EFFECT OF FIRE ON GORSE SEEDS

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Summary

Quantitation of gorse (*Ulex europaeus*) seed in soil at five locations within New Zealand showed that an average reduction to 66% of the original numbers could be expected after a burn-off. Most seeds were in the top 6 cm but the viability of those undestroyed by fire was only slightly reduced. However heat could accelerate germination; temperatures below 100° were stimulatory, those above became lethal even after short exposures. The temperature of the germination medium markedly affected the germination rate and total numbers germinating.

INTRODUCTION

Fire is a well established, even essential, management procedure in forestry in New Zealand. In conjunction with chemical sprays one of its main applications is for pre-planting ground clearance in scrub or hill-country land which includes areas covered in gorse (Chavasse and Davenport 1973). In such a procedure it has been found (Zabkiewicz and Gaskin unpublished) that most of the gorse regrowth is from seed, not from stem sprouting. There has been only one previous attempt at determining gorse seed numbers in soil (Moss 1959) and there the objective was to establish viability with age. It was found that seeds could survive in the soil for up to 30 years and still be viable. In that event this presents a serious continuing problem to a forestry regime based on a rotation cycle of less than 30 years such as is frequently the case in New Zealand. One possible solution is a more thorough destruction of the gorse seed pool in the soil prior to planting. As the recommended land clearing method includes fire, its effectiveness in reducing seed numbers was examined critically.

To determine the direct effects of fire on gorse seed an assessment was made of the numbers, distribution in soil and residual numbers left in the soil after normal burn-off operations. A laboratory germination assay was also used to determine the viability of seeds not destroyed by fire and the germination response to specific heat treatments under controlled conditions.

MATERIALS AND METHODS

Sites

Soil samples were collected from the following districts: Northland (Waitangi Forest, April and May 1975; Puhipuhi Forest, February 1977); Rotorua (Glasgow Farm, March 1975); Nelson (Golden Downs Forest, March and April 1975); Canterbury (Ashley Forest, March 1975; February 1977; Southland (Herbert Forest, April 1975; November 1976; and March 1977).

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Soil sampling/seed extraction

Soil blocks (30 x 30 x 30 cm, or as close as practicable) were dug up from selected gorse areas either pre- or post-burn. These were sliced into 3 cm layers and the individual lots despatched to Rotorua for extraction. The top layer included litter where it was present. The soil was partly dried at ambient temperatures, gently crushed, then dry sieved (10 and 5 mm mesh size); the residue was washed over a 1.4 mm mesh sieve to retain the seeds which were then picked out by hand and counted.

Germination assay

Various methods were evaluated for rapid germination of gorse seed (Gaskin 1977), but the following technique was used in this work. A random sample of seeds was selected, a shallow slice of the seed coat removed with a scalpel (taking care not to cut into the embryo) and the scarified seed soaked in distilled water for 24 hrs at 20°C. The swollen seeds were removed from the water and coated with thiram dust in latex to prevent fungal decay.

A modified 'raft' system (Knight *et al* 1969) was utilised for the assay. This consisted essentially of gorse seed on terylene mesh cloth supported on polystyrene beads floating on water in separate dishes. This allowed a constant water supply and consequently more even germination. These units were kept at 16° - 17° C under fluorescent lighting for up to 2 months; 50 seeds (or as many as were available, at 25 per raft) were used for each assessment.

Effect of temperature on germination

Batches of dry gorse seeds were exposed to different temperatures for varying intervals either on trays in an oven or in linen bags immersed in a water bath. Subsequent germination tests were on rafts as described above.

RESULTS AND DISCUSSION

Soil blocks from different gorse areas before and after normal burn-offs were divided into appropriate layers and the gorse seeds extracted from each layer. The total numbers are shown in Table 1 which shows that numbers of seeds from each block vary widely both within and between sites. On pre-burn sites a maximum count of over 20 000 seeds/m² was recorded, with a mean of under 6 000 seeds/m² and values of between 100 - 1 000 seeds/m² considered as low. Post-burn numbers were reduced, namely a maximum count of 15 000 seeds/m², a mean of 3 600 seeds/m² and a greater frequency of low values. The seed numbers after a fire on these trial plots were reduced on average to 66% of the pre-burn values. There was considerably greater reduction in some situations such as the Southland trial, where less than 20% of the original seed remained after the burn-off.

Although soil cores were taken down to 30 cm depth, most of the seeds were found in the top 6 cm of the soil. This was clearly evident from the percentage of seeds in the top 6 cm (Table 1). The overall mean percentage of seeds found within this depth is 90%, regardless of the effect of fire. Hence, though fire can reduce the seed population substantially under normal conditions, at no time can complete seed destruction be expected.

However seed viability could have been affected by fire. Accordingly the viability of seed lots from each of these soil block layers was evaluated. Within the 126 separate seed lots from pre- and post-burn samplings, 113 gave 90-100% germination; 10 lots gave 80-90% germination and only three lots gave less than 80% germination. This

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TABLE 1: Individual soil block gorse seed numbers calculated on a m² basis from the five sampling regions.

