Medium pH

The pH of the black earth soil remained steady at *c.* 6.6. The pH of the peat core was initially quite acid (pH 4.6) but increased gradually with time to 5.8, whilst in the podzolic soil, pH dropped from 5.3 to 4.7 during the experiment.

DISCUSSION AND CONCLUSION

Plant growth in the infertile, acid podzolic soil from Beerwah was improved when seedlings grew from small cores of black earth or peat moss embedded in the soil. Improved top and root growth was associated with enhanced nodulation. The higher inherent fertility of soil core mediums may have influenced early growth but subsequently was deemed to have had minimal effect as roots were well distributed throughout the implanted pots by week 6.

In the black earth cores, nodulation was detected from week 4 and top growth was greater than for the podzolic soil by week 6. Top and root growth in peat cores did not show an advantage over the podzolic soil until weeks 8 and 10, respectively. This slower response was associated with a delay in nodulation in the peat until week 10.

The lack of nodulation in the podzolic soil may be due to the low pH and associated aluminium toxicity (Hutton and Andrew 1978). By comparison, the pH of black earth cores remained steady at *c.* 6.6, while the pH of the peat cores, which were highly acid initially, increased to a level known not to inhibit nodulation (S. Ruaysoongnern 1984, personal communication).

It is clear that growth of leucaena seedlings in infertile acid soils will be improved by the use of cores of a fertile medium to promote earlier nodulation. Brewbaker and Hutton (1983) noted that the transplanting of seedlings raised in plastic dibble tubes (12.5 × 30 cm) is standard practice for establishing leucaena forests. In Australia, there may be scope for contract planting of large areas using forestry planters. Further work is required to determine the optimum size of cores and age of seedlings for transplanting.

REFERENCES

BREWBAKER, J. L. and HUTTON, E. M. (1983)—Leucaena: versatile tropical tree legume. *In* "New Agricultural Crops". (Ed. G. A. Ritchie), pp. 207–259. (American Society of Advanced Science: Washington).

HUTTON, E. M. and ANDREW, C. S. (1978)—Comparative effects of calcium carbonate on growth, nodulation and chemical composition of four *Leucaena leucocephala* lines, *Macroptilium lathyroides* and *Lotononis bainesii*. *Australian Journal of Experimental Agriculture and Animal Husbandry* **18:** 81–88.

LESLEIGHTER, L. C. (1985)—Adoption of *Leucaena leucocephala* (Lam.) de Wit in Central and South-East Queensland. Master of Agricultural Studies Report, Department of Agriculture, University of Queensland.

NORTHCOTE, K. H. (1979)—"A Factual Key for the Recognition of Australian Soils" (4th Ed.). (Rellim Technical Publications: Glenside, South Australia).

OLVERA, E., WEST, S. H. and BLUE, W. G. (1982)—Establishment of *Leucaena leucocephala* in acid soils. *Leucaena Research Reports* **3:** 84–85.

RUAYSOONGNERN, S., SHELTON, H. M. and EDWARDS, D. G. (1984)—The influence of lime, combined nitrogen supply and *Rhizobium* strain on growth, nodulation and nitrogen status of *Leucaena leucocephala* cv. Cunningham. *In* "The Seventh Australian Legume Nodulation Conference". (Eds. I. R. Kennedy and L. Copeland), Australian Institute of Agricultural Science Occasional Publication No. 12, pp. 21–22.

THOMPSON, C. H. (1958)—The soils of the C.S.I.R.O. Beerwah experimental area, coastal lowlands, south-eastern Queensland. C.S.I.R.O., Australia, Division of Soils, Divisional Report No. 15/57.

