

ESTABLISHING TREES TO CONTROL SERRATED TUSSOCK (*NASSELLA TRICHOTOMA* (NEES) ARECH.)

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Abstract Eight experiments set down between 1995 and 1998 in the southern tablelands and the Monaro NSW examined the establishment of *Pinus radiata* and *Eucalyptus viminalis* in serrated tussock (*Nassella trichotoma* (Nees) Arech.) infested areas. Successful establishment of *P. radiata* and *E. viminalis* from direct drilling was obtained in, respectively, 75% and 87% of sowings compared to 37% and 50% of sowings from aerial sowing. Mean establishment from planted seedlings was 69% for *P. radiata* and 46% for *E. viminalis*. The major factor limiting establishment from direct drilling and aerial sowing was competition from annual grasses and broadleaved weeds in the winter and spring after sowing. Control of serrated tussock in the 3.7 years after sowing varied from 80% to 99%. This was achieved by excluding grazing animals from the experiments which resulted in volunteer plants smothering regenerating tussock seedlings. Results suggest that direct drilling and planted seedlings can yield sufficiently reliable results for the establishment of trees to control serrated tussock but more research is necessary before aerial sowing is sufficiently reliable.

INTRODUCTION

At present serrated tussock (*Nassella trichotoma* (Nees) Arech.) infests 1.02 million ha in Australia and is forecast to spread to 32 million ha unless stringent control methods are taken in the near future (McLaren *et al.* 1998). However control of serrated tussock (*Nassella trichotoma* (Nees) Arech.) on non-arable hill country (308,000 ha in NSW) using introduced pastures, the most effective control method, is not profitable in areas of low/medium rainfall and low/medium soil fertility (Vere *et al.* 1993). At present producers endeavour to restrict the spread of the weed on non-arable land by aerial application of herbicide which is only a short-term measure as reinfestation generally occurs within 5 to 10 years. Establishing trees is a long term solution that will also preserve the environment. *Pinus radiata* has been used to control serrated tussock in NSW. The trees were established by conventional planting of seedlings. By using aerial sowing or direct drilling large areas of the weed could be sown to trees more quickly and at a lower cost than by planting seedlings.

Therefore experiments were set down between 1995 and 1998 to compare the effectiveness of establishing *P. radiata* and *Eucalyptus viminalis* by aerial sowing, direct drilling and planting seedlings on non-arable land infested with serrated tussock. The aims of this paper are to report on the reliability of the three methods of sowing and to discuss the factors that influenced the results.

MATERIALS AND METHODS

Two experiment sites were chosen in situations representing the major areas of serrated tussock infestation in NSW; one near Tuena in the north of the southern tablelands and the second on the Monaro. Both sites had soil of low fertility and the respective annual rainfall was 726 mm and 457 mm. Ten experiments were set down near Tuena and two on the Monaro. This paper reports on 6 experiments near Tuena and 2 on the Monaro where *P. radiata* and *E. viminalis* were sown in winter into unburnt serrated tussock that had been sprayed once to kill weeds.

Herbicides were applied to kill serrated tussock and other weeds with a hand-held pneumatic sprayer prior to sowing trees. Tree seeds and seedlings were sown in 4x5 m plots arranged in randomised blocks with 3 to 5 replications. Seeds were treated with permethrin to reduce losses due to ants. The aerial sown seed was hand broadcast on unploughed land. The direct drilled seed was sown into drill runs 15 cm wide scalped with a mattock and the seedbed firmed by walking on the furrows after sowing; *P. radiata* seed was sown 2.5 cm deep and *E. viminalis* seed was sown on the disturbed soil surface.

Mycorrhiza in litter gathered from under existing *P. radiata* trees was top-dressed on the soil surface of aerial and direct drilled *P. radiata* treatments, at respectively, 7 and 3.5 t dry matter ha⁻¹. Seedlings were planted by digging a hole 15 cm deep, planting the seedling, firming the soil and watering once, immediately after planting.

All experiments were fenced to prevent animals from gaining access. Rainfall was recorded at the respective sites.

Table 1. Summary of effect of method of sowing on establishment of *E. viminalis* and *P. radiata* in experiments where seeds and seedlings were sown in winter into unburnt serrated tussock after one herbicide treatment to kill weeds.

