Seed yield and quality of buffel grass (*Cenchrus ciliaris*) as influenced by row spacing and fertiliser level

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Abstract

A field experiment investigated the impact of different row spacings and fertiliser (N and P) levels on seed yield and quality of buffel grass (*Cenchrus ciliaris*) on an infertile soil during 1997 and 1998 at Jhansi, India. The experiment was a factorial design comprising all combinations of 3 row spacings (40, 60 and 75 cm) and 3 levels (kg/ha) of N and P fertiliser (20 N:8.7 P, 40 N:17.5 P and 60 N:26.0 P), arranged in 3 randomised blocks. The results showed that wider row spacing (75 cm) enhanced seed production in this experiment. Number of total tillers/tussock, fertile tillers/tussock and spikelets/spike plus spike length and seed yield were significantly greater under the widest row spacing (75 cm). Seed yield and its attributes increased significantly up to the highest level of fertiliser. In general, seed quality improved significantly with increased row spacing, but fertiliser level had little effect on seed quality.

Introduction

Cenchrus ciliaris (buffel grass), known as Dhaman grass in India, is widely distributed in the plains of Rajasthan, Punjab and Western U.P. extending into the foothills of Jammu to an elevation of 400m in India (Dabadghao and Shankarnarayan 1973). The minimum temperature for growth is 5–16°C (Russell and Webb 1976), and altitude range is from mean sea level to 2000m. While the optimum soil reaction is pH 7–8, buffel grows on soil with a pH as low as 5.5. Humphreys (1967) has reviewed the different aspects of buffel grass history, adaptation and management, *etc*. in Australia.

Growing of pasture seed crops in rows, rather than in swards, is advocated for most species in the first year, and for some species continuation in rows is recommended (Humphreys and Riveros 1986). Seed production is maximised at an optimum plant density (row spacing), with both very low and very high densities reducing seed yield in grasses. However, the realisation of higher seed yield from different plant densities is dependent on fertility status of the soil and the fertiliser applied (Boonman 1972). Studies indicate that application of nitrogen increases seed production in buffel grass (Asare 1970). Seed yield of grasses may also benefit from improved phosphorus nutrition as shown for *Cenchrus ciliaris* (Ayerza 1980) and for *Chrysopogon fulvus* (Dwivedi *et al*. 1983).

In view of the above considerations, we examined the effect of row spacing and level of fertiliser (N and P) on seed production and quality of buffel grass (*Cenchrus ciliaris*).

Materials and methods

The experiment was conducted during 1997 and 1998 at the Research Farm of Indian Grassland and Fodder Research Institute, Jhansi, India (78.35°E, 25.7°N; elevation 275 masl). The soil of the experimental site was medium in texture with a pH of 7.7. Soil contained 0.04 % total N and 3 ppm available P (bicarbonate extraction). The buffel grass was sown in mid-July 1997. The experiment was a factorial design comprising all combinations of 3 row spacings (40, 60 and 75 cm) and 3 levels (kg/ha) of N and P fertiliser (20 N:8.7 P, 40 N:17.5 P and 60 N:26.0 P), arranged in 3 randomised blocks. The amounts of seed sown for the 3 row spacings (40, 60 and 75 cm) were 8, 6 and 4 kg/ha, respectively. The size of individual plots was 6 m × 4 m. Due to

