Seed yield response of marvel grass (*Dichanthium annulatum*) to cutting management and nitrogen fertilisation in central India

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Abstract. A three-year field trial (1997–2000) was conducted to determine the most suitable cutting management practice and nitrogen level for enhanced seed production in *Dichanthium annulatum* grass under central Indian conditions. The trial was arranged in a randomized complete block design with 3 replications, comprising all combinations of 3 cutting management practices (clipping, one cut and uncut) and 4 nitrogen levels (0, 20, 40 and 60 kg N ha^{-1}). In general, cutting and clipping did not favour seed production in marvel grass in this experiment. The uncut treatment produced significantly more seed (mean 68.6 kg ha^{-1}) than clipping (mean 58.9 kg ha^{-1}) and one-cut (mean 52.4 kg ha^{-1}) treatments at all the seed harvests, except during April 1999 and April 2000. During Nov. 1997, Nov. 1998, and Nov. 1999 seed harvests, N levels 20, 40 and 60 kg ha^{-1} did not differ significantly with respect to seed yield. However, in April 1999 and April 2000 seed harvests, the seed yield increased significantly up to 40 kg N ha^{-1}. The average seed yields obtained during April 1999 and 2000 at 0, 20, 40 and 60 kg N ha^{-1} were 70.7, 75.6, 84.2 and 84.9 kg ha^{-1}, respectively.

Key words: marvel grass, *Dichanthium annulatum*, cutting management, nitrogen fertilisation, seed yield, seed yield attributes

INTRODUCTION

Marvel grass (*Dichanthium annulatum* (Forssk.) Stapf) is a highly preferred forage grass in India. Being indigenous to the Indian and African gene centres, it shows maximum genetic diversity in India and South Africa (Mehra & Magoon, 1974). Out of the 20 species of the genus *Dichanthium* reported from the tropics and subtropics, India has 8 species distributed in various agro-ecological zones (Arora et al., 1975), but only two species, *viz*. *D. annulatum* (Forssk.) Stapf and *D. caricosum* (L.) A. Camus, are widely used for large scale forage production. Marvel grass commonly occurs throughout the plains and hills of India up to 1500 m altitude (Gupta & Shankar, 1995). It has a wide range of adaptations from low rainfall areas in Rajasthan and Gujarat states to heavy rainfall areas of western and southern India (Kanodia, 1987). Furthermore, Dabadghao & Shankarnarayan (1973) reported that it is mostly found in India in the 500–900 mm rainfall regime. It tolerates a wide range of soils but prefers black cotton soils in India and will not thrive in acidic soils (Skerman & Riveros, 1990). Gupta & Shankar (1995) have reviewed the different aspects of marvel grass's origin, distribution, environmental adaptation, germination, growth and yield, and management aspects, *etc*. in India.

This grass can be established easily from seed, which is an important key to encouraging the farmers in India to plant forage for their livestock, since it is cheaper to establish from seed than from vegetative propagation. The demand for seed of many forage grasses including marvel grass has increased tremendously and there is a long hiatus between demand and supply of forage grass seeds. Singh & Hazra (1995) have estimated a deficit of over 85% seed of grasses in India. Hence, there is need to develop methods and techniques to obtain high yields of good quality seed in grasses. The excessive vegetative growth of grasses, under certain conditions, may discourage their seed yield. Thus there is a need to strike a balance between the amount of vegetative growth and the reproductive phase. By cutting management practices, the growth and sprouting of the grasses could be suitably managed in such a way so as to synchronize the reproductive phase with most favourable photoperiod and temperature regimes. In grass *Setaria sphacelata*, Dwivedi et al. (1999) reported that defoliation/cutting suppressed the seed yield over uncut crops. Besides management of vegetative growth, seed yield also depends on the fertility status of the soil and on the amount of fertiliser, especially N fertiliser, applied. Adequate nitrogen nutrition increases tiller density and the number of inflorescences and subsequently seed yield in tropical grasses (Boonman, 1972, Bahnisch & Humphreys, 1977; Loch, 1980; Loch et al., 1999; Dwivedi et al., 1999; Gobius et al., 2001; Kumar et al., 2005).

