ENVIRONMENTAL FACTORS INFLUENCING THE ESTABLISHMENT AND GROWTH OF *ACACIA NILOTICA* AND *PROSOPIS PALLIDA*

M.J. Barker[A], W.J. Dorney[B], A.M. Lindsay[B] and J. Vitelli[B]
[A] 29 Meredith Street, Banyo, Queensland 4014, Australia
[B] Tropical Weeds Research Centre, Department of Natural Resources, PO Box 189, Charters Towers, Queensland 4820, Australia

Summary Influence of soil type and water regime on the establishment and early growth of *Acacia nilotica* (prickly acacia) and *Prosopis* (mesquite), and depth of burial and mulch on emergence of mesquite were studied. Results indicate that soils must have at least a moderate water holding capacity to allow substantial establishment and growth. In such soils (a loam and a clay) additional water improved growth of both species although it did not necessarily increase establishment.

Emergence of *P. pallida* seedlings was greatest from seed buried at 2 cm and least from seed at 5 cm depth. A grass mulch cover improved emergence only for the first two months of observations. Implications for further investigations and management are considered.

INTRODUCTION

Invasion of Australia's northern rangelands by exotic woody species threatens both commercial and ecological values of these areas (March 1995). *Prosopis* spp. (mesquite) are declared weeds in all mainland states and *Acacia nilotica* (L.) Willd. ex Del. (prickly acacia) (Ross 1979) is declared in Queensland and the Northern Territory.

Acacia nilotica was originally introduced as a shade tree to the Mitchell Grass Downs in Queensland. *Prosopis pallida* (Willd.) Kunth (Parsons and Cuthbertson 1992) was also planted for shade and amenity throughout northern and western Queensland. More recently, particularly since cattle replaced sheep on many properties in the 1970s, stock movement has played a major part in the spread of both species (Mackey 1996, Parsons and Cuthbertson 1992).

Mackey (1996) has stated that *A. nilotica* prefers heavy soils. Both *A. nilotica* and *P. pallida* are most commonly found on such soils in Australia, but can establish on a wide variety of soil types (March 1995, Parsons and Cuthbertson 1992). Information from both Australia and overseas suggests that both species are most likely to thrive in arid to semi-arid climates (March 1995, Mackey 1996, Parsons and Cuthbertson 1992). None-the-less their establishment and development is favoured by soil water levels above those experienced in most years in the rangelands, and dense infestations are found in wetter locations.

Present distributions of the two species may be determined as much by past history and management as edaphic and climatic factors. If this is so they may be able to thrive in soil and climatic zones beyond those where they are currently most abundant. Apart from a source of seed, the major factor influencing establishment of these weeds appears to be the availability of soil water (Brown and Archer 1990, Mackey 1996, Parsons and Cuthbertson 1992). This, in turn, is a function of water provided to the soil, the texture and structure of the soil, and location of seed and roots in the soil.

The two preliminary studies reported here examine the influence of soil type, applied water and position of seed in the soil, on emergence, establishment and growth of seedlings.

MATERIALS AND METHODS

The two experiments were undertaken at the Tropical Weeds Research Centre, Charters Towers, Australia. Charters Towers has a semi-arid tropical climate (Anon. 1970, Parkinson 1986) with an average rainfall of 657 mm falling predominantly in summer (Willcocks and Young 1991). As is general in the region, rainfall is extremely variable (Willcocks and Young 1991).

Experiment 1 This experiment was conducted between 4 March 1994 and 6 May 1994. Seedling establishment and early growth of *A. nilotica* and *P. pallida* were measured under six treatments representing all combinations of three soils (SCL, HC and CS, Table 1) and two watering regimes. The HC was a self-mulching clay with an approximate 15% swelling potential when saturated; the other soils exhibited little or no swelling upon wetting. The water regimes were natural rainfall only (Table 2), and natural rainfall plus 1 litre per pot per day of additional tap water supplied by a drip irrigation system – equivalent to approximately 10 mm of additional precipitation. Each treatment was replicated 10 times.

Pots (36 cm internal diameter by 30 cm deep) were filled with unsieved soil to minimize disturbance of soil structure. The top 4 cm of the pots was left unfilled and three fresh, healthy, scarified seeds were sown at a depth of 1 cm in each. Pots were placed at random in the open on a 20 cm, level pad of coarse sand, and the space between them was filled with sand to within 5 cm of the top of each pot.

