ESTABLISHMENT AND PERSISTENCE OF SOME LEGUMES AND GRASSES AFTER ASH SEEDING ON NEWLY BURNT BRIGALOW LAND

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ABSTRACT

In one experiment seed of four legumes and four grasses were broadcast on to the ash covering newly burned brigalow land on which the forest had been felled about one year before burning. There was no other treatment of the land. In a second experiment sown a year later under similar conditions three of the same legumes and two of the same grasses were used.

Of the legumes, Phaseolus atropurpureus (*Siratro*) *and* P. lathyroides (*phasey bean*) *both established well by this method of sowing but failed to persist beyond the first year for reasons not connected with the planting technique.* Medicago sativa (*lucerne, cv. Hunter River*) *showed poor establishment from the mid-summer sowing used, but it persisted much better than the other legumes.* Glycine javanica (*cv. Cooper*) *gave much poorer establishment than the other two tropical legumes.*

As a group the grasses did better than the legumes with success in establishment in the order: Sorghum almum (*columbus grass*), Cenchrus ciliaris (*buffel grass*), Chloris gayana (*rhodes grass*), Panicum maximum *var.* trichoglume (*green panic*). *After three years of drought buffel grass dominated the whole area of the one experiment in which it was planted.*

There was considerable drifting of seeds between plots on both experiments due to both wind and water. The results of these two experiments quantify the performance of grasses already used successfully in commercial seedings on to ash, and suggest that there is no reason why legumes could not be sown similarly if suitable cultivars are chosen.

INTRODUCTION

The common method of converting virgin brigalow land to pasture is to burn the fallen forest and then to spread seed from aircraft on to the ash as soon as it is cool. Since the ash is from ½ to 1 inch thick over perhaps 50% of the area (typical brigalow forest may contain over 100 tons per acre of dry matter above ground; Moore, Russell and Coaldrake 1967), this has been found to provide an excellent seed bed for the grasses commonly used in this region. However, there has been little experience with ash-seeding of legumes suited to the brigalow region. Again, it is common practice to use a mixture of grasses and this can lead to subsequent dominance of one grass, especially when differences in palatability lead to unequal seed-set apart from other effects of selective grazing. Finally, ash-seeding can lead to very uneven dispersal of seed, largely by wind, between seeding and germination.

The experiments reported in this paper were designed to examine some of these aspects of ash seeding on brigalow land.

MATERIALS AND METHODS

The choice of sites was governed finally by availability of a newly burned area. The two sites used were three miles apart on privately owned land 30 miles west of Moura (lat 24° 30° S). The first ("Thalmera North") was on a sedentary clay soil (Isbell 1962) and the original vegetation was a brigalow-softwood community (Johnson 1964) in which brigalow (*Acacia harpophylla*) and bottle tree (*Brachychiton rupestre*) were the common trees. Although the second site ("Sunset Plains") was on generally similar land there was some gilgai micro-relief (Isbell 1962) up to 12 inches deep. At

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both sites the forest was felled with anchor chain dragged between two tractors about one year before burning; each site was about 100 yards inside the boundary of a block of over 1,000 acres which was burned in the one fire. Seeding commenced when ash at the bottom of deeper heaps (4 inches deep) was cool to the hand. One experiment was carried out at each site with one year between them.

In each case, the design was a randomised block with three replications. The plots, each 22 yards square, were arranged in two rows per block to avoid excessive elongation of the layout. There were laneways 10 feet wide between the rows of plots. The results were based on counting of seedlings at various intervals after sowing, using 10 quadrats of 5×2 links in randomised positions in each plot at each count.

At both sites stock were excluded for three months after which the areas were opened to grazing by station cattle from the surrounding pasture where the stocking rate was about 1 steer to 5 acres.