In view of the above considerations, we examined the effect of cutting the management and level of N fertiliser on seed yield attributes and seed yield of marvel grass (*D. annulatum*).

MATERIALS AND METHODS

Field experiments were conducted during 1997–2000 at the Research Farm of the Indian Grassland and Fodder Research Institute, Jhansi (UP), India (78.35 ^{0}E, 25.7 ^{0}N; elevation 275 m). The soil of the experimental site was sandy-loam in texture having 0.065% total nitrogen, 12 kg ha^{-1} available P and a pH value of 7.2, at the beginning of the experiment. The experiment was a factorial design comprising all combinations of 3 cutting management schedules (clipping, one-cut and uncut) and 4 levels of N (0, 20, 40 and 60 kg ha^{-1}), arranged in 3 randomized blocks. In the one cut treatment (severe cutting), the cutting height was 10 cm and in the clipped treatment (lenient cutting), the cutting height was 45 cm above ground level, as has been described by Dwivedi et al. (1999). The grass was cut or clipped manually with the help of a sickle. The rooted slips of the grass (cv. IGFRI-585) were transplanted in the 3rd week of July, 1997, at a spacing of 50 x 30 cm^2. The individual plot size was 4 x 3 m^2. A uniform dose of 30 kg P_2O_5 and 20 kg K_2O ha^{-1}, through single super phosphate and muriate of potash, respectively, was applied as basal in all the plots at the time of transplanting in year 1. Afterwards, the same amount of P and K was topdressed during late August 1998 and 1999 in all the plots. Nitrogen, through urea, was applied as per the treatment. At the start of the experiment, N was applied basally followed by topdressing in every subsequent crop at the time of imposition of the cutting treatment. All the other recommended practices, except treatments, were followed to raise the seed crop of marvel grass. The treatments (cutting management and N levels) were imposed (two times) separately during late August and early February every year. The crop wherein treatments were imposed in late August was harvested in late November and the next crop, in which treatments were imposed in February, was harvested during late April every year. Up to April 2000, the grass was maintained continuously in the same field. In total, the seed was harvested manually for six consecutive harvests for six different seasons (Nov. 1997, April 1998, Nov. 1998, April 1999, Nov. 1999 and April 2000). At each harvest, the seed was collected manually, and then the plant tops were harvested to determine dry matter yield. A 500 g sample of plant tops was dried in an oven at 85ºC for 24 h to calculate dry matter percentage. Seed test weight was determined by weighing 1000 seeds from each replicate of each treatment. The seed yield was recorded in kg plot^{-1} and has been converted to kg ha^{-1}. The data were analyzed by using the standard procedures of statistical analysis for randomized complete block design (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

In total, six seed harvestings were taken during three years of the study. The crops were harvested during the months of November and April every year. At each harvest observations were carried out on plant height, total tillers tussock^{-1}, fertile tillers tussock^{-1}, spike length, yields of dry matter and clean seed and 1000-seed weight. The data thus accumulated have been divided and discussed in three groups: growth parameters, seed yield attributes and seed yield.

Growth parameters

Plant height, dry matter yield (Table 1) and total tillers tussock^{-1} (Fig. 1) were affected significantly ($P < 0.05$) by cutting management practices at all the seed harvests. In general, the April seed harvests had taller plants and a greater number of total tillers tussock^{-1} as compared to the preceding November seed harvests. Overall, the uncut crop had better growth than the clipped or one-cut crop, especially with respect to plant height and dry matter yield, at almost all the seed harvests. The uncut crop produced significantly ($P < 0.05$) taller plants and more dry matter over the one-cut or clipped crop, at all the seed harvests. Similarly the clipped crop also produced taller plants and more dry matter over the one-cut crop at all the seed harvests, except for the plant height during Nov. 1999. In the Nov. 1999 harvest, the plant height in clipped and one-cut crops was statistically at par. As regards to total tillers tussock^{-1}, the uncut and clipped crops did not differ significantly ($P > 0.05$), but both produced significantly ($P < 0.05$) more tillers tussock^{-1} over the one-cut crop. Therefore, imposing a cut in this crop caused a significant reduction in tiller density. The severe cutting (one-cut) and even the lenient cutting (clipping) of this grass decreased all the growth parameters studied drastically in comparison to the uncut crop. It appears that cutting or clipping reduced the sprouting of new tillers and their regrowth as compared to the uncut crop.