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the varying row spacing, a net plot sampling area of 3.6 m × 3 m (9 rows), 3.6 m × 3 m (6 rows) and 3.75 m × 2.88 m (5 rows) was selected for estimating seed and dry matter yields at row spacings of 40, 60 and 75 cm, respectively. The nitrogen and phosphorus were applied as urea and single superphosphate, respectively, as per the designated treatment at the time of sowing in Year 1 (1997) and during the onset of the monsoon (mid-July) in Year 2 (1998). Each year, the seed was collected manually (hand collection) twice (late September and mid-October), and then the plant tops were harvested to determine dry matter yield. Observations were made on growth, development (days to 50% flowering and maturity), seed yield attributes and seed yield during both years. 'Days to 50% flowering' was determined as the number of days taken from seedling emergence (first year) and from commencement of regrowth after cutting (second year) to when 50% of tillers started to flower. Likewise, 'days to seed maturity' was assessed as days taken from seedling emergence (first year) and from regrowth after cutting (second year) to first seed harvest, when most of the seed was straw coloured. A 500g sample of plant tops was dried in an oven at 85°C for 24 h to calculate dry matter percentage in plant tops. The seed was cleaned by using a jet of air before determining seed yield. Seed test weight was determined by weighing 1000 seeds from each replicate of each treatment. It may have included some unfilled seed since the cleaning method may not have been fully effective. Germination percentage was assessed separately on 100 seeds (air-cleaned) from each plot in petri dishes at 28°C, after 5 months of storage. Distilled water was used for germination testing. This was done to provide preliminary information on quality of the seed produced, although strict seed-testing and statistical procedures were not followed as the emphasis of the present investigation was on seed production. Vigour index of seed, a relative measure of seed quality, was obtained by multiplying the germination % by average seedling length for each treatment. All the seedlings were allowed to grow in respective petri dishes till 28 days. The length of 10 randomly selected seedlings was measured from the tip of the shoot to the tip of the root at 28 days stage, and the average seedling length was obtained by dividing the total length of all seedlings by 10 for seed from each plot (total 27 plots).

Results and Discussion

Overall, the data for Year 2 were probably more representative of those to be expected from the stands of buffel grass over time than either the average over two years or the data from the initial year. As a result the emphasis in this section will be on Year 2.

Growth and development attributes

The effects of different treatments on various growth and development parameters are given in Table 1. Plant height increased significantly as row spacing increased with the main increase

Table 1. Growth and development attributes of *Cenchrus ciliaris* as influenced by row spacing and fertiliser level.

Treatment	Plant height at harvest		Dry matter yield		Days to 50% flowering[1]		Days to maturity[2]	
	1997	1998	1997	1998	1997	1998	1997	1998
Row spacing	(cm)		(t/ha)					
40 cm	97	105	4.5	6.4	56	54	103	107
60 cm	119	125	5.6	7.3	59	55	107	113
75 cm	124	137	3.6	7.7	61	58	112	118
LSD (P < 0.05)	6.4	5.6	0.6	0.3	0.6	0.9	0.9	2.1
Fertiliser[3]								
F_1	106	117	4.3	6.9	57	55	106	112
F_2	114	122	4.5	7.2	59	56	108	113
F_3	121	127	5.0	7.3	60	57	109	114
LSD (P < 0.05)	6.4	5.6	NS	0.3	0.6	0.9	0.9	NS

[1] Days to 50% flowering refers to the number of days taken from seedling emergence (first year) and from regrowth after cutting (second year) to when 50% of tillers started to flower.
[2] Maturity is defined as days taken from seedling emergence (first year) and from regrowth after cutting (second year) to first seed harvest when most of the seed was straw coloured.
[3] F_1 – 20 N:8.7 P; F_2 – 40 N:17.5 P; F_3 – 60 N:26.0 P (kg/ha).

occurring between 40 and 60 cm. Highest dry matter yield (7.7 t/ha) was recorded at 75 cm row spacing in Year 2, being significantly greater than the 7.3 t/ha at 60 cm and 6.4 t/ha at 40 cm row spacing. During the first year (1997), dry matter yield was very low at the widest (75 cm) row spacing ($P < 0.05$). We are unable to explain these low yields; the number of tillers/tussock was highest at the widest spacing in both years and plant density per unit area on the different treatments was similar between years.