The number of seedlings which emerged, seedling survival, height, basal diameter and leaves per plant were noted at the intervals indicated in Figure 1. With the large soil volume there was likely to be little competition between plants at this early stage of growth.

At the end of the experiment soil was carefully washed from the roots. Top and root dry weights (50°C), tap root length and top height were measured. Results were analysed using analysis of variance.

Experiment 2 This experiment ran from 25 July to 2 December 1994. Pots similar to those used in Experiment 1 were filled as in that experiment with a cracking light-medium clay (LMC, Table 1) which was free of *P. pallida* seed. Thirty fresh and apparently health seeds of *P. pallida*, with initial viability of 73%, were sown per pot, either during or after filling, depending on the treatment. Treatments were:

1. Seeds spread evenly on the soil surface.
2. As for 1, with a 2 cm layer of dry mitchell grass mulch over the seeds.
3. Seeds spread evenly over the soil then buried by a further 2 cm of soil.
4. As for 3 but seeds buried at a depth of 5 cm.

Each treatment was replicated five times. Pots were randomly positioned in a glasshouse. Water was provided by a rainfall simulator which delivered 25 mm of 'rain' each week as a single fall. Temperatures in the glasshouse ranged from 20–35°C. Thus conditions were similar to those commonly experienced over summer at Charters Towers.

Seedlings which emerged each week were counted, then cut off at the soil surface. Results were analysed using analysis of variance.

Table 1. Soils used in Experiments 1 and 2.
a) physical properties[A].

Texture	Infiltration ($mm\ m^{-1}$)	% water (v/v)	air filled porosity (%)
	at field capacity		
sandy clay loam (SCL)	9.4	22	32
heavy clay (HC)	0.051	45	6
coarse sand (CS)	10.0	9	25
light medium clay (LMC)	0.23	39	24

[A] Descriptions according to McDonald *et al.* (1990).

b) chemical properties[A].

Soil	chemical			
	P (Colwell) $mg\ kg^{-1}$)	organic C %	K meq 100 g^{-1}	Ca
SCL	8	0.52	0.32	12.9
HC	11	0.31	1.06	36.6
LMC	2	0.1	0.08	1.25
LMC	25	0.61	1.33	49.4

[A] Analyses undertaken by CSBP Laboratories.

Table 2. Natural rainfall (mm) at Charters Towers during 10 day periods from 4 March 1994.

period (days)							
-10 to -1	0 to 10	11 to 20	21 to 30	31 to 40	41 to 51	51 to 60	61 to 63
55.5	58.5	1.2	0	0	0	0.8	2.5

RESULTS

Experiment 1 Establishment of plants was defined as the proportion of seedlings which survived to the date of measurement as a percentage of seeds sown (Figure 1). Effect of soil type on establishment of both species was highly significant ($P<0.0001$ for survival to 60 days). Neither species established in the sand (CS) without supplementary water, and only 13% (17% of *A. nilotica* and 6% of *P. pallida* at 60 days) established with additional water Differences between establishment on the clay (HC) and loam (SCL) were not significant, although there was a possible trend ($P=0.09$) for supplementary water to reduce establishment in the HC.

Too few plants survived in the CS for meaningful measurements to be made of their subsequent growth. Results of measurements on plants in the HC and SCL are illustrated by dry weight comparisons in Figure 2.

For all measurements except tap root length there were significant differences between species ($P<0.01$). *Prosopis pallida* plants were, on average, 30% taller than *A. nilotica* plants. Effects of soil type and water on growth of both species was either significant ($P<0.05$ for shoot dry weight, tap root length and ratio of top to root length) or showing a possible trend ($P<0.1$) similar to the significant effects (Figure 2). Supplementary water increased growth in the SCL, and reduced it in the HC for both species. It appeared that growth of *P. pallida* was less adversely affected than *A. nilotica* by supplementary watering of the HC, but this interaction was not significant. Supplementary water increased the dry weight of tops relative to roots for *P. pallida.*

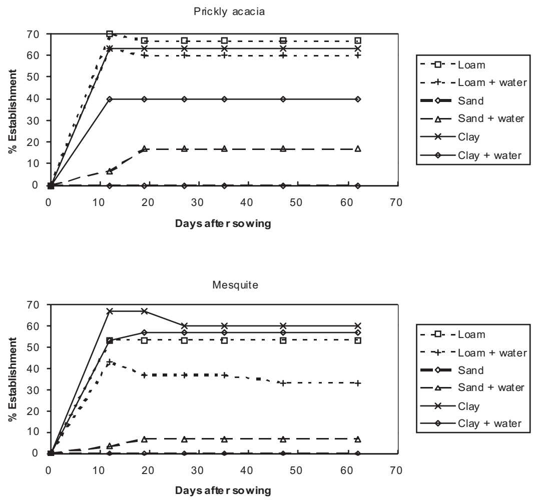

Figure 1. Effects of soil type and watering on establishment of *A. nilotica* and *P. pallida* seedlings.