Nitrogen application also affected the above growth parameters significantly, except the plant height and total tillers tussock^{-1} during November 1997 *i.e.* at first seed harvest. In general, the crop responded significantly up to 40 kg N ha^{-1} with respect to plant height, dry matter yield and total tillers tussock^{-1} at all the seed harvests, with some exceptions. For example, during April 1999 an N rate of 20 kg ha^{-1} was not enough to induce a significant difference in plant height over control (no nitrogen). In the above case, 40 kg N ha^{-1} produced significantly taller plants over control and 20 kg N ha^{-1}. Similarly, there was not any significant ($P > 0.05$) increase in dry matter production by 20 kg N ha^{-1} over control during April 1999. However, 40 kg N ha^{-1} rate recorded significantly greater amounts of dry matter over control and 20 kg N ha^{-1} from the same seed harvest. But at the April 2000 seed harvest, 40 and 20 kg N ha^{-1}, and 20 and 0 kg N ha^{-1} treatments did not differ significantly ($P > 0.05$) among themselves with respect to dry matter production. An amount of 40 kg N ha^{-1} was required to bring a significant increase in dry matter yield over control during April 2000. Total tillers $tussock^{-1}$ also increased significantly by N application in this experiment. In general total tillers $tussock^{-1}$ increased significantly up to 40 kg N ha^{-1} application at all the seed harvests, except during April 1999. At this harvest, the response was achieved up to 60 kg N ha^{-1}. In general, April seed harvests exhibited better growth as compared to the preceding November seed harvests.

Seed yield attributes

Fertile tillers $tussock^{-1}$, spike length (Table 2) and 1000-seed weight (Table 3), the principal yield components of grasses, were affected significantly by different cutting management practices in the present investigation on marvel grass. Generally, cutting and clipping did not favour the improvement in seed yield attributes of marvel grass. Uncut crop recorded a significantly higher number of fertile tillers $tussock^{-1}$, longer spike length and greater 1000-seed weight over clipped or one-cut crop at all the seed harvests, except 1000-seed weight during the April 1999 and April 2000 seed harvests. During the April 1999 and April 2000 seed harvests, uncut and clipped crops recorded at par 1000-seed weight, being significantly ($P < 0.05$) greater than the one-cut crop. The clipped crop, in general, also recorded greater values of the above parameters as compared to the one-cut crop. However, in the Nov. 1999 seed harvest there was no significant difference ($P > 0.05$) in 1000-seed weight of the clipped and one-cut crop. The mean values of fertile tillers, spike length and 1000-seed weight were generally greater in April seed harvests as compared to their preceding November seed harvests. It indicates that the crop received better environmental conditions (*i.e.* temperature, humidity, photoperiod, etc.) during the month of April in comparison to November that may have resulted in improved seed yield attributes in all three seed harvests in April.

Nitrogen fertilisation also affected the seed yield attributes of marvel grass significantly at each seed harvest. Successive levels of N increased progressively and significantly the fertile tillers $tussock^{-1}$ and spike length up to 40 kg N ha^{-1} at every seed harvest. However, further increase in N level to 60 kg ha^{-1} could not achieve a significant increase in fertile tillers and spike length at any of the seed harvests. Contrary to the fertile tillers and spike length, no set trend was observed in respect to the 1000-seed weight vis-à-vis N rates. In general, the highest 1000-seed weight was recorded at 60 kg N ha^{-1}, being significantly greater than 40 kg N ha^{-1} at all the seed harvests, barring April 2000. Application of 20 kg N ha^{-1} increased the 1000-seed weight significantly over control at all the seed harvests, except during Nov. 97. There was no significant difference ($P > 0.05$) in 1000-seed weight between 40 and 20 kg N ha^{-1} during Nov. 1997, April 1998, Nov. 1999 and April 2000. From the foregoing discussion it is evident that the response of N with respect to 1000-seed weight was inconsistent, however, in the case of fertile tillers and spike length it responded up to 40 kg N ha^{-1}.

