Research reports

Seed dormancy in serrated tussock (*Nassella trichotoma* (Nees) Arech.) in New South Wales

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Summary

Serrated tussock (*Nassella trichotoma* (Nees) Arech.) seeds harvested when mature in December 1994, 1995 and 1996, from two locations 50 km apart in New South Wales, Australia and stored in brown paper bags in light/dark in a laboratory, had dormancy periods of up to five months before normal germination occurred. This dormancy was broken to some extent by cutting off 0.4 mm of the awn end of the seed indicating that the covering structures on the seed were restricting germination. Dormancy was also partially broken by gibberellic acid + potassium nitrate and by cutting + gibberellic acid/potassium nitrate. Seeds stored in a laboratory for 2, 14, 24 and 34 years had, respectively, 88%, 0–7%, 0% and 0% germination.

Introduction

Research in New Zealand (Taylor 1987) showed that seeds of serrated tussock (*Nassella trichotoma* (Nees) Arech.) collected soon after maturation on the plant in December and stored in a laboratory had a period of dormancy of three months before normal germination commenced. For the purposes of this paper 'normal germination' is defined as germination of the majority of seeds (>50%) in 10–30 days after water is added to the seeds. Recently harvested South African seeds had a dormancy period of >3 years (Joubert and Small 1982). Australian seeds collected in February exhibited normal germination (60% in 20 days) in the following August (Campbell 1965).

No germination studies have been undertaken in Australia on serrated tussock seeds in the first five months after maturation. The study reported by Campbell (1965) showed that seed germinated without a dormancy period six months after collection. However dormancy could have been exhibited had germination tests been done in the preceding months. Because serrated tussock produces large numbers of seeds that are widely distributed by wind and large reserves build up in the soil (Healy 1945, Joubert 1984), the germination behaviour of these seeds would appear important when planning control strategies (Joubert and Small 1982). The aims of the four experiments in this paper were to examine the germination behaviour of seeds from Australian populations of serrated tussock in the initial months after maturation on the plant in the field and to compare these results with those recorded elsewhere.

Material and methods

Recently matured seeds of serrated tussock were harvested from two locations, Gallymont and Trunkey, in the central tablelands of New South Wales (NSW), and stored in fully elongated seedheads in brown paper bags in a laboratory at 17–25°C. Germination tests were conducted by removing the seeds from the seed heads with their awns attached and placing them in glass petri dishes. The seed of serrated tussock is a fruit almost completely enveloped by a hard lemma with a thin papery palea; it has a ring of silky hairs at the embryo end and a 2.5 cm awn at the other end. Two Whatman 1 filter papers and a germination pad were used in the dishes with 6 mL of deionized water. Tests were conducted in a laboratory at 17–25°C with 8 h light (100 µ $Em^{-2}s^{-1}$) during the day and 16 h dark at night. Seeds were coated with metalaxyl (Apron®) prior to testing to kill fungi and dishes were watered weekly. Observations were made at 3- to 10-day intervals depending on germination activity (at 3-day intervals when germination was fast and at 10-days when slow), for up to 330 days. In each experiment, 100 seeds were used per dish and three or four samples (not replicates) of each seed collection (treatment) were germinated in randomized block arrangements.

Experiment 1

Seedheads of serrated tussock containing mature seeds were collected from Gallymont NSW on 20 December 1994 and seed germinated after 3, 4, 5, 6, 7, 8 and 14 months storage in a laboratory. Germination was recorded for 130–330 days depending on the rate of germination of samples. Four seed samples were taken after each of the seven storage times and used in each germination test.

Experiment 2

To compare the effect of seed maturation in the laboratory, in the field and in an oven on germination, seeds from seedheads collected from Trunkey NSW on 12 December 1995, 16 December 1996 and 29 January 1997 were germinated after different intervals of storage and after different maturation treatments. Seeds from the December 1995 collection were germinated after 13 months storage and seeds from the December 1996 collection were germinated after one months storage and after 0, 1, 5, 10 and 20 days in an oven at 36°C. An open beaker containing water was added to prevent desiccation of the seeds. The 36°C temperature was chosen because it represented high summer temperatures and would not affect viability. Seeds from the January 1997 collection were germinated immediately on collection, i.e. after one months maturation in the field. Three samples from each seed source were germinated for 253 days.