Experiment 2 Unmulched surface soil was visibly dry to a depth of approximately 2 cm a week after each watering. Below this, soil in contact with seeds was maintained near field capacity after the initial 2–4 waterings.

Seed buried at 2 cm had the highest, and that buried at 5 cm the lowest percentage emergence throughout the period of observations. Early emergence of surface sown seed was improved by the mulch cover, but this effect disappeared after two months.

DISCUSSION

The effects of soil type on establishment and growth of both species (Experiment 1) could relate to three factors – differences in nutritional status, availability of water and aeration. While the nutritional status of the CS was very low, the SCL was also generally poorer nutritionally than the HC. Results show no indication that either species was influenced by differences in soil nutrient status. Both *A. nilotica* and *P. pallida* grow on soils with widely varying fertility, suggesting that this is not usually a major factor determining their growth.

Aeration would not have limited growth in the CS; it can be concluded that inadequate available water was responsible for failure of plants to establish in that soil.

Many workers (e.g. Greenwood 1968, Willoughby and Willatt 1981, Lindsay 1995) have shown that terrestrial plants are likely to have reduced growth where air-filled porosity is less than 10%. This situation pertained at field capacity with the HC. With its very low saturated hydraulic conductivity (as inferred by its low infiltration rate), the HC would have been wetter than

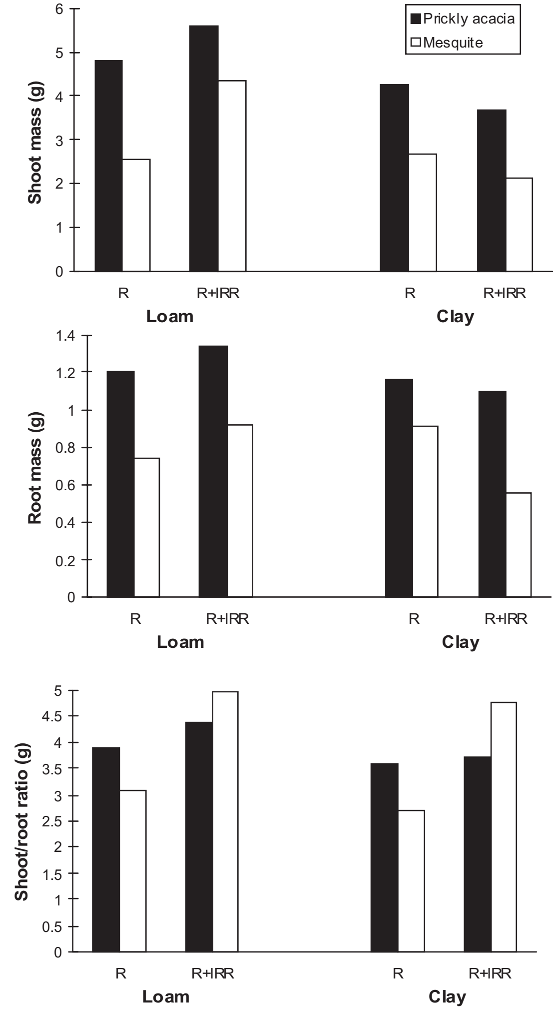

Figure 2. Effects of soil type and watering on the growth of *A. nilotica* and *P. pallida* seedlings at harvest.

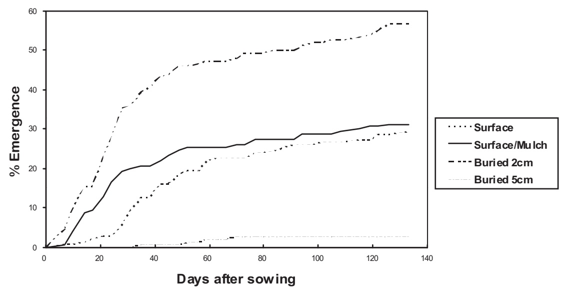

Figure 3. Emergence of *P. pallida* seedlings after sowing at 0, 2 and 5 cm depths, with and without grass mulch.

field capacity for much of the experiment. In the SCL plants could take advantage of supplementary water without the harmful effects of poor aeration, and so grew better in that soil.