Seed yield

In general, higher (mean) seed yield was obtained from the April seed harvests over their respective preceding November seed harvests. This can be easily explained due to wider variations in rainfall during the growing seasons of November and April seed harvests (Fig. 2). A much greater amount of rainfall was received during the November growing season than during April seed harvest. It suggests that heavy rainfall suppressed the growth and seed yield in November harvest and the crop performed better on residual soil moisture in the April seed harvest. Lowest seed yield was recorded during the first cycle (Nov. 97 & April 98), highest during the second cycle (Nov. 98 & April 99) and intermediate in the third cycle (Nov. 99 & April 2000), indicating a probable decline in seed yield beyond April 2000. Therefore, the experiment was concluded after the April 2000 seed harvest, presuming a decrease in seed yield in subsequent years.

Varying cutting management schedules affected the seed yield of marvel grass significantly at all six seed harvests (Table 3). The uncut treatment produced significantly more seed than clipping and one-cut treatments in every harvest, except during April 1999 and April 2000. The higher seed yield under the uncut crop resulted mainly from production of a significantly higher number of fertile tillers $tussock^{-1}$, longer spikes and heavier seeds over the clipped or one-cut crop. During April 1999 and April 2000, the uncut and clipped crop produced at par seed yield. Barring the Nov. 1999 seed harvest, significantly greater quantity of seed was recorded in clipping over one-cut treatment at all the seed harvests. The low seed yield in one-cut or clipped crop in comparison to uncut crop may be due to slower regrowth, poor synchronization of tiller development and also delayed inflorescence emergence (Dwivedi et al., 1999).

Different N levels also influenced the seed yield significantly at all the harvests, except in April 1998. Generally, seed yield response to N application was inconsistent depending upon the season of seed harvest. During the Nov. 1997, Nov. 1998, and Nov. 1999 seed harvests, N levels 20, 40 and 60 kg ha^{-1} did not differ significantly with respect to seed yield. However, in April 1999 and April 2000, the seed yield increased significantly up to 40 kg N ha^{-1}. It is evident that the increased levels of N (40 kg ha^{-1}) produced significantly more seed as compared to respective November seed harvests, which, in general, responded only up to 20 kg N ha^{-1}. Overall, N application increased the fertile tillers' density, spike length and 1000-seed weight, all causing a significant increase in seed yield over control. Several other workers have also reported a positive seed yield response to N application in different tropical grasses (Loch et al., 1999; Dwivedi & Kumar 1999; Gobius et al., 2001; Kumar et al. 2005).

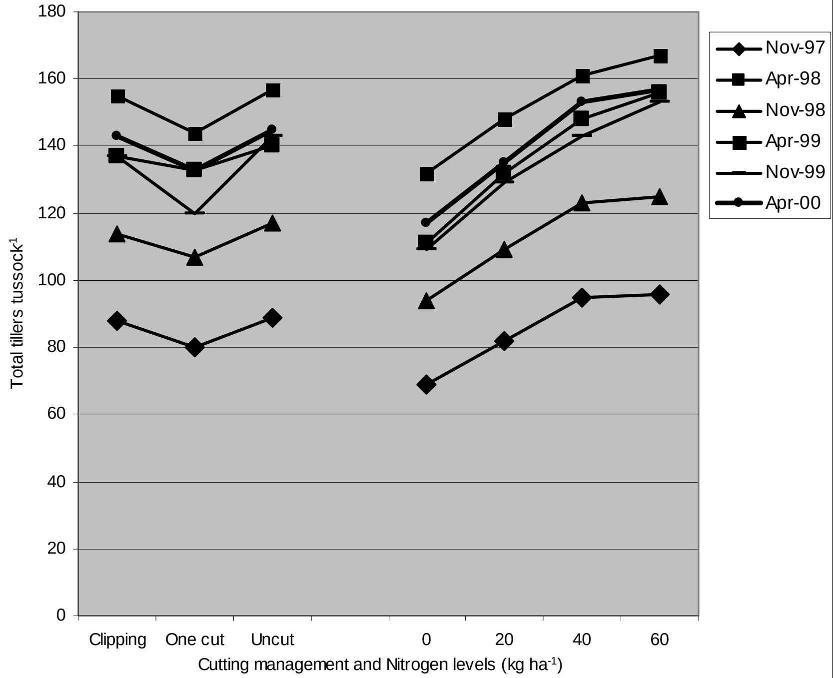

Figure 1 Effect of cutting management and nitrogen levels on total tillers tussock^{-1} of marvel grass at different harvests

