0.17	0.08
		20	6.72	13.61	18.4	6.4	0.20	0.10
		40	7.72	15.63	19.0	7.6	0.22	0.11
	5.75	0	5.68	12.45	18.7	6.4	0.16	0.08
		20	7.16	16.53	21.0	7.6	0.21	0.12
		40	8.66	19.43	20.1	8.2	0.23	0.13
	11.5	0	5.63	12.97	18.7	6.7	0.17	0.07
		20	6.05	14.81	20.1	7.3	0.21	0.12
		40	6.99	16.79	21.0	7.9	0.24	0.13
	23.0	0	4.44	11.55	17.2	7.0	0.17	0.07
		20	6.21	15.63	19.0	6.7	0.20	0.11
		40	5.51	14.79	19.2	7.3	0.22	0.12
Seca	0	0	4.89	10.56	15.5	5.6	0.15	0.07
		20	7.18	14.74	16.0	5.6	0.17	0.08
		40	8.32	16.46	17.2	6.1	0.18	0.10
	5.75	0	5.25	12.20	16.1	5.8	0.15	0.07
		20	7.23	16.36	16.8	7.3	0.18	0.10
		40	8.14	19.07	17.4	7.0	0.20	0.11
	11.5	0	4.76	11.56	15.5	6.7	0.15	0.07
		20	6.39	14.67	16.1	6.1	0.19	0.10
		40	6.84	16.37	16.9	7.6	0.20	0.12
	23.0	0	4.68	11.35	15.5	6.1	0.16	0.07
		20	5.31	12.81	15.8	6.7	0.18	0.09
		40	5.49	14.10	15.8	6.4	0.18	0.10
	LSD (P<0.05)		1.97	4.27	2.17	1.56	0.013	0.012

forage increased almost linearly up to the highest level of P fertiliser applied. While the P levels in the leaf portion of forage in our study would provide a satisfactory P intake for acceptable animal performance, the level in stems, which comprised more than two-thirds of the harvested forage, would be low, especially for lactating females (ARC 1980). Feeding of a phosphorus supplement with this forage would be recommended.

The interaction between sowing rate and row spacing in terms of forage yields was interesting, suggesting that closer row spacing at low sowing rates provided better access to available soil by plants as row spacing was reduced. However, as sowing rate increased, the advantages of closer row spacing seemed to be counteracted by the additional plants competing for available space. Based on our findings, a sowing rate of 3.5–4 kg/ha in rows 45 cm apart should provide a satisfactory stand of legume, while keeping cost of seed for planting at an acceptable level. In Australia, where seed is broadcast into natural pasture, a sowing rate of 4 kg/ha is common (Shaw *et al*. 1994). Perhaps, the reduced competition between plants for soil nutrients coupled with the manual weeding was responsible for the highest CP and P concentrations at the lowest seeding rate and widest row spacing. The reverse was exhibited at the highest seeding rate and closest spacing, where lowest CP concentrations occurred, particularly for cv. Seca. Concentrations of CP and P appeared higher in 2000 than in 2001. This may be attributed to the low rainfall which was well below the 20-year mean.

The failure of added N fertiliser to increase DM yield of legumes in most treatments indicates that it is not necessary to apply N to these pure legume pastures. It would be a more economical use of the resources to consider application of P fertiliser. Our results would suggest that, if funds are restricted, application of 20 kg/ha P to a given area would give a better return than applying 40 kg/ha to only half the area.

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Table 5. Effects of cultivar, nitrogen and phosphorus fertiliser application on dry matter yield and crude protein and phosphorus concentrations of leaf and stem fractions in the second year of assessment (Experiment 2).

Cultivar	N	P	Yield		CP		P	
	rate	rate	Leaf	Stem	Leaf	Stem	Leaf	Stem
	(kg/ha)		(t/ha)			(%)		
Fitzroy	0	0	4.45	9.85	16.3	6.1	0.14	0.07
		20	6.79	14.67	18.0	6.4	0.17	0.09
		40	7.58	15.85	18.1	7.3	0.18	0.09
	5.75	0	5.90	13.33	17.8	6.7	0.16	0.07
		20	6.81	16.54	18.7	7.6	0.17	0.10
		40	8.06	17.89	18.6	7.9	0.20	0.10
	11.5	0	5.79	14.72	17.8	7.0	0.17	0.07
		20	7.34	17.04	19.1	7.6	0.19	0.10
		40	8.44	19.45	19.7	8.2	0.20	0.11
	23.0	0	4.95	12.98	17.5	7.3	0.17	0.06
		20	6.49	15.89	18.3	7.3	0.20	0.08
		40	7.13	17.64	19.1	7.9	0.20	0.10
Seca	0	0	3.73	9.01	15.2	5.3	0.13	0.06
		20	6.00	13.28	15.8	5.8	0.15	0.07
		40	6.84	14.83	16.9	5.7	0.16	0.08
	5.75	0	4.75	11.21	15.8	5.8	0.13	0.06
		20	6.20	14.43	16.9	6.3	0.16	0.08
		40	6.29	14.78	17.9	6.9	0.17	0.10
	11.5	0	4.90	12.73	16.9	6.3	0.14	0.06
		20	6.17	15.65	17.1	6.7	0.17	0.09
		40	6.90	17.21	17.9	7.2	0.18	0.10
	23.0	0	4.64	11.88	17.2	6.7	0.15	0.06
		20	5.85	15.11	17.6	7.2	0.17	0.09
		40	6.32	16.33	17.4	7.3	0.17	0.09
	LSD (P<0.05)		0.95	3.93	1.57	1.04	0.015	0.013

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