Application of fertiliser had a significant impact on growth parameters, except dry matter yield in Year 1. The greatest plant height ($P < 0.05$) was recorded at the highest level of fertiliser [60 N:26.0 P (kg/ha)] but responses in dry matter yield were generally unresponsive to fertiliser. Humphreys (1958) examined the effects of variation in N and P supply on growth characters of five *Cenchrus* genotypes . In general, responsiveness to nutrients was simply related to genetic potential for growth, but the effect of P supply on root growth differed; P application widened the shoot:root ratio more in varieties such as West Australian which already possessed a high shoot:root ratio.

Both row spacing and fertiliser level had a significant impact on days taken to 50% flowering and seed maturity. In general, increasing row spacing or fertiliser level delayed the time to 50% flowering and ultimately seed maturity in both years ($P < 0.05$).

Seed yield and its attributes

Seed yield and its various attributes were affected significantly by both row spacing and fertiliser level (Table 2). The number of total and fertile tillers/tussock, spike length and number of spikelets/spike were significantly affected by row spacing (75 > 60 > 40 cm, $P < 0.05$). The superiority of the wider row spacing may be attributed to better transmission/distribution of light to the lower canopy, which resulted in greater tillering of these plants. As regards fertiliser levels, the effects were inconsistent between years with no consistent effect on total or fertile tillers/tussock, spike length or spikelets/spike.

Closer spacing did not favour seed production of *Cenchrus ciliaris* in this experiment. In fact, the highest seed yield (97 kg/ha) was recorded from the 75 cm row spacing in Year 2. This was significantly higher than yields for 60 cm (83.7 kg/ha) and 40 cm (75.9 kg/ha). Overall, seed at the widest spacing was 26% heavier than seed produced at the lowest spacing, the difference being 35% in Year 2. However, seed yield at the widest spacing was only 28% greater than that at the narrowest spacing in Year 2. Big seed obviously played an important role in contributing to the increased yields, as fewer seeds were produced at the widest spacing but they were bigger seeds. Contrary to the above results, Phaikaew *et al*. (2001) did not find significant differences in seed yield of *Paspalum atratum* with varied row spacings in Thailand.

Seed yield increased significantly with increase in level of fertiliser in both years. The highest seed yield (90.1 kg/ha) was recorded from the highest level of fertiliser in Year 2, with a significant gradation to the lowest fertiliser level (75.9 kg/ha) ($P < 0.05$). The response to N and P fertiliser resulted mainly from a combination of increased number of fertile tillers,

Table 2. Seed yield and its attributes in *Cenchrus ciliaris* as influenced by row spacing and fertiliser level.

Treatment	Total tillers/ tussock		Fertile tillers/ tussock		Spike length		Spikelets/ spike		Seed yield	
	1997	1998	1997	1998	1997	1998	1997	1998	1997	1998
Row spacing					(cm)				(kg/ha)	
40 cm	56.9	67.2	11.5	20.8	8.4	10.5	115	124	58.9	75.9
60 cm	69.4	77.9	13.6	22.8	9.6	11.9	130	138	60.5	83.7
75 cm	80.9	85.0	14.5	29.2	10.7	13.0	140	147	54.5	97.0
LSD ($P < 0.05$)	4.6	4.0	1.5	2.7	0.6	0.9	10.5	3.9	4.2	3.3
Fertiliser[1]										
F_1	64.3	72.8	12.6	20.7	9.1	11.4	125	133	54.6	80.1
F_2	68.7	77.3	13.0	24.6	9.5	11.7	128	135	57.6	86.3
F_3	74.3	80.0	14.0	27.6	10.2	12.3	132	140	61.7	90.1
LSD ($P < 0.05$)	4.6	NS	NS	2.7	0.6	NS	NS	3.9	4.2	3.3

[1] F_1 – 20 N:8.7 P; F_2 – 40 N:17.5 P; F_3 – 60 N:26.0 P (kg/ha).