(Accepted for publication, December 2, 1985)

TECHNICAL NOTE

THE POTENTIAL FOR PERSISTENCE OF SAFARI KENYA WHITE CLOVER BY SEEDLING REGENERATION

H. PHILPOTTS

Agricultural Research Centre Wollongbar, N.S.W. 2480
Present address: 'Bundilla' Wollongbar, N.S.W. 2480

ABSTRACT

Seed set, soil seed reserves, germination and seedling survival of Safari Kenya white clover (Trifolium semipilosum) *were followed in a grazing experiment at Wollongbar in* *northern New South Wales. Recordings were made over a three year period in kikuyu* (Pennisetum clandestinum) *and carpet grass* (Axonopus affinis) *pastures being grazed by cattle at two stocking rates. Seed set was affected by grazing pressure, while soil seed reserves were greater under carpet grass than kikuyu and reflected the previous year's seed set. High seedling numbers were associated with high seed reserves but tended to be less at greater pasture dry matter levels. The highest germination occurred each year at the initial germination flush in late summer. Seedling survival increased from about 10% to about 60% for germinations in February and May respectively.*

INTRODUCTION

Under subtropical conditions, where survival over summer can be adversely affected by a range of factors such as high temperature, drought, excess rain, diseases favoured by high humidity, pest attack and competition from vigorous grasses, white clover (*Trifolium repens*) tends to act as an annual (O'Brien 1970). An alternative to white clover is Kenya white clover (*T. semipilosum*), especially cultivar Safari, which is more drought tolerant than white clover (Mackay 1973) and has better stolon persistence over summer (Jones and Jones 1982). However, adverse conditions can still cause the content of this clover in the pasture to reach low levels.

Studies on white clover have found that there is a marked decline in stolon numbers over the summer and that seedling regeneration and survival is an important factor affecting spring production and persistence (Jones 1980). Factors likely to affect regeneration from seed include good seed production, survival of that seed in the soil, its subsequent germination at times conducive to seedling establishment, and seedling survival. Although these attributes have been studied for white clover under subtropical conditions (Jones and Evans 1977; Jones 1980) little is known of them for Safari. Hence the present study was initiated, and seed set, seed reserves in the soil, germination and subsequent seedling survival of Kenya white clover cv. Safari under several grazing systems are reported.

METHODS

The study was undertaken at Wollongbar (Lat. 28°50′ Long. 153°25′ Elev. 160 m) on a krasnozem soil on an established grazing experiment with cattle at two stocking rates (3.2 and 4.7 steers ha^{-1}). The pastures were kikuyu (*Pennisetum clandestinum*) and carpet grass (*Axonopus affinis*) into which *Trifolium semipilosum* cv. Safari had been oversown two years previously. The Safari clover established well in the carpet grass but less well in the kikuyu. Its respective yield at the commencement of this study was 368 and 276 kg ha^{-1} in the two grasses respectively. Of the six paddocks used for the study, two of kikuyu and two of carpet grass received a high rate of 660 kg ha^{-1} of superphosphate each year, and two of kikuyu a low rate of 220 kg ha^{-1} of superphosphate each year. All received 200 kg ha^{-1} of muriate of potash and 200 g ha^{-1} of sodium molybdate at establishment and 200 kg ha^{-1} and 50 g ha^{-1} respectively after three years.

At the height of flowering in August 1980 and September 1981 an estimate of the seed set was made. In 1982 and 1983 no estimates were made as only sparse flowering occurred over a prolonged period due to close grazing of the clover caused by dry conditions. Seed set was determined by counting flowering heads in fifty 25 × 25 cm quadrats thrown at random in each paddock and by collecting at random twenty mature heads and counting the number of flowers per head and number of seeds per pod. Seed set was then calculated as seeds m^{-2}.

Soil seed reserves were measured in early winter each year from 1980 to 1983 using the method of Jones and Bunch (1977). Three samples, each of twenty-five 2.5 cm diameter cores to 5 cm depth were taken from each paddock.

In 1981 and 1983 after the first flush of germination in February, seedling numbers were counted in fifty 25 × 25 cm quadrats thrown at random in each paddock. This was repeated in March 1983 when there was further germination. The counts were made as soon as germination had occurred. In 1982 when there was continuous wet weather during summer no flush of germination occurred.