Experiment	Years after sowing	Establishment of trees from:					
		Aerial sowing (trees 10 m ⁻²)		Direct drilling (trees 10 m ⁻¹ drill run)		Planting seedlings (% establishment)	
		<i>E. viminalis</i>	<i>P. radiata</i>	<i>E. viminalis</i>	<i>P. radiata</i>	<i>E. viminalis</i>	<i>P. radiata</i>
1. 1995 - Tuena	3.7	13.0	6.5	59.5	13.5	90	100
2. 1996 - Tuena	2.7	0.4	0.2	4.2	0.4	54	81
3. 1996 - Monaro	2.3	1.9	23.1	10.0	14.4	6	81
4. 1996 - Monaro	2.3	0.0	0.0	0.0	0.0	0	42
5. 1997 - Tuena	1.6	2.9	0.0	2.9	5.4	50	55
6. 1997 - Tuena	1.7	0.3	0.0	6.6	8.0	49	31
7. 1998 - Tuena	0.8	6.3	3.5	7.2	32.0	not sown	not sown
8. 1998 - Tuena	0.7	0.0	0.3	2.8	13.8	70	91
% successful sowings		50	37	87	75	12	50

RESULTS AND DISCUSSION

A summary of the results of the experiments carried out in this project is given in Table 1. A higher percentage of "successful" establishments was obtained from direct drilling than for aerial sowing or planting seedlings. *E. viminalis* appeared slightly more successful than *P. radiata* from aerial sowing and direct drilling but the reverse was the case for planted seedlings. For aerial sowing and direct drilling successful establishment was defined as >1 tree 10 m⁻² (population necessary for *P. radiata* to control serrated tussock) and for planted seedlings successful establishment was defined as >80%. The major factors controlling establishment appeared to be method of sowing, weed competition, time of sowing, and seedbed preparation.

Method of sowing

Aerial sowing and direct drilling Of 8 sowings made over 3 years in this project from 75% to 87% were successful from direct drilling compared to 37% to 50% from aerial sowing (Table 1). The density of trees that established from direct drilling was higher than from aerial sowing (Table 1). Therefore where the terrain allows, direct drilling would be a more reliable method of establishment than aerial sowing. However as 65% of the land infested with serrated tussock in NSW occurs on non-arable land it would be convenient if tree establishment could be reliably achieved from aerial sowing.

Planted seedlings The low establishment of planted seedlings of *E. viminalis* in this project (Table 1) was

due to poor quality seedlings (tall and etiolated; supplied by State Forests of NSW) in experiments 5 and 6 and to the unsuitability of this species to the Monaro environment (experiments 3 and 4). Low establishment of *P. radiata* was due to the supply of poor quality two year-old seedlings in experiments 5 and 6. One year-old seedlings planted in an unreported experiment at Tuena in September 1997 had 87% establishment compared to 31% and 55% for 2 year-old seedlings in experiments 6 and 5. Two year-old seedlings were sown because they were the only seedlings available from State Forests of NSW in June. Dry conditions in summer and autumn reduced establishment of both species.

Control of competition

Aerial sowing and direct drilling: Weed control in the first winter and spring after sowing was the major factor on which successful establishment depended. This conclusion agrees with many, e.g. Bird *et al.* (1990). Selection of sites where weed competition will be low, eg, areas that have never been sown with introduced species or top-dressed with fertilizer, could be a major factor in improving the chances of successful establishment of trees. However such sites are rare and generally trees will have to compete with weeds during establishment.

The weeds that caused most losses in this project were annuals that established with the trees in winter and grew during the first spring. Seedlings trying to establish after aerial sowing were at most risk from weeds

because there was no reduction in numbers of weed seeds as there was in direct drilling where the scalped drill run 15 cm wide removed most weed seeds with the displaced soil.