Experiment 3

Seedheads of serrated tussock were collected from Trunkey NSW on 12 December 1995, placed in a laboratory and seeds germinated after 2, 4, 6, and 8 months storage. Four treatments were imposed: nil, gibberellic acid (GA) + potassium nitrate (KNO_3), cutting and cutting + GA / KNO_3. The GA / KNO_3 treatment was 0.14 mmole L^{-1} (48 ppm) GA + 1 mmole L^{-1} (101 ppm) KNO_3 (Young and Evans 1972) and was imposed once, at the start of the experiment. The cutting treatment was the removal of 0.4 mm of the awn end (opposite end to the embryo) of the seed with a scalpel after overnight imbibition. Four samples of each treatment were germinated for 64 days.

Experiment 4

Seeds of serrated tussock, collected from various sites on the central tablelands of NSW and stored in aluminium tins for 2, 14, 24, and 34 years were germinated after nil, cutting and GA / KNO_3 treatments (Table 1). Three samples of 100 seeds from each source were germinated over 53 days. Further samples of the seed sources used in this experiment were tested for viability by NSW Agriculture Seeds Laboratory using the tetrazolium test.

Statistical methods

Of the various non-linear functions fitted to the results of the experiments, the best fit for the results of experiments 1 and

3 was the exponential curve of the form

$$y = a + br^x$$

where x = number of days, y = percentage germination and a, b and r = estimated parameters. For experiment 2, the best fit was the generalized logistic function of the form

$$y = a + c/(1 + te^{-b(x-m)})^{1/t}$$

where a, b, c, e, m and t = estimated parameters; this function allowed for the delayed start in germination of the seeds with strong dormancy.

Results

Seeds of serrated tussock collected from two sites 50 km apart on the central tablelands of NSW in December 1994, 1995 and 1996 had an after-ripening requirement of up to five months before normal germination occurred.

In experiment 1, the curves expressing the germination data were compared using the statistical method outlined above and found to differ ($P<0.001$) between months ($R^2=96.1\%$). The seeds, collected from Gallymont NSW in December 1994, did not exhibit normal germination rate and capacity, as exhibited by 14 month-old seeds, until they were 6 months-old (Figure 1). Three month-old seeds germinated slower ($P<0.05$) than 4 and 5 month-old seeds which in turn germinated slower ($P<0.05$) than 6, 7, 8 and 14 month-old seeds (Figure 1). Data for all treatments in Figure 1 were extrapolated to 330 days.

In experiment 2, seeds collected from Trunkey NSW in December 1995 germinated normally after 13 months storage in a laboratory but strong dormancy, indicated by slower ($P<0.001$) germination than the 13 month-old seeds, was evident in seeds collected in December 1996 and stored in a laboratory for one month and treated for 0, 1, 5, 10 or 20 days in an oven at 36°C (Figure 2). Seeds left to mature in the field for one month also exhibited strong dormancy.

In experiment 3 dormancy was evident in seeds stored for two and four months after harvest. For these seeds, cutting and cutting + GA/KNO_3 broke dormancy by promoting ($P<0.05$) the rate of germination and increasing ($P<0.05$) germination capacity (Figure 3). GA/KNO_3 had little effect on the dormancy of 2 month-old seeds but broke dormancy in 4 month-old seeds (Figure 3). For seeds that had overcome dormancy by storage for six or eight months, GA/KNO_3 alone promoted ($P<0.05$) germination capacity of both whereas cutting had no effect on 6 month-old seeds but reduced ($P<0.05$) germination capacity of 8 month-old seeds. Cutting + $GA/KN0_3$ had no effect on the germination of 6 or 8 month-old seeds.

In experiment 4, 24 and 34 year-old seeds failed to germinate and had no viable seeds as indicated by the tetrazolium test (Table 1). Cutting or GA/KNO_3 had no effect in promoting germination of these seeds. Seeds of the three 14 year-old collections had low germination capacities despite the treatments imposed and the tetrazolium test indicating they had from 0 to 90% viable seeds. The 2 year-old seeds had a high germination capacity and high viability as determined by the tetrazolium test. The rate of germination of 14 year-old seeds was much slower than that of the 2 year-old seeds indicating a loss of seedling vigour with increasing age. Most of the 14 year-old seeds that germinated had plumule emergence but no radicle emergence.

Table 1. Effect of age on the viability and rate of germination of serrated tussock seeds collected from different sites in New South Wales after nil, cutting and GA/KNO_3 treatments.

Age (years)	Site	Germination (%) in 53 days			Rate (days to 50% of final)	Tetrazolium test (% viable)
		Nil	Cutting	GA/KNO_3		
34	Rockley	0	0	0	–	0
24	Mt. David	0	0	0	–	0
14	Mt. David	0	0.1	0	40	0
14	Rockley	4	1	2	30	35
14	Orange	2	0	7	39	90
2	Trunkey	91	83	90	6	96

Table 2. Degree of dormancy of serrated tussock seed from New South Wales, New Zealand and South Africa, after storage from 1 to 36 months, based on germination (%) in 40 days.