To follow seedling survival seedlings were ringed, while still at the cotyledon stage, with fine plastic covered wire within two fixed (0.5 × 0.5 m) quadrats per paddock. Twenty seedlings per quadrat were marked after the initial flush of germination in 1981 and 1983. In 1981 more seedlings were marked in March, April and May–June, but in 1983 after the initial flush there were insufficient new seedlings until May. Survival was recorded weekly for 20 weeks except for the May 1983 germination where recordings terminated after 15 weeks.

RESULTS

Seed set was higher under low grazing pressure in the two years this was measured but grass effects were reversed from 1980 to 1981 (Table 1). Soil seed reserves fluctuated widely from a low 791 seeds m^{-2} under heavily grazed kikuyu in 1981 to 8827 seeds m^{-2} under lightly grazed carpet grass the same year (Table 1). They were generally higher under carpet grass than under kikuyu and there was a tendency for them to be higher under the low rather than the high stocking rate but this was not consistent. They were also higher in 1982 following the heavy seed set in 1981 (Table 1). Hard seed content was greater than 95% in each seed lot when recovered (data not presented).

TABLE 1

Seed set, soil seed reserves and seedling populations of Safari Kenya white clover in summer grass pastures

Attribute	Month & Year	Accompanying species and stocking rate			
		Kikuyu		Carpet grass	
		High	Low	High	Low
Seed set (*seeds m*$^{-2}$)	Aug 1980	220	1,769	10,893	14,871
	Sep 1981	8,658	23,595	5,187	6,396
Soil seed (*seeds m*$^{-2}$)	Jun 1980	1,702	1,054	6,871	4,013
	Jun 1981	791	1,558	6,767	8,827
	Jun 1982	4,094	7,773	8,163	8,582
	Jun 1983	2,525	1,764	3,382	8,025
Seedling population (*plants m*$^{-2}$)	Feb 10 1981	12	16	227	234
	Feb 28 1983	47	8	242	140
	Mar 24 1983	6.0	0.4	13.5	15.0

Seedling numbers were consistently higher in carpet grass than in kikuyu even in March 1983 when only 13 to 15 seedlings m^{-2} were present in carpet grass (Table 1). Although stocking rate effects were not consistent there was a trend for better germination under heavier grazing in 1983 (Table 1).

Seedling survival from late summer/early autumn germinations declined rapidly in both years with only between 10% and 20% of seedlings reaching a well established stage (Fig. 1a and b). The best survival was from germinations in May to June being 66.6% in 1981 after 20 weeks and 54.5% after 15 weeks in 1983. However, few seedlings emerged after the main early flush.

There were no effects of grass species or stocking rates on survival.

DISCUSSION

The lower seed set at the higher stocking rate can be accounted for by the more severe grazing of the clover at the time of the main flowering of the Safari clover (August) when feed on offer is low. The reverse effect of grass species on seed set in 1980 compared to 1981 is a reflection of the different amount of clover in the grass pastures