Experiment 1. ("Thalmera North")

The following species were used:—

Medicago sativa	cv. Hunter River (lucerne)
Phaseolus lathyroides	cv. Murray (phasey bean)
Glycine javanica	cv. Cooper (glycine)
Phaseolus atropurpureus	cv. Siratro
Cenchrus ciliaris	cv. Biloela (buffel grass)
Chloris gayana	cv. Pioneer (rhodes grass)
Sorghum almum	cv. Crooble (columbus grass)
Panicum maximum var. trichoglume	cv. Petrie (green panic)

Within each block each legume was sown once with each grass and twice alone, resulting in 24 plots per block. The inclusion of these "legume—alone" plots was to increase the sensitivity of the test on legumes (the primary objective) in the face of the high variation in thickness of the ash over distances of a few feet. It was felt that the alternative of increased replication with smaller plots would introduce error when seeding with the light seed of such grasses as rhodes grass and buffel grass. The total layout of the experiment covered 8·2 acres.

All seed was broadcast by hand from waist height in still air on November 26th-27th, 1963, four days after the clearing fire was lit. Sowing was stopped whenever a local whirlwind was moving across the plots. There was no further treatment of the land.

The seeding rate was 2 lb. per acre for all species. Legume seeds were pelleted by the method described by Norris (1964) using peat inoculum of appropriate strains of *Rhizobium* with plasterer's lime, and gum arabic as the sticker. Grass and legume seeds were sown separately.

Experiment 2 ("Sunset Plains")

Of the species listed for Experiment 1, the following were used:—

lucerne	columbus grass
Siratro	green panic
phasey bean	

Because of suspected seed harvesting by ants in experiment 1 and because of results from other experiments in progress (Russell, Coaldrake, and Sanders 1967) treatment of the legume seed with an insecticide was included in the design. The seed of each legume was treated as follows:—

(a) Pelleted with chlordane (1 gm active ingredient per pound of seed).
(b) Pelleted without chlordane.
(c) Unpelleted with chlordane.
(d) Unpelleted without chlordane.

With treatment (a) the three legumes were planted with each of the two grasses; in addition, with treatments (a) to (d) the legumes were planted alone giving a total of

18 plots per block. The resultant additional seeding of species within blocks was also intended partly to offset variation within blocks due to the effects of scattered gilgai micro-relief.

Layout, plot size, and planting procedure were all the same as in Experiment 1. The seed was sown in still air on December 20th, 1964, seven days after the clearing fire was lit.

RESULTS

Climate

With Experiment 1 there was 0·35 inches of rainfall of light intensity overnight during the two-day planting period. Since this fell on dry soil in hot weather both the ash and the bare soil were dry again by noon. Arrangements for collection of rainfall records at the site failed and only general figures were available until December 1964. Light germinating rains in December (total about 1 inch) were followed by 2 to 2·5 inches in the last week of January. This was followed by about 5 inches in February and 3 inches in July. The total rainfall for 1964 was about 18 inches compared with a long term mean annual rainfall of 28 inches (Anon. 1965). From December 1964 the records quoted for Experiment 2 may be taken as indicating rainfall on Experiment 1 since the sites were only 3 miles apart.

Experiment 2 received 1·80 inches of rain one week after planting. This was a thunderstorm with rainfall of high intensity and surface wash moved seed between plots. As shown in Table 1 further good rain fell in January and April 1965 while the total rainfall for 1965 was 20·5 inches and for 1966 it was 22·8 inches.

TABLE 1

Rainfall for Experiment 2 (inches)

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1965	5·00	0·71	0·58	3·26	0·24	1·10	0·50	0·05	1·62	0·80	2·65	4·00	20·5
1966	3·33	2·52	2·44	0·10	1·05	1·24	1·28	4·20	0·66	1·74	2·55	1·70	22·81

Wind is another aspect of weather that affects experiments of this type. With Experiment 1 heat-wave conditions in the absence of a steady wind generated whirlwinds of up to 30 feet in diameter and reaching to heights of over 100 feet. Such a whirlwind would wander erratically across the experimental area three or four times a day during the two days of planting, and this would have continued for some days afterwards. These moved large amounts of ash and must inevitably have redistributed some of the seed, especially the lighter grass seed (see Table 3). With both experiments there were indications after the first year of grass seed having been transported by the prevailing northerly to easterly winds.

ESTABLISHMENT

In spite of the variability of ash deposits and the presence of some gilgai micro-relief the only significant block effect was in the grass segment of Experiment 2.