Experiment		Germination (%) after months of storage													
Location		1	2	3	4	5	6	7	8	9	12	13	14	24	36
NSW	1			1	19	28	31	40	25				45		
	2	1										54			
	3		0		30		52		49						
NZ[A]		10		76			74			71	60			44	
Sth. Africa[B]		2									4			6	9

[A] Taylor (1987).
[B] Joubert and Small (1982).

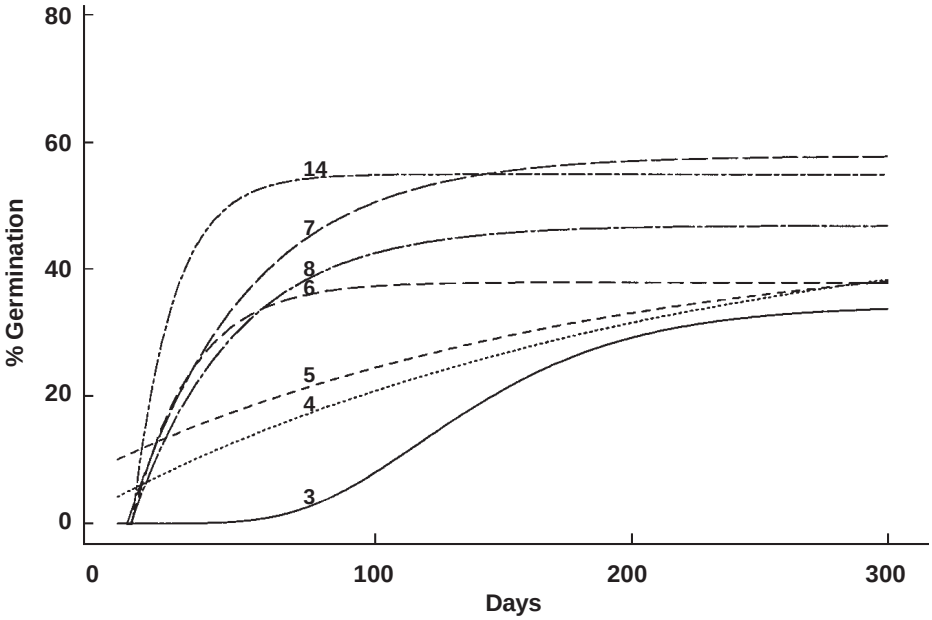

Figure 1. Effect of storage of serrated tussock seeds in a laboratory at 17 to 25°C for 3, 4, 5 , 6, 7, 8 and 14 months on germination.

Discussion

These experiments showed that serrated tussock seeds harvested when mature in December, from two locations 50 km apart in NSW and stored in a laboratory, had dormancy periods of up to five months before normal germination occurred.

Healy (1945) noted that germination in autumn in the field in New Zealand only included a small proportion of the current season's seed; most germination occurred from seed set in previous seasons. Campbell (1965) found no dormancy in seeds collected in NSW in February and germinated after six months storage in a laboratory. This resulted in statements (Campbell 1982, Campbell and Vere 1995) that seeds of serrated tussock did not appear to have a dormancy period which was incorrect. The correct conclusion from this germination test should have been that seeds stored in a laboratory for six months after collection (eight months after maturity on the plant in the field) were not dormant.

The dormancy period in NSW and New Zealand seeds differs markedly from the dormancy period in South African seeds (Table 2). In New Zealand, Taylor (1987) found normal germination began after three months storage whereas in South Africa, Joubert and Small (1982) found normal germination did not occur even after 36 months storage at temperatures ranging from 2 to 23°C (Table 2).

The difference could be explained by the South African seeds having a very long dormancy period in storage or by the fact that the South African seeds were stored in the dark in glass bottles with tight fitting screw caps whereas the NSW and New Zealand seeds were stored in paper bags in alternating light and dark or for a number of other reasons. It is unlikely that the South African seeds would have a >3 year dormancy in the field, because, if so, it would have a much slower rate of invasion in South Africa than in Australia. Wells and De Beer (1987) observed 'very rapid invasion of disturbed and overgrazed areas' in South Africa which is similar to the Australian experience.

The effects of cutting off the awn end of serrated tussock seed in breaking dormancy (Figure 3) agree with the results of Joubert and Small (1982) where they had a similar effect by removing covering structures on the seed. They showed that the inhibitory effect of covering structures, mainly the lemma, was not due to the restriction of the supply of oxygen or water but to the restriction of embryo expansion and outward diffusion of inhibitory substances. Cutting the awn end off seeds broke dormancy and promoted fast germination of seeds stored for two and four months in experiment 3 but few seeds germinated after the initial flush indicating that cutting may also damage the seeds and reduce germination capacity.