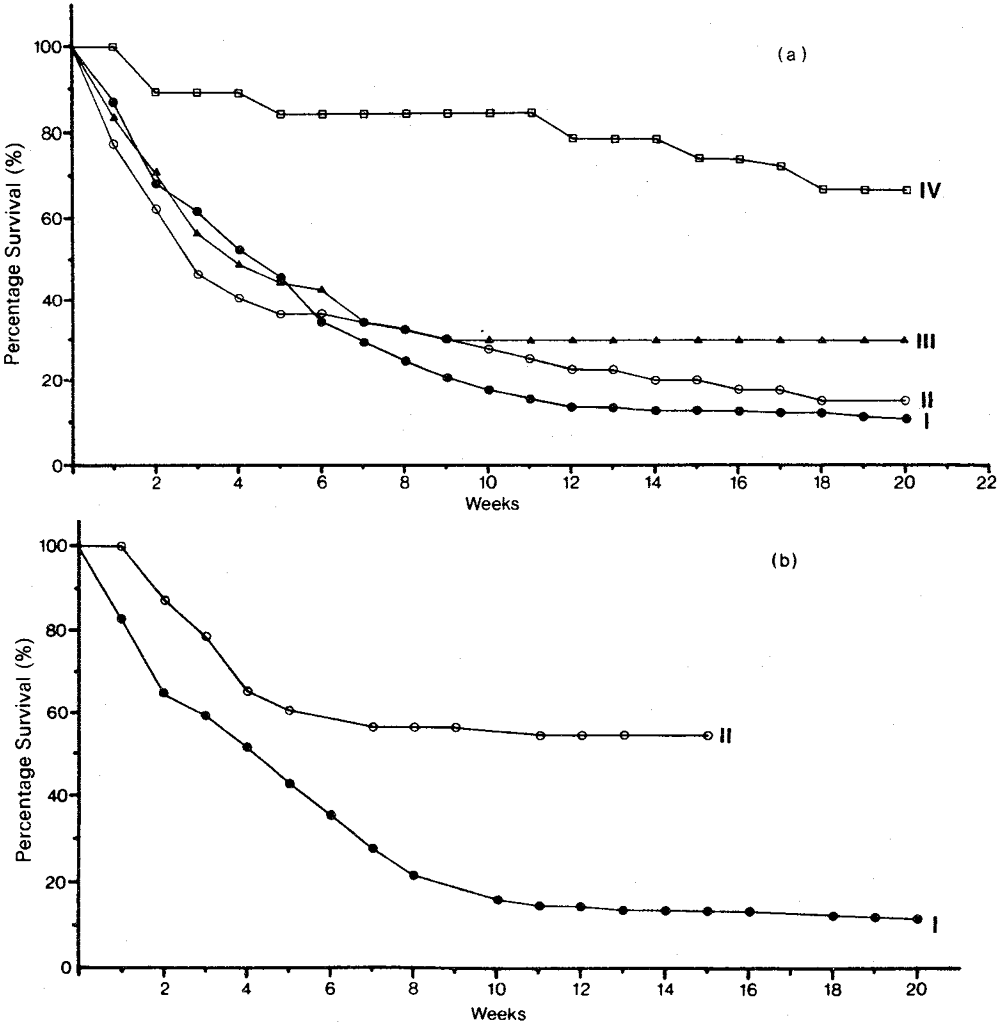

FIGURE 1

The percentage survival of Safari Kenya white clover seedlings from germinations at different dates in (a) 1981—I, February 10; II, March 3; III, April 8; IV, May–June, and (b) 1983—I, March 1; II, May 17.

in the two years. In 1980 the presentation clover yield in August was 368 kg ha^{-1} in carpet grass and 276 kg ha^{-1} in kikuyu whereas in 1981 the corresponding yields were 261 kg ha^{-1} and 447 kg ha^{-1} (K. R. Helyar, unpublished data). Growth of Safari was particularly good in kikuyu paddocks at the low stocking rate in 1981 (538 kg ha^{-1}). The highest calculated seed set, 23 600 seeds m^{-2} (= 340 kg ha^{-1}) is close to measured yields which have been harvested (up to 400 kg ha^{-1}) (Mackay 1973).

Soil seed reserves seem to be influenced by the previous year's seed set and previous seed reserves, with the former having the greater influence. After the good seed set in 1981 soil seed reserves increased under kikuyu, when measured in June 1982, but with very little flowering in 1982 seed reserves in 1983 had decreased substantially (Table 1). The same occurred in carpet grass at the high but not the low stocking rate. Soil seed levels between 8,000 and 8,400 as found in pastures by Jones and Jones (1982) are of a similar order to those found in some paddocks in this study.