i.e. inflorescences, greater spike length and more spikelets/spike. Loch *et al*. (1999) also reported that the main effect of fertiliser N on tropical/subtropical grass seed crops was to increase seed yield via inflorescence density. In Thailand, Gobius *et al*. (2001) recorded a significant increase in inflorescence density and seed yield with the intermediate and high N levels over the low level of N ($P < 0.05$) in *Brachiaria decumbens*, *Digitaria milanjiana* and *Andropogon gayanus*. Similarly, seed yield of grasses may also benefit from improved P nutrition as has been shown for *Cenchrus ciliaris* at Villa Dolores, Argentina (Ayerza 1980) and for *Chrysopogon fulvus* at Jhansi, India (Dwivedi *et al*. 1983). Significant differences occurred between years with greater yields ($P < 0.05$) in the second year. This was primarily a function of a higher density of fertile tillers, longer spikes and larger seeds. Humphreys (1967) suggests that seed production of *Cenchrus* spp. is enhanced by row culture and proper nutrition.

Seed quality

In general, seed quality improved as row spacing increased, although fertiliser level generally had no effect on quality (Table 3). The highest 1000-seed weight and vigour index were recorded from a widely spaced crop (75 cm) ($P < 0.05$). The main contributing factor to improved seed quality under the wider spacing was the higher 1000-seed weight (bigger seeds), which resulted in higher germination and more rapid seedling growth. In Thailand, Phaikaew *et al*. (2001) obtained higher yields of good quality seed from the wider row spacings of 100 and 125 cm in all 3 years of their study on *Paspalum atratum*. Both the high and medium fertiliser levels produced significantly higher 1000-seed weights than did the lowest fertiliser level in Year 2 but there were no significant effects in Year 1. Dwivedi *et al*. (1999) also reported that seed germination and 1000-seed weight improved with N application in *Setaria sphacelata* cv. Nandi. Overall, the germination percentages obtained were satisfactory but on the low side for buffel grass. In India, Yadav *et al.* (2001) reported a germination of 32.4 % in buffel grass after one year of storage. The germination rates obtained in our study may reflect the possible inclusion of some unfilled seeds during the germination test as the seed was cleaned by jets of air and cleaning may have been incomplete. In addition, the seed may still have been experiencing residual dormancy.

This study suggests that, of the row spacings tested, the highest seed yields of buffel grass can be obtained at a row spacing of 75 cm in the semi-arid areas of India. Application of fertiliser will increase seed yields but economic considerations would determine whether these increases are profitable. An added benefit of wider row spacings is that seed produced is bigger and results in more vigorous seedlings.

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Table 3. Seed quality parameters of *Cenchrus ciliaris* as influenced by row spacing and fertiliser levels.

Treatment	1000-seed weight		Germination		Av. seedling length[1]		Vigour index[2]	
	1997	1998	1997	1998	1997	1998	1997	1998
Row spacing	(g)		(%)		(cm)			
40 cm	1.75	1.82	28.6	30.1	8.5	10.2	2.4	3.1
60 cm	1.90	1.98	30.7	32.8	10.3	11.7	3.2	3.8
75 cm	2.03	2.46	34.6	35.7	11.5	12.3	4.0	4.4
LSD ($P < 0.05$)	0.09	0.12	—	—	2.1	0.6	0.9	0.3
Fertiliser[3]								
F_1	1.85	1.97	31.0	32.4	9.8	11.6	3.1	3.8
F_2	1.87	2.14	31.4	32.7	9.8	11.3	3.1	3.7
F_3	1.95	2.15	31.6	33.4	10.9	11.3	3.5	3.8
LSD ($P < 0.05$)	NS	0.12	—	—	NS	NS	NS	NS

[1] Average seedling length was obtained by dividing the total length of all seedlings (from shoot tip to root tip) by their number for each replication of a treatment at 28 days stage.
[2] Vigour index = germination % x seedling length (cm).
[3] F_1 – 20 N:8.7 P; F_2 – 40 N:17.5 P; F_3 – 60 N:26.0 P (kg/ha).

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