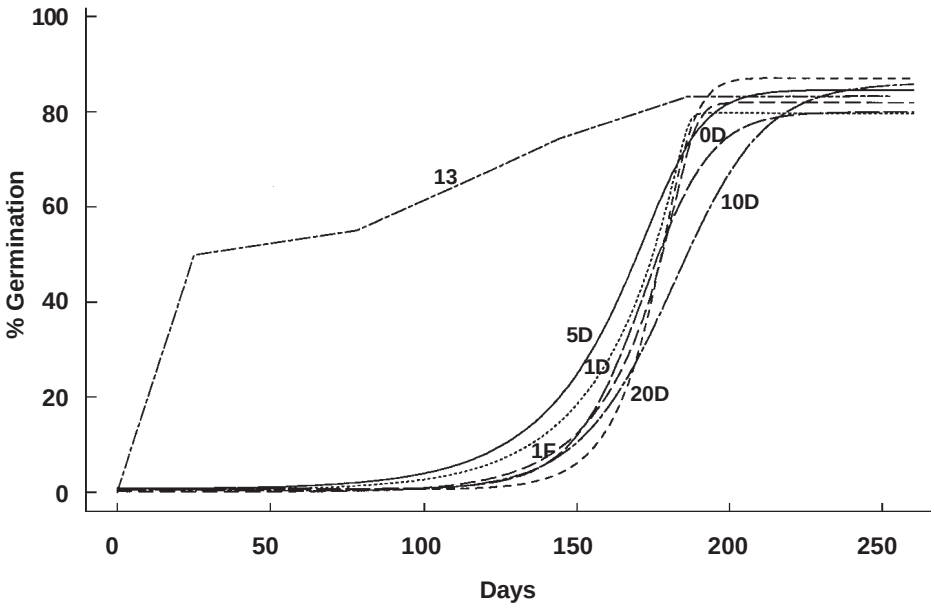

Figure 2. Effect of seed maturation in the laboratory, in the field and in an oven on germination of serrated tussock seeds collected from Trunkey NSW. Seeds collected on 12 December 1995 and stored in a laboratory for 13 months before germination (13); seeds collected on 16 December 1996, stored for 1 month in a laboratory and then germinated after 0, 1, 5, 10 and 20 days in an oven at 36°C (0D, 1D, 5D, 10D, 20D); seeds collected on 29 January 1997 and germinated immediately, i.e. after one months maturation in the field (1F).

As GA + KNO_3 broke dormancy in seeds stored for four months in experiment 3 (Figure 3) and because the action of GA + KNO_3 in breaking dormancy is attributed to a chemical substitution for light quality (Young and Evans 1972) it is possible that if the South African seeds used by Joubert and Small (stored in the dark) had been treated with GA + KNO_3 dormancy would have been broken in the five months after collection.

The period of up to five months dormancy allows serrated tussock seed in Australia to escape the hot dry months of January to March and germinate and establish in late autumn or winter when the probability of obtaining effective rainfall is much higher than in summer or early autumn in the central tablelands of NSW. Taylor (1987) arrived at a similar conclusion for New Zealand seeds.

Once the initial dormancy period is over, some seeds still remain dormant for long periods. For example, Healy (1945) found seeds collected on 5 December 1941 (length of storage before germination began not recorded) germinated over 800 days. This type of germination was explained on the grounds of varying degrees of permeability of the lemma (Healy 1945). Seeds of serrated tussock kept in a laboratory remained viable for 20 years (Healy 1945) whilst seed from soil in a forest that had no fresh seeds added for 13 years had a germination capacity of 8% (W.F. Leonard personal communication). In experiment 4, seeds kept in a laboratory for 24 and 34 years failed to germinate whilst 14 year-old seeds had a germination capacity ranging from 0 to 7%. It appears that the covering structures on the seed provide protection against destructive forces as well as prolonging the germination of serrated tussock seeds over very long periods which allows the weed to invade pastures in response to the negative influences of drought and overgrazing. Therefore, control can only be achieved by the annual removal of invading plants over a long period of time (Campbell 1985) or the selective removal from an introduced pasture by overall spraying in spring/summer with low rates of flupropanate (Campbell 1997) whenever massive seedling infestations occur.