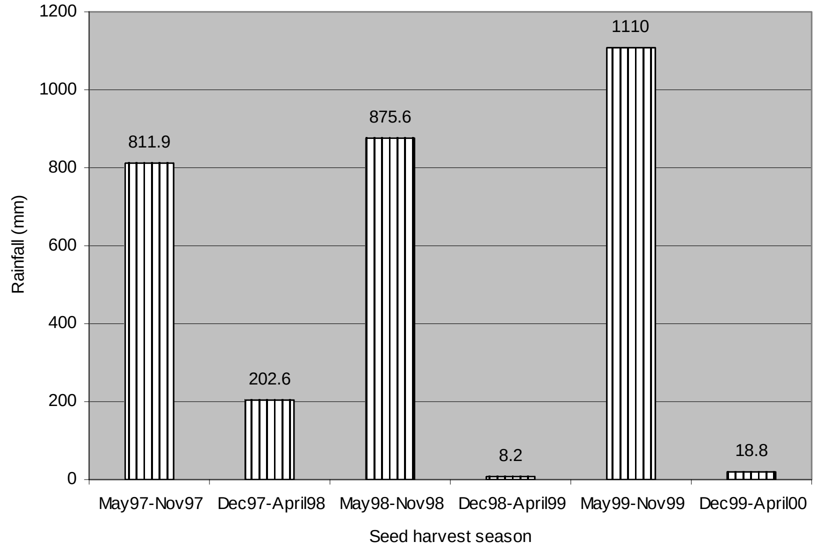

Figure 2. Rainfall (mm) received during the different cropping seasons

Table 1. Effect of cutting management and nitrogen levels on major growth attributes of *Dichanthium annulatum* at different harvests.

Treatment	Plant height (cm)						Dry matter yield (t ha^{-1})					
	Nov. 1997	April 1998	Nov. 1998	April 1999	Nov. 1999	April 2000	Nov. 1997	April 1998	Nov. 1998	April 1999	Nov. 1999	April 2000
Cutting management												
Clipping	108	169	158	179	162	174	3.5	4.1	7.3	7.2	9.0	8.8
One-cut	92	147	138	151	145	154	3.0	3.4	6.3	5.9	7.3	8.1
Uncut	115	193	179	206	184	189	3.9	4.6	8.4	8.4	10.2	9.5
SEm±	1.5	3.9	4.1	6.5	4.6	3.3	0.05	0.1	0.2	0.3	0.1	0.2
LSD (0.05 P)	5.9	15.3	16.2	25.6	18.4	13.2	0.21	0.4	0.8	1.1	0.4	0.7
Nitrogen levels (kg ha^{-1})												
0	98	152	139	163	146	155	3.0	3.4	6.8	6.6	7.6	8.3
20	104	172	152	172	161	169	3.4	3.9	7.2	6.9	8.7	8.7
40	106	177	168	189	174	182	3.8	4.2	7.8	7.7	9.5	9.0
60	112	178	175	191	174	184	3.8	4.5	7.7	7.8	9.6	9.2
SEm±	5.2	3.8	3.5	4.8	4.2	3.2	0.07	0.09	0.2	0.1	0.2	0.2
LSD (0.05 P)	NS	11.5	10.4	14.3	12.6	9.5	0.21	0.27	0.6	0.4	0.7	0.6
Mean	105	169.7	158.4	178.7	163.7	172.4	3.5	4.0	7.3	7.2	8.8	8.8

Table 2. Effect of cutting management and nitrogen levels on major seed yield attributes of *Dichanthium annulatum* at different harvests.