Without supplementary water growth was at least as good in the SCL as in the HC. Although these plants, and particularly *A. nilotica*, are most commonly found on the heavy soils of the rangelands, these results suggest that soil type would not restrict their spread to lighter soils in areas of higher rainfall. Indeed, for soils which are less prone to waterlogging, these species could well benefit from a greater rainfall.

Further work is needed to establish the water holding characteristics of soils where these weeds occur. This will indicate where there is a risk of substantial weed establishment after particular rainfall events.

Early emergence data for *P. pallida* seedlings suggest that seeds on the soil surface (Experiment 2) retained too little water from up to three (weekly) rainfall events for more than a few seeds to germinate. With more prolonged, regular rain there can be substantial emergence from surface seeds (40% of viable seeds). These conditions would only occur infrequently, but could lead to particularly high establishment rates from surface seed. A grass mulch presumably reduced drying of the surface soil and thus helped to promote germination to some degree. However, in the field such a mulch would usually be thin or absent.

Shallow burial of seed (2 cm in this study) provided the best conditions for both early and sustained emergence of *P. pallida* seedlings. This is presumably because seeds and young seedlings were placed in contact with moist soil after only small amounts of rain, and seedlings did not need to expend large amounts of energy to emerge from the soil. Shallow burial can occur readily in self-mulching soils. As *Prosopis* spp. pods are voraciously sought by stock, native herbivores and feral animals, much viable seed also ends up effectively buried at a shallow depth in dung (Simpson 1977, DeLoach 1979). How the wetting and moisture retaining properties of dung compare with a LMC deserves investigation. Ingestion of pods and the self mulching properties of many rangeland soils are likely to ensure that *P. pallida* seed is located ideally to take advantage of moderate or prolonged summer rain.

ACKNOWLEDGMENTS

The Meat Research Corporation for financial support of the studies and Shane Campbell, Tropical Weeds Research Centre, for assistance with statistical analysis and formatting of the text.

REFERENCES

Anon. (1970). 'Queensland resources series, Burdekin-Townsville Region. Climate'. (Department of National Development and Commonwealth Government Printer, Canberra).

Brown, J.R. and Archer, S. (1990). Water relations of a perennial grass and seedlings vs. adult woody plants in a subtropical savanna, Texas. *Oikos* 57, 366-74.

DeLoach, C.J. (1979). 'Mesquite, a weed of south western rangelands: A review of its taxonomy, biology, harmful and beneficial values, and its potential for biological control'. Report to USDA, Temple, Texas.

Greenwood, D.J. (1968). Root growth and oxygen distribution in soil. *Trans, 9th International Cong. Soil Sc., Adelaide* 1, 823-31. (ISSS/Angus and Roberts, Melbourne).

Lindsay, A.M. (1995). 'Effects of soil compaction on early growth of forest species in south eastern Australia'. Ph.D. Thesis, La Trobe University, Melbourne.

March, N. (ed.) (1995). 'Exotic woody weeds and their control in north-west Queensland.' (Queensland Department of Lands, Brisbane).

Mackey, A.P. (ed.) (1996). 'Prickly acacia (*Acacia nilotica*) in Queensland: Pest status review series – Land Protection Branch'. (Queensland Department of Natural Resources, Brisbane).

McDonald, R.C., Isbell, R.G., Speight, J.G., Walker, J. and Hopkins, M.S. (1990). 'Australian soil and land survey: Field handbook', Second Edition. (Inkata Press, Melbourne).

Parsons, W.T. and Cuthbertson, E.G. (1992). 'Noxious weeds of Australia'. (Inkata Press, Melbourne).

Parkinson, G. (1986). 'Atlas of Australian resources, third series, Volume 4, climate'. (Division of National Mapping and Commonwealth Government Printer, Canberra).

Ross, J.H. (1979). 'A conspectus of the African acacia species'. (Botanical Research Institute, Department of Agric. Tech. Serv., Republic of South Africa).

Simpson, B.B. (ed.) (1977). 'Mesquite: Its biology in two desert ecosystems'. (Dowen, Hutchinson and Ross Inc., Stroudsburg, Pen.).

Willcocks, J. and Young, P. (1991). 'Queensland's rainfall history'. (Queensland Department of Industries Publication, Brisbane).

Willoughby, P. and Willatt, S.T. (1981). Penetration of pea radicals into saturated soil cores related to organic matter amendment. *Aus. J. Soil Res.* 19, 342-53.