Healy (1945) showed that treatment of serrated tussock seeds with a number of chemicals in the laboratory can reduce germination. However the most practical ways of stopping seed production are either to kill the plant by cultivation or herbicide application (Campbell 1985) or by applying low rates of glyphosate in the two to four weeks before the seedheads begin to emerge (Campbell *et al.* 1998). The latter treatment will not kill the plant but will reduce seedhead production by 91–99%.

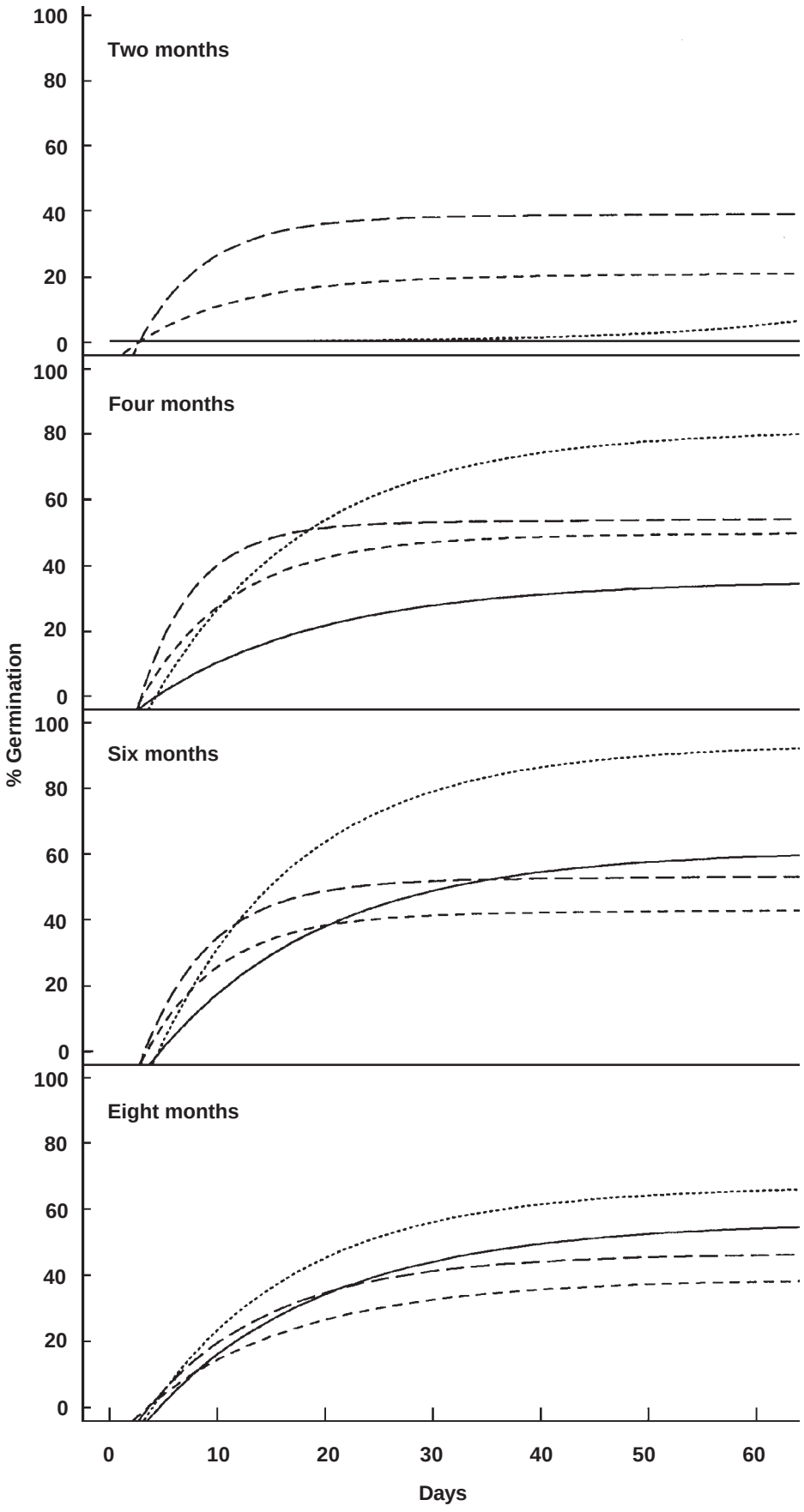

Figure 3. Effect of cutting off the awn end of serrated tussock seeds and adding gibberellic acid (GA) + potassium nitrate (KNO_3) on germination of seeds collected from Trunkey NSW on 12 December 1995 and stored for 2, 4, 6 and 8 months in a laboratory at 17 to 25°C: uncut - GA/KNO_3 (——); uncut + GA/KNO_3 (……); cut- GA/KNO_3 (------); cut + GA/KNO3 (——).

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