Seedling population differences in 1981 can mostly be accounted for by the amount of seed set and soil seed reserves the year before. However for 1983 one would have expected good germination in the kikuyu pasture as seed reserves were high in 1982, but this did not occur. Heavy growth of kikuyu in 1983 may have been responsible because the yield of kikuyu in February to March was in the order of 2700 kg ha^{-1} while that of carpet grass was only 480 kg ha^{-1} (K. R. Helyar unpublished data). No seedlings were found in heavy growth of kikuyu.

In 1981 there was little effect of stocking rate on germination, but in 1983 clover seedling numbers were higher in both the carpet grass and kikuyu pastures at the higher stocking rate. The finding of Jones and Jones (1982) of a negative relation between seedling numbers and grass yield probably explains these data. This is also supported by field observations of the densest germinations occurring in areas of sparse grass, particularly on bare soil patches in closely grazed carpet grass stands.

The low germination after the initial flush could be due to the remaining hard seed needing a prolonged softening period or specific conditions for softening.

The rapid decline in seedling numbers during the first few weeks after germination was observed to be mainly due to insect attack. The insects responsible were various small green caterpillars and small grasshoppers. However, as some slugs were also present they probably accounted for some losses. Death due to diseases such as damping off was rare and moisture stress was not a major factor. These findings differ from those of Jones (1980) for white clover where in south-east Queensland seedling losses were mainly related to unfavourable moisture conditions and pests were not important. The different time of germination of Safari clover (February–March) compared to white clover (June–August) could explain this discrepancy.

The number of seedlings surviving in a pasture depends on the number germinating and the time of germination. Although much higher survival results from late autumn germinations the number of seedlings emerging at this time is low, so the final contribution to the pasture is probably smaller than from the early germination. With germination in late summer of about 200 seedlings m^{-2} and 10% survival then 20 plants m^{-2} would remain, but in late autumn with perhaps as few as 15 seedlings germinating and 60% survival there would be only 9 plants m^{-2}.

The sparse population resulting from seedling regeneration would be slow to build up to a desirable clover content. Hence, survival of a high number of established plants and stolons is needed to give more regular clover production.

However, long term persistence will ultimately depend on an adequate number of new plants to replace losses, and management practices to ensure high seed set and favourable conditions for germination should be the aim. Heavier grazing during summer to reduce the amount of grass seems necessary for good regeneration and, by reducing grass competition, should result in a better clover stand for seed production in late winter. The avoidance of overgrazing in late winter is needed for high seed set.

ACKNOWLEDGEMENTS

I wish to thank Dr. K. R. Helyar for the use of paddocks of his experiment, for supplying data and for constructive comments on the manuscript.

REFERENCES

JONES, R. J. and JONES, R. M. (1982)—Observations on the persistence and potential for beef production of pastures based on *Trifolium semipilosum* and *Leucaena leucocephala* in subtropical coastal Queensland. *Tropical Grasslands* **16**: 24–29.

JONES, R. M. (1980)—Survival of seedlings and primary taproots of white clover (*Trifolium repens*) in subtropical pastures in south-east Queensland. *Tropical Grasslands* **14**: 19–22.

JONES, R. M. and BUNCH, G. A. (1977)—Sampling and measuring the legume seed content of pasture soils and cattle faeces. C.S.I.R.O. Australia, Tropical Agronomy Technical Memorandum No. 7.

JONES, R. M. and EVANS, T. R. (1977)—Soil seed levels of *Lotononis bainesii, Desmodium intortum* and *Trifolium repens* in subtropical pastures. *Journal of the Australian Institute of Agricultural Science* **43**: 164–166.

MACKAY, J. E. (1973)—Register of Herbage Plant Cultivars. 1. Clover. *Trifolium semipilosum* Fres. var. *glabrescens* Gillet (Kenya white clover) cv. Safari. *Journal of the Australian Institute of Agricultural Science* **39**: 274–276.

O'BRIEN, A. D. (1970)—White clover (*Trifolium repens* L.) in a subtropical environment on the east coast of Australia. Proceedings of the XI International Grassland Congress, Surfers Paradise, Australia. pp. 165–168.

(Accepted for publication, December 3, 1985)