SEED PRODUCTION IN THE FORAGE GRASSES PENNISETUM POLYSTACHYON AND ANDROPOGON GAYANUS IN THE INDIAN TROPICS

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SUMMARY

Maximum yields of seed (with fluff) in the years 1962 to 1966, in *Pennisetum polystachyon* (420 kg/ha[3]) and *Andropogon gayanus* (90 kg/ha[6]) were obtained from spaced plants, fertilized with 38.9 kg N and 22.2 kg P_2O_5/ha, and defoliated twice, in mid-January and early July. The kernel contents in seed (with fluff) were 30% in *P. polystachyon* and 10% in *A. gayanus*. *A. gayanus* maintained its seed yield with an additional cutting in early August but *P. polystachyon* did not. Anthesis occurred 3–4 days after complete ear emergence. Seeds mature in 20 days after anthesis but the spikelets were prone to shatter, thus necessitating hand seed collections twice a week.

Increases in seed yield were directly related to the increases in the number of flowering tillers per plant, those forming between January to March and June to July, contributing most to the yield. Tiller number per plant increased in successive years but seed yields declined because of the fall-off in flowering tillers. In a similar manner the more vigorously tillering species (*A. gayanus*) produced the lowest seed yield due to the low proportion of flowering to vegetation tillers.

INTRODUCTION

In India little attention has been paid to the improvement of forage crops, especially with respect to seed production. *Pennisetum polystachyon* and *Andropogon gayanus* are reputed to be high yielding grasses that can be established from seed (Singh and Chatterjee 1968). *A. gayanus* has given high yields in West Africa (Oyenuga 1957). Grasses grown for use as fodder do not usually produce large amounts of seeds. Thus, for seed production different defoliation and fertilization schedules have to be recommended. Method and time of collection of seeds are also important points that have to be considered for commercial production of grass seeds.

Seed production in grasses is generally related to tillering habit. In the present work, two grasses were chosen for study: *A. gayanus* with a large number of tillers per plant and *P. polystachyon* with few tillers per plant. On this basis therefore, it is suggested these results have a wider applicability than the two species to which they pertain.

MATERIALS AND METHODS

The experiments were conducted on upland red soils of the Ranchi Agricultural College farm (23° 23'N and 85° 19'E) at 625 m altitude. The mean annual rainfall in 1321 mm, almost all received between June and October. No additional irrigation was given. There is a definite winter period, with a few ground frosts in January but no air frosts.

Clones from very similar plants of both *P. polystachyon* and *A. gayanus* were transplanted in drills 60 cm apart (maintaining a spacing of 45 cm in rows) on 24–27 August in plots, 2.4 x 2.7m[2]. The design of the two experiments, laid out separately in continuous blocks was a randomised block design with 6 replications. The treatments were:

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[3]1 kg/ha = 1.1 lb/ac.

Treatments	No. of defoliations	Rates of Nitrogen kg N/ha	Fertilzer Phosphate kg P_2O_5/ha.
1	cut once	0	0
2	cut once	27.8	0
3	cut once	27.8	22.2
4	cut twice	27.8	22.2
5	cut thrice	27.8	22.2
6	No cut	27.8	22.2

Nitrogen and phosphate were applied in July in the form of ammonium sulphate and single superphosphate. All plots received an additional dose of basal nitrogenous fertilizer at 11.1 kg/ha in June every year. Each year a pre-treatment defoliation was made in the first week of July followed by, to the 'cut once' treatments one cut on 3 August, to the 'cut twice' treatments two cuts on 3 and 26 August and to the 'cut thrice' treatments three cuts on 3 and 26 August and 15 September. All the treatments were again cut in January every year following the collection of seed.

RESULTS

The seed yield (with fluff) in *P. polystachyon* (Table 1) was maximum (417 kg/ha) in the treatment 'no cut' with N and P and minimum (21 kg/ha) in the treatment of 'cut thrice' with N and P. Treatment cut once and receiving N (228 kg/ha) or N and P (240 kg/ha) yielded significantly more than the treatment 'cut once with no N and P' (128 kg/ha). The effect of defoliation proved more depressing than the effect of fertilizing. The effect of P was not always significant. The seed (with fluff) yield in *A. gayanus* was much lower (16 to 90 kg/ha) than *P. polystachyon*. In *A. gayanus* 'no cut' and 'once cut treatments with N and P yielded equally.

TABLE 1

Mean seed (with fluff) yield and percentage of flowering tillers per plant (1962–66)

Treatment	*P. polystachyon*			*A. gayanus*		
	Seed yield kg/ha	Per cent flowering tillers per plant		Seed yield kg/ha	Per cent flowering tillers per plant	
		Converted	Original		Converted	Original
Cut once with no N and P	128	36	35	69	35	33
Cut once with N only	228	41	43	90	38	37
Cut once with N and P	240	43	46	88	42	45
Cut twice with N and P	21	22	14	16	14	6
Cut thrice with N and P	59	17	8	16	18	9
No cut with N and P	417	60	75	85	53	64
S.E. (±)	24	2.0		12	2.7	
C.D. at 5%	75	6.1		34	10.4	

Treatments which yielded high also showed a higher percentage of seed kernel contents in seed with fluffs than the low yielding treatments. *A. gayanus* had lower kernel content (5–10%) in the harvested seed with fluff than in *P. polystachyon* (16–27%).