Treatment	Fertile tillers/tussock						Spike length (cm)					
	Nov. 1997	April 1998	Nov. 1998	April 1999	Nov. 1999	April 2000	Nov. 1997	April 1998	Nov. 1998	April 1999	Nov. 1999	April 2000
Cutting management												
Clipping	53	98	84	111	94	103	8.0	11.4	9.2	11.6	10.6	11.6
One-cut	26	74	57	82	67	93	7.2	10.2	8.6	10.5	9.8	10.3
Uncut	76	117	106	138	120	112	9.2	12.9	9.8	13.3	11.8	12.9
SEm±	5.4	4.7	5.2	6.7	5.9	1.9	0.15	0.18	0.11	0.19	0.15	0.11
LSD (0.05 P)	21.3	18.7	20.6	26.4	23.2	7.4	0.61	0.72	0.44	0.74	0.60	0.46
Nitrogen levels (kg ha^{-1})												
0	27	72	61	76	68	85	7.4	10.1	8.0	10.4	9.1	10.1
20	46	91	78	102	86	98	8.1	11.4	8.8	11.6	10.6	11.7
40	65	109	93	130	104	111	8.6	12.2	9.9	12.5	11.6	12.2
60	69	113	97	133	116	116	8.9	12.3	10.1	12.7	11.7	12.4
SEm±	5.9	4.3	4.7	8.2	5.5	3.7	0.13	0.17	0.11	0.18	0.31	0.12
LSD (0.05 P)	17.4	12.9	14.2	24.4	16.4	11.1	0.39	0.50	0.32	0.53	0.92	0.36
Mean	52.4	96.3	82.3	110.3	93.6	102.6	8.2	11.5	9.2	11.8	10.7	11.6

Table 3. Effect of cutting management and nitrogen levels on 1000-seed weight and seed yield of *Dichanthium annulatum* at different harvests.

Treatment	1000-Seed weight (g)						Seed yield (kg ha^{-1})					
	Nov. 1997	April 1998	Nov. 1998	April 1999	Nov. 1999	April 2000	Nov. 1997	April 1998	Nov. 1998	April 1999	Nov. 1999	April 2000
Cutting management												
Clipping	1.10	1.32	1.14	1.55	1.22	1.45	35.2	66.2	38.5	81.6	57.9	74.0
One-cut	0.94	1.19	0.98	1.23	1.17	1.23	29.4	56.9	36.5	73.1	54.0	64.8
Uncut	1.32	1.45	1.42	1.72	1.48	1.55	41.9	80.7	42.5	96.3	66.7	83.3
SEm±	0.03	0.02	0.03	0.07	0.06	0.05	0.8	1.9	0.5	1.0	1.1	1.7
LSD (0.05 P)	0.12	0.10	0.14	0.27	0.24	0.20	3.2	7.7	1.9	4.1	4.5	6.6
Nitrogen levels (kg ha^{-1})												
0	0.90	1.18	0.97	1.26	1.14	1.27	31.9	64.8	37.1	71.4	54.2	70.1
20	0.98	1.27	1.13	1.42	1.26	1.38	34.9	67.4	39.1	78.3	59.7	72.9
40	1.25	1.33	1.24	1.58	1.31	1.47	37.1	73.7	40.5	91.1	61.5	77.3
60	1.35	1.50	1.38	1.74	1.45	1.52	38.1	65.8	40.0	94.0	62.8	75.9
SEm±	0.30	0.02	0.04	0.04	0.03	0.03	1.2	3.7	0.7	1.6	1.7	1.0
LSD (0.05 P)	0.90	0.08	0.12	0.13	0.10	0.10	3.7	NS	2.2	4.8	5.2	3.0
Mean	1.12	1.32	1.18	1.50	1.29	1.41	35.5	67.9	39.2	83.7	59.5	74.0

SUMMARY

The present study suggests that the April seed harvest, in general, produced more seed than the November seed harvest. Heavier rains during the growing period of the November seed harvest depressed the seed yield more than in the April seed harvest, which grew well on residual soil moisture. Cutting or clipping of the marvel grass did not favour seed production in either harvest. An amount of 20 kg N and 40 kg N ha^{-1} is sufficient for November and April seed harvests, respectively.

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