District	Seed numbers/m ²			
	Pre-burn		Post-burn	
	Total	% in top 6 cm	Total	% in top 6 cm
Northland	133	83.5	15342	85.9
	2521	88.0	9065	91.8
	4344	64.4	1422	64.1
	10132	81.0		
Rotorua	Not available		4421	92.5
			14598	89.0
			8076	93.1
Nelson*	14054	83.3	799	97.2
	3255	90.8	1599	94.4
	1011	98.8	2588	97.9
	1466	97.0	3110	98.6
	722	95.3	1044	100.0
Canterbury	1966	75.7	44	0
	5666	75.7	1822	76.2
			1466	91.7
			4510	71.9
			1166	46.7
Southland	9932	93.7	2733	95.5
	10898	97.7	2766	78.7
	20742	95.0	866	83.4
	4032	89.9	300	62.7
	4399	90.9	66	83.3
	1677	95.3	1166	97.2
MEAN (standard error)	5446 (± 1364)	92.6	3589 (± 929)	87.9

* This data is abstracted from Holloway (unpublished).

showed that, of any seeds not destroyed by a fire, virtually all were capable of subsequent germination. The three low germination values were 66%, 20% and 33% respectively. The last result can be ignored due to the fact that only three seeds were available in that lot: similarly five of the ten lots which showed between 80-90% germination had only a few seeds for testing. However, all the remaining lower germination lots represented seed either in the top 3 or 6 cm from the soil surface and were from post-burn blocks. In other words, residual viability is only slightly affected. However it can be demonstrated that in a few favourable instances reduction of germination ability can be achieved as well as complete seed combustion. This seems to indicate that where a burn-off is properly conducted, there can be very considerable consumption and heat sterilisation of seed.

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The results of this assay showed that there was very little variation in the time taken for all seeds to germinate and little difference from the non-heat treated control seeds. However the temperature of the germination medium (water in the assays, soil in reality) did affect the rate and final numbers germinating. This effect is illustrated in Figure 1. Gorse seed was scarified, treated with thiram and its germination recorded at different temperatures using a temperature gradient table. In accordance with a previous literature report (Moss 1959) the optimum germination temperature was found to be around 16°C. There was however a marked reduction in the rate of germination with increasing temperature, as well as a reduction in the final numbers germinating. The reason for the latter effect was not determined, but eventual bacterial infection could have been a contributing factor.

90 germination of scarified seed
FIG 1: Effect of fire on gorse seeds.

Hence under field conditions germination would seem to depend on the ease of water uptake and soil temperature at the time of germination. This will have considerable practical implications. If chemical control of gorse seedling regrowth is desired after a burn-off, then chemical application times should be dependent on germination rates, and these in turn would depend on soil temperatures. Hence seasonal or regional differences in environment will ultimately determine the best chemical application times.

Although the information on the effects of fire on gorse seed under field conditions is of considerable use, its value is diminished, to some extent, because the actual temperatures required to produce seed sterility or cause germination enhancement are unknown. A series of controlled temperature trials were conducted in the laboratory to determine the effect of both dry and wet heat over periods that might be produced in the field during a burn-off. The results of these trials are presented in Table 2.

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TABLE 2: Effect of wet or dry heat pre-treatments on gorse seed germination rates and percentage. Controls were scarified but not heat treated, 50 seeds per treatment.

Temp./ treatment time (mins)	Days to final germination (%)	
	Dry Heat	Wet Heat
150° / 10	60 (4)	NA
5	60 (0)	NA
2	60 (2)	NA
1	60 (0)	NA
100° / 15	35 (84)	27 (2)
10	14 (88)	15 (16)
5	17 (96)*	27 (48)
2	19 (96)*	13 (90)
1	12 (98)*	27 (94)
80° / 30	12 (100)*	60 (98)
15	10 (100)*	27 (92)
10	10 (100)*	10 (90)*
5	14 (100)*	15 (94)*
2	21 (100)*	13 (98)*
1	NA	17 (94)*
60° / 30	10 (100)*	10 (98)*
15	17 (100)*	15 (100)*
10	10 (100)*	8 (100)*
5	12 (100)*	10 (100)*
2	NA	13 (100)*
Control	17 (100)	
	10 (100)	

* Signifies stimulation of germination equivalent to that produced by scarification. N.A. signifies no data.

Reduction of germination was not achieved until seeds were exposed to temperatures of 100°C or more: similarly the time taken to complete germination started to increase at the same temperatures. Virtually total seed sterilisation could be attained by pre-treatment at 150°.

On the other hand, all the treatments marked* gave enhanced germination, equivalent to that achieved by scarification. It is presumed that treatment of seed at 60°, 80° or even 100° for up to 5 mins permits accelerated water uptake equivalent to that from scarification i.e. complete fracture of the testa. It was also noticeable that wet heat became lethal at lower temperatures or shorter exposures than the equivalent dry heat treatment. Hence in field conditions a slower burn of less dry material would be more effective than a fast burn of dry material.

CONCLUSIONS

Gorse seed numbers vary widely within and between sites but at all times the vast majority of the seeds are in the top 6 cm of soil. Fire can reduce the number of seeds left, but at present either the techniques used or practical difficulties prevent the full application of this potential

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method of gorse seed elimination. Under ideal conditions seed numbers can be reduced to less than 20% of the original, as well as significantly reducing the viability of the unburned seeds.

The rate of seed germination after a fire is largely dependent on both the ability to take up water and the temperature of the medium. Appropriate heat treatment appears to enhance water uptake markedly, presumably by damaging the seed coat and making it permeable. However temperatures above 100° reduced germination and exposure to 150° for even a short time caused seed death.

These results show that more research on fire methods is required so that optimum conditions may be specified for consistent maximum seed consumption.

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REFERENCES

- Chavasse, C. G. R. and Davenhill, N. A., 1973. A review of chemical control of bracken and gorse for forest establishment. *Proc. 26th N.Z. Weed and Pest Control Conf.*: 2-6.
- Gaskin, R. E., 1977. Standard methods of gorse propagation from seed and cuttings. Unpublished, *Forest Res. Inst. Tree Physiology Internal Report No. 3*.
- Knight, B. E. A., Taylor, H. F. and Wain, R. L., 1969. Studies on plant growth regulating substances XXIX. *Ann. Appl. Biol.*: 63, 211-223.
- Moss, G. R., 1959. The gorse seed problem. *Proc. 12th N.Z. Weed and Pest Control Conf.*: 59-64.