Ear emergence and maturation of seeds in *P. polystachyon* (6 weeks) continued for a longer time than in *A. gayanus* (4 weeks).

Further, there were fewer collections in the defoliated treatments than in the 'no cut' treatments.

Tillering, ear bearing tillers and seed production in P. polystachyon

At the beginning of the experiment the tiller numbers per plant were 30 to 45 (1962–63) and in the end (1965–66) they were 37 to 78. The number of tillers per plant from August to November remained very constant and then there was a reduction in December. Very few tillers initiated between October to December; they were mostly formed in spring (Feb.–Mar.). There were some deaths of tillers in April, May and June due to drought.

Ear emergence in tillers started late in October or in the first week of November; floral primordia having been observed in late September. The percentage of tillers classed as flowering tillers was greatest in the treatments 'no cut' (pre-treatment cut in July only). The percentage of flowering tillers (Table 1) was maximum (75%) in the treatment 'no cut with N and P' and minimum (8%) in the treatment 'cut thrice with N and P'. Application of nitrogen only, caused an increase of 8%in the flowering tiller contents of the plants; addition of phosphate caused further increase of 3%. Second (26 Aug.) and third cutting (15 Sep.) caused severe reductions in flowering tillers.

Anthesis was recorded 4–5 days after ear emergence and seed collections started 22–24 days after this. From Figure 1 it can be seen that treatments cut twice and thrice still produced a high number of tillers per plant but little seed

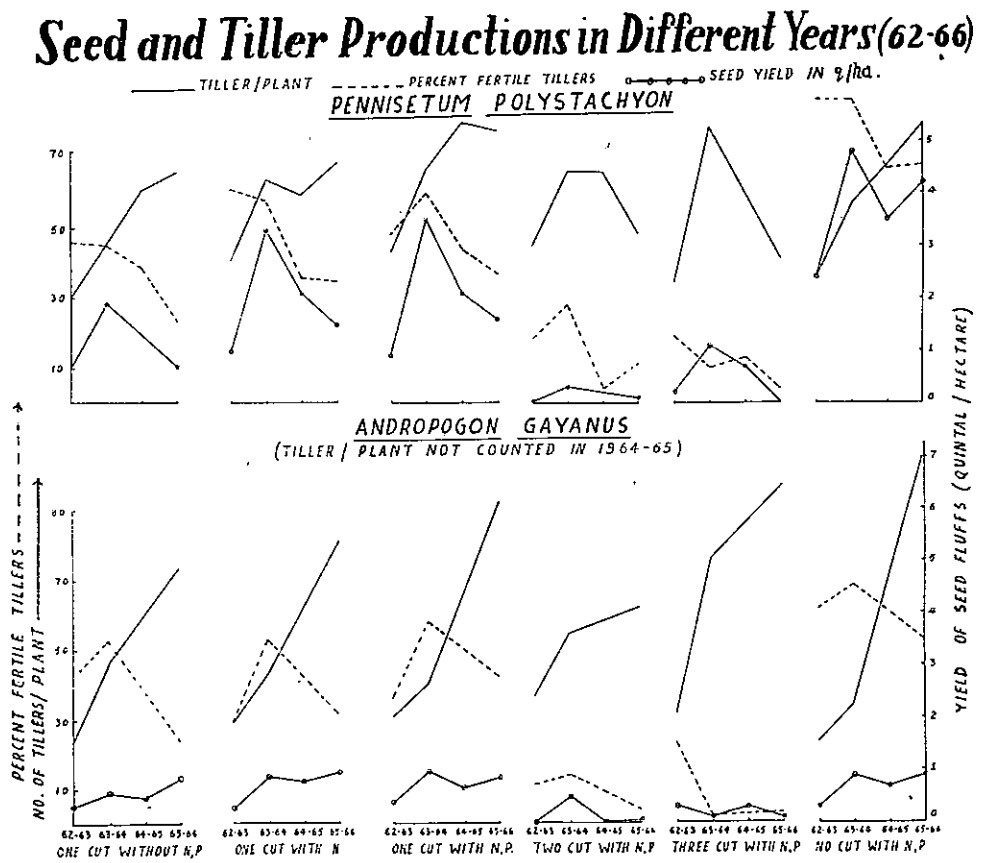

FIGURE 1.

Seed and tiller production from *Pennisetum polystachyon and Andropogon gayanus* over the years 1962–66.

since the proportion of flowering tillers was low. After the first two harvest years the tiller number per plant remained the same or increased but the flowering tiller contents of the plants were reduced and so seed yield declined with the age of the plants.