Efforts to control these annual weeds included spray-topping in spring, burning, spraying immediately before sowing and pre- and post-emergence herbicides. Spray-topping to control the most competitive weed, *Vulpia* spp., was essential. Burning in late winter-early spring achieved better weed control than spray-topping as weeds other than annual grasses were also killed. In experiment 1, a mean of 2.3 m² *E. viminalis* established on burnt treatments compared to 1.1 m² on unburnt treatments 3.7 years after sowing (Campbell and Nicol 1998b). Spraying immediately before sowing was essential but rarely eliminated weeds for long enough for the tree seedlings to survive competition in spring. This treatment would be successful if all weeds germinated in response to the seasonal break before spraying and the herbicide was effective in killing these weeds. Rarely did all weeds germinate before spraying and glyphosate was ineffective in killing all *Vulpia* spp. Use of the pre-emergence herbicide atrazine to remove *Vulpia* spp. was effective when sowing *P. radiata* but could not be used when sowing eucalypts. Post-emergence herbicides (hexazinone + atrazine for *P. radiata*; terbacil + sulfometuron methyl for *E. viminalis*) used in experiments 6 and 8 did not assist tree establishment because the rates used to kill the weeds had deleterious effects on establishing tree seedlings. Glasshouse experiments have shown that tree seedlings will tolerate low rates of these post-emergence herbicides (Campbell and Nicol 1998a). Whether these low rates will be sufficient to control weeds and assist tree establishment will be tested in the field in 1999.

Planted seedlings: In all experiments weed control with herbicides in the year trees were sown was essential for maximum establishment. Planted seedlings were far better able to compete with weeds and to withstand the rates of pre- and post-emergence herbicides necessary to kill weeds than seedlings from aerial sowing or direct drilling.

Time of sowing The experiments were sown in winter to take advantage of the high probability of receiving effective rain (a mean of 94% in each winter month). This follows the accepted practice of aerial sowing pasture species in winter which has been in operation in NSW for the past 30 years (Campbell 1963, Campbell *et al.* 1996).

Aerial sowing and direct drilling: Results showed that trees could establish in winter from aerial sowing and direct drilling (Table 1). Establishment from aerial sowing depended on obtaining rain with no long dry periods during the period of radicle entry into the soil. For example, higher establishment was obtained in 1998 from aerial sowing in July (3.2 trees m² meaned for both species; experiment 7) than from sowing in late May (0.4 trees m²; experiment 8) because the former had 7 consecutive dry days in the month after germination occurred compared to the latter with 13 consecutive dry days in the month after germination; the respective rainfall was 95 mm and 149 mm.

Because establishment from direct drilling is less subject to dry conditions than from aerial sowing, direct drilling could be successful over a wider range of times and thus not restricted to winter.

Planted seedlings: Establishment of planted seedlings was favoured by planting in early rather than in late winter because of the greater time for roots to grow to depth before dry periods in following summers and autumns. Results from experiment 2 demonstrated this with establishment from the June sowing being inferior to that of the August sowing in the year of establishment (49% June, 61% August) but after 2.7 years the June sowing had the higher establishment (38% June, 26% August).

Seedbed preparation

Aerial sowing and direct drilling: In experiment 1 establishment of aerially sown and direct drilled *E. viminalis* was favoured by a bare soil surface (5.2 trees m² on burnt, 3.7 m² on unburnt) whereas establishment of *P. radiata* was favoured by litter on the soil surface (0.5 m² on burnt, 1.2 m² on unburnt) (Campbell and Nicol 1998b). This results reflects the size of the seed; *E. viminalis* being small with a small radicle unable to enter the soil even through small amounts of litter. *P. radiata* has a large seed which needs the protection from desiccation during germination and radicle entry provided by dead plant litter.

Planted seedlings: A seedbed of dead serrated tussock leaves on the soil surface favoured the establishment of planted seedlings because the leaves conserved soil moisture and controlled weeds.

Control of serrated tussock Ground cover of serrated tussock that had regenerated from seed in the soil 3.7 years after spraying and sowing trees in experiment 1 was 20%. In the other experiments ground cover of serrated tussock was <1% in the 0.7 to 2.7

years after spraying and sowing. Regeneration of serrated tussock was retarded by volunteer annual grasses and broadleaved plants that established after spraying and sowing in response to the exclusion of grazing animals. These volunteers could be assisted by applying subterranean clover (*Trifolium subterraneum* L.) seed and fertilizer once the trees had attained sufficient height to withstand competition for light.

Landholders may be able to afford to establish trees on small areas of their properties but large scale plantings can only be funded by public intervention in the weed control process. Jones *et al.* (1999) have economically assessed this situation and have concluded that on low rainfall-low soil fertility country, the socially optimal control option for serrated tussock is to retire the land from agricultural production and re-vegetate it with trees.

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