TABLE 2
*Establishment at 2 weeks in relation to viable seed sown**

Species	Plant numbers as a loaded percentage of viable seed sown Experiment 1		Experiment 2	
Siratro	4·03		13·29	
		N.S.		**
phasey bean	3·41		2·51	
		***		
glycine	0·49		n.p.	
		N.S.		
lucerne	0·14		0·06†	
columbus grass	5·49		4·10	
		***		
buffel grass	2·71		n.p.	***
		**		
green panic	0·33		0·51	
		N.S.		
rhodes	0·22		n.p.	

n.p. — not planted.
† — excluded from statistical analysis due to obvious difference.
* — germination tests by Seed Testing Laboratory, Department of Primary Industries, Brisbane.

Table 2 shows the percentage success of viable seed sown after 7 weeks at each site. Plant counts on both experiments at 7 weeks were adjusted by application of the formula of Anscombe (1948) which compensates for unequal variances when low percentages are involved.

$\%\ \text{Success} = \frac{r}{n} + \frac{0{\cdot}375}{0{\cdot}75} \times 100$ where r = number of seedlings counted, and n = number of viable seeds sown. The results are shown in Table 4.

Experiment 1

The results of plant counts over a 3 year period on Experiment 1 are summarised in Table 3. As a group the grasses were more successful than the legumes with initial success after 7 weeks in the order columbus grass, buffel grass, rhodes grass, and green panic. After 1 year rhodes grass had the highest frequency, but thereafter buffel grass began to increase until it reached the prominence shown in the counts after 3 years.

TABLE 3
Experiment 1. Plant numbers at 3 intervals after sowing.

Species	7 weeks		48 weeks	34 months†
		average number of plants per 100 square links		
	on plot	drifted* %	on plot	on plot
Siratro	2·44	0	4·56	<0·1
phasey bean	3·11	2	7·83	<0·1
lucerne	0·39	0	0·22	<0·1
glycine	0·17	0	0·39	<0·1
L.S.D.	1·06 (P = 0·05)		2·75 (P = 0·05)	
	1·41 (P = 0·01)		3·67 (P = 0·01)	
	1·86 (P = 0·001)		4·80 (P = 0·001)	
buffel grass	4·33	37	17·67	13·3
rhodes grass	3·75	34	86·17	3·8
columbus grass	6·08	24	74·08	0·1
green panic	0·75	11	11·75	1·0
L.S.D.	3·00 (P = 0·05)			
	4·04 (P = 0·01)		55·53 (P = 0·001)	‡

* Number of seedlings in adjoining plots expressed as a percentage of the total number of seedlings for that species.
† This count on mature pasture was obtained by counting crowns in a mown strip 3 feet wide across the middle of each plot.
‡ Excluded from statistical analysis.

Of the legumes, phasey bean and Siratro both gave satisfactory establishment in the first year. Observation indicated that the increase in these two species between 7 weeks and 48 weeks after sowing resulted both from self-sown seed and from surviving hard seed from the original sowing. While lucerne established poorly, observation showed that it was the best of the legumes in terms of relative survival after 3 years. Phasey bean (the only annual species among the legumes) failed to regenerate in the second and third years. The stand of Siratro (4,500 plants per acre) made a substantial contribution to total production at the end of the first year since most plants formed prostrate rosettes up to 3 feet in diameter; thereafter it declined. Glycine gave much poorer establishment than the other two tropical legumes.

The big differences in seed drift between grasses and legumes shown in Table 3 reflects the influence of wind on the lighter grass seed — especially whirlwinds.

Experiment 2

The results of plant counts over the first 40 weeks are summarised in Table 4. As in Experiment 1 columbus grass established better than green panic under this system of seeding and increased the advantage throughout the first year until counting ceased. Later observation showed a decline in columbus grass similar to that found in Experiment 1 after 3 years.

After 14 weeks Siratro was the only legume producing an adequate stand and there were significant differences between legumes with Siratro better than phasey bean, and both of these better than lucerne ($P=0{\cdot}01$). Thereafter self-seeding of phasey bean increased its numbers beyond those of Siratro, but these stands were mainly in the bottoms of gilgais where there was more soil moisture.