In December, when the seeds of *P. polystachyon* generally mature, there are high winds; the fascicles in the spikes (starting from the tips) are easily detached and blown away. After anthesis the dry matter accumulation in the lower florets of the spikes occurred rapidly at the beginning and subsequently the dry matter accumulation rates were very similar in all the regions of the spikes, so that the seeds attained their maximum weights (18 gm/50,000) 20 days after anthesis. Thus, matured seeds could safely be collected 20 days after anthesis.

Tillering and ear-bearing tillers in A. gayanus

With increasing age of the plants the number of tillers per plant increased (70–107), but the percentage of tillers bearing ears decreased as did the yield (Fig. 1). The percentage of flower bearing tillers (Table 1) was maximum (64%) in the treatment 'no cut with N and P' and was minimum in the treatment cut twice (6%) and thrice (9%). Defoliation treatments reduced the ear bearing capacity of the tillers. Nitrogen fertilizing increased the fertility of tillers. Treatment receiving both N and P showed a higher percentage of fertile tillers than the treatment receiving N only; this difference was not always significant. A large number of tillers forming between January and July 1966 produced ears but those originated in subsequent months mostly did not produce ears in the following autumn and most of them died in April and May.

A second flush of flowering tillers appeared in spring in the plants cut in January after seed production. The seed yield from such tillers was low.

DISCUSSION

In cereals (Watson 1952) as well as in grasses (Moriya *et al.* 1956, Langer 1959, Wilson 1959, Calder and Cooper 1961, Lambert, D. A. 1963, 1964, 1966, Lambert, J. P. 1956, Ryle 1964, Ryle and Langer 1963) variation in grain yield per unit area has usually been resolved to the number of flowering tillers produced and the number and weight of grains per tiller. In these experiments nitrogenous fertilizing and fewer defoliations increased the number of flowering tillers per unit area and also the size of the inflorescence axis. This confirmed earlier work and observations of Ryle (1964) on seed production of grasses under controlled conditions.

Earlier formed tillers (arriving in spring — Feb. and Mar.) produced more seeds per tiller. Defoliation in late August or mid-September appeared to be very harmful and it is quite possible that the apices of many of the earlier formed tillers were damaged. In *A. gayanus,* which contained greater number of tillers per plant than *P. polystachyon,* 'one cutting on August 3 with N and P' produced as much seed as 'no cutting with N and P'. This appears due to better development of fewer tillers (34–45%) in the 'once cut' treatment compared with the 'no cut' (64%) treatment.

The covariance analysis of the number of flowering tillers per plant and seed (with fluff) yields per plant under different treatments in *P. polystachyon* indicated that (1) the seed yield per plant was affected by the treatment through its affect on the number of flowering tillers per plant and (2) after eliminating the variation in seed yield caused by the number of flowering tillers there was no significant difference in yields between treatments (Table 2). On the other hand, in *A. gayanus* treatments had an affect both on tiller number per plant and yield per tiller.

TABLE 2

Convariance analysis of flowering tillers per plant and seed (with fluff) yield per plant under different treatments in *A. gayanus* and *P. polystachyon*

Treatments	*A. gayanus*		*P. polystachyon*	
	Adjusted yields in gm/plant	Unadjusted yields in gm/plant	Adjusted yields in gm/plant	Unadjusted yields in gm/plant
Cut once with no N and P	1.63	1.50 (3)	1.66	0. 92 (2)
Cut once with N only	1.60	1.70 (4)	1.60	1.98 (4)
Cut once with N and P	0.95	1.55 (3)	1.44	1.85 (4)
Cut twice with N and P	1.43	0.70 (1)	1.72	1.39 (2)
Cut thrice with N and P	2.88	0.78 (2)	1.90	0.82 (1)
No cut with N and P	1.21	1.75 (5)	1.77	3.12 (5)
S.E. (+)		0.17		0.40
C.D. at 5%		0.51		–

Yields are transformed in scale and not actual yields. Figures in brackets indicate the indices for number of flowering tillers per plant.

Thus these two grasses differ to some extent in the culture necessary for maximizing harvestable seed yields. *P. polystachyon* a plant producing relatively few tillers (30–45), will produce up to 420 kg/ha of seed when grown as spaced plants, fertilized with nitrogen and superphosphate in July and cut twice, early in July and in January. *A. gayanus,* on the other hand is a plant with a large number of tillers (70–100), and, when similarly fertilized and cultivated, will produce only 90 kg/ha of seed with 2 or 3 cuttings, one or two in July-August and the other in January.

The significant feature of these studies lies, therefore, in the lack of relationship between the gross tillering characteristics of these two grasses and their seed yields. The important criterion is the number of fertile tillers, which may be quite low, even in a vigorously tillering species. This is a feature of some importance for plant introduction and selection, particularly since vigorous tillering is a desirable attribute for forage purposes.

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