There were no positive results from the treatment of seed to prevent removal by ants. In this experiment drift was caused by water. This accounts for the relative uniformity of drift over all species in contrast to Experiment 1 where wind drift tended to affect light seeds the most.

DISCUSSION

There is ample farm experience of successful establishment of various tropical grasses from aerial seeding on to uncultivated land that has recently been burned over. The results of these two experiments suggest that there is no reason why suitable legumes should not be equally successful by this method. In the first year of these experiments, stands of up to 6,500 plants per acre of Siratro and 11,000 of phasey bean were obtained by this method. These were years of below-average rainfall.

Since these experiments were started there has been widespread experience that the present cultivar of Siratro does not persist on clay soils in the climate of the brigalow region (cf. Table 3). Later experience with other experiments on brigalow land by one of us (M.J.R.) shows that glycine is difficult to establish in the brigalow region except under patterns of rainfall more favourable than those required by Siratro and phasey bean. Being an annual, phasey bean is very susceptible to patterns of rainfall for regeneration from year to year. In these experiments the persistence of all three of the above legumes must certainly have been affected by the fact that the three years spanned by the experiments were all years of relative drought.

In the case of lucerne much of its comparative failure must be attributed to unsuitable times of planting (viz. midsummer), e.g. it is possible that seedlings died from the effects of heat waves in Experiment 1 before our first count. Autumn or winter are the safest times for the sowing of lucerne in the brigalow region (Cameron 1968) but with these experiments all planting had to be done when newly burned land was available, and summer is the commonest time for burning. Since all of the grasses concerned are known to establish satisfactorily from sowing in autumn, it may be worthwhile to postpone clearing burns until autumn so that lucerne can be included in the seeds mixture. In this connection, it should be noted that although the number of lucerne plants was low in each experiment, observation showed that lucerne was better than the other legumes after three years with regard to survival and vigour. In Table 4 the apparent increase in lucerne over 40 weeks is cancelled out by the standard errors shown.

TABLE 4

Experiment 2. Plant numbers at 4 intervals after sowing

Species	7 weeks		14 weeks	23 weeks	40 weeks
	average number of plants per 100 square links				
	on plot	drifted* %	on plot	on plot	on plot
Siratro	8·9	21	4·3	5·2	6·5
phasey bean	2·3	30	1·9	11·0	7·8
lucerne	0·1	11	0·1	0·7	1·6
L.S.D. legumes	5·6 (P = 0·01)		2·1 (P = 0·01)	8·4 (P = 0·001)	3·8 (P = 0·01)
S.E. of Mean	±1·5		±0·4	±2·2	±1·0

* Number of seedlings in adjoining plots expressed as a percentage of the total number of seedlings for that species.

In these experiments much of the seed fell into brigalow ash which is known to have a high pH (up to pH 12·6) and a high content of calcium. Again since these experiments started Norris (1967) has pointed out that lime (in pellets) may be deleterious to the *Rhizobium* for the three tropical legumes used depending on the circumstances. In spite of these possible disadvantages all of the legumes were vigorous, possibly because of the high nitrogen status of newly burned brigalow land.

Expression of species capability as per cent success of viable seed sown (Table 2) shows a possible advantage of large seeds over small ones. The poorer success of glycine (a large-seeded species) was due to poor rainfall conditions as already mentioned.

That buffel grass succeeded better than green panic and rhodes grass suggests that this species has a competitive advantage in germination and establishment as well as in later competition (Table 3) under dry conditions. In Experiment 1 the failure of rhodes grass in the second year and the ultimate dominance of buffel grass both reflect the drought conditions that prevailed through much of the life of this experiment. This superior drought resistance of buffel grass is consistent with its performance elsewhere (Coaldrake *et al.* 1969). In the case of buffel grass there is the additional factor of selective grazing since buffel grass is the least preferred of the grasses in these experiments when they are offered in a mixture. This combines with its capacity for rapid seed-set to give it ultimate dominance.

While the effects of drift due to wind and wash become marked within the small plots of this experiment such effects can also be important in large scale plantings where they can lead to very patchy establishment in the first season.

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