FACTORS AFFECTING THE ESTABLISHMENT OF MANUKA (*LEPTOSPERMUM SCOPARIUM*)

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Summary

Experiments and observations in the Manawatu indicate that establishment of manuka is favoured by the production of large numbers of readily dispersed seed which are shed throughout the year. Peaks in seed shed occur in autumn and spring. The ability to germinate over a wide range of temperature must also have a positive effect on establishment.

Indications are that establishment is limited by the requirement of light for germination and by the action of increasing plant cover reducing seedling survival.

Despite unpalatability, the upright growth form of the species makes seedlings susceptible to grazing damage.

INTRODUCTION

MANUKA is one of New Zealand's most important weeds of unploughable infertile hill country. This plant is an indigenous shrub, characteristic of the early stages of succession to forest in a wide range of habitats (Cockayne, 1928). In the ten years prior to 1959-60, nearly 44,000 acres of unimproved grassland reverted annually to scrub, fern and second growth, of which manuka is a principal component. By 1959-60 the total area of reverted land in New Zealand was 5.67 million acres, 3.56 million being in the north Island (N.Z. Govt., Farm Production Statistics).

Control of manuka on unploughable hill country has been limited to pulling, cutting, or cutting and burning, depending on stage of growth. Chemical methods and standing burns have generally proven unsuccessful and most methods are expensive.

It is apparent that the prevention of reversion on most grassland must be a desirable aim and it has been postulated by Levy (1923, 1932, 1940, 1946) that establishment of manuka in pasture could be prevented by good farming techniques (*e.g.*, application of fertilizer where required, and controlled grazing). Current practical evidence supports this hypothesis (Suckling, 1959; Anon., 1963, 1964).

Few quantitative data exist on the more fundamental mechanisms controlling establishment in manuka and the influence that variations in farming techniques have on this process. To supply some of this information, a series of plot and field experiments were conducted during 1965-6 in the Manawatu.

RESULTS AND METHODS

The seed of manuka is borne in woody 5-valved capsules between 5 and 6 mm in diameter. In the autumn-winter period, 8,000 capsules have been found on a 10-year-old plant. Capsules contain from 240 to

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Fig. 1: The effect of season on seed shed.

470 seeds each, with the average around 300. Seeds are small and extremely light, with an average weight of 0.005 mg. Viable seed may be distinguished under a microscope by their creamy brown colour and plump appearance as compared with the darker brown, shrivelled, inviable seed. Results from seed collection tins spaced through a stand of manuka indicate that seed fall occurs throughout the year with a major peak rate of fall (50% of the year's total) occurring in the late winter-spring period and a minor peak in autumn (Fig. 1).

Week-old seedlings are normally less than 0.125 in. high. On medium fertility bare ground, six-month-old seedlings from seed sown in late winter average 6 in. high, while seedlings of the same age in low fertility pasture have a maximum height of 1.5 in. under conditions conducive to etiolation.

In germination tests carried out at 20°C under continuous light, the first cotyledons appeared on the fourth day after moistening and by the tenth day germination was complete. Germination averaged 19.05% ($d\ 0.1 \pm 3$). Comparison of these results with those of tetrazolium embryo viability tests indicates that there were no restrictions on germination as a result of dormancy mechanisms in these circumstances.

The influence of temperature on germination was studied over the range 4.5 to 32°C. Normal germination (about 19% $d\ 0.1 \pm 4$) occurred at 20°C and above but germination was reduced to about 14% ($d\ 0.1 \pm 3.75$) at temperatures below 20°C. Above 20°C, germination was complete in 9 days. At 15°C, 16 days were required, and at 4.5°C 43 days.

Darkness almost completely inhibited germination. Exposure of moistened seed to 1 minute per day of fluorescent light at about 100 foot-candles was sufficient to promote complete germination, although the time required for the process was increased to 16 days.

When viable seed was exposed in nylon mesh bags pinned to the soil surface, only 50% remained viable after two weeks and none after

TABLE 1: MEAN PERCENTAGE LIGHT PENETRATION TO GROUND LEVEL IN GRASS PLOTS TWO MONTHS AFTER MANUKA SEED SOWN

Applied Fertilizer Treatments		
None	Low	High
21.24 (13.71)	12.25 (4.86)	10.92 (3.96)
S.E. = ± 1.11		
d .05 (0.01) = 2.71 (3.75)		

Cutting Frequency Treatments		
Uncut	Monthly	Fortnightly
— (.009)	12.23 (5.24)	17.38 (9.78)
S.E. = ± 0.90		
d .05 (0.01) = 2.71 (3.75)		

Data transformed to arc sine $\sqrt{\%}$.

Figures in parentheses in main body of the table represent true means.

eight weeks. Of viable seed buried 1 to 2 in. in the soil in similar bags, 72% was still in a viable condition after 12 weeks.

The influence of season on the ability of fresh seed to germinate and survive on bare ground was tested by sowing seed each month on to bare plots and recording seedling appearance and survival. Germination occurred over 9 months of the year. The most favourable period was from July to September when there was a 16 to 30% establishment of seedlings. Relatively high rates (35%) of seedling appearance occurred in autumn but considerable mortality resulted from frost lift. From December until March germination was very low or did not occur.

Study of seedling appearance and survival was also followed in a hill pasture by monthly examination of permanent quadrats. A seasonal pattern emerged in which seedlings appeared in the pasture from June to December, with 75% appearing from September to October. By November, seedling numbers were as high as 200 per square foot, although such numbers were confined to within a few yards of the manuka stands.

To simulate the influence of management practices on germination and seedling survival, a randomized block experiment was set up in which known amounts of manuka seed were sown into bare and grassed (browntop, *Agrostis tenuis*) plots with different levels of applied fertilizer. The grassed plots were subject to various defoliation treatments to provide a greater range of cover differences than those from fertilizer alone. The effectiveness of these different treatments in providing a range of covers was estimated by taking light measurements 0.6 cm above ground level within the plots (Table 1). Irrigation was carried out to minimize differences of water stress between grassed and bare plots. The most significant features of this experiment (Fig. 2) were the demonstrations that, within two months from sowing:

- (1) The most frequently defoliated plots contained high seedling numbers.
- (2) Plots to which no fertilizer was applied contained high seedling numbers.
- (3) Where large numbers of seedlings did appear in grass plots, mortality was greatest where fertilizers had been applied.

- (4) In all cases low seedling numbers or high mortality rates were coupled with low illumination values 0.6 cm above ground-level (Table 1).
- (5) The most frequently defoliated grass plots contained more seedlings than bare plots.

Seedling counts on permanent quadrats in hill pasture also suggest that mortality is increased as herbage height increased when set-stocked ewes and lambs were removed from the pasture in autumn. However, the most significant reduction in seedling numbers in these pasture observations coincided with heavy mob stocking, first with sheep and then cattle, in the late autumn-early winter. Little damage to seedlings occurred under set-stocked grazing ewes and lambs.

Fig. 2: Manuka seedlings in grassed and bare plots two months after sowing.

DISCUSSION

It is apparent that establishment of manuka is favoured by the production of large numbers of very light seed which are shed throughout the year. The ability to germinate over a wide temperature range must also have a positive influence on establishment.

Because the seeds are light they are probably dispersed considerable distances by wind. Marshall (1962) recorded seedling ingress in a clean paddock up to half a mile away from the nearest manuka stand.

Although only 15 to 20% of seed produced is viable, the yearly production of viable seed by a manuka plant is larger when the number

of seeds per capsule and the large number of capsules per bush are considered.

The production of a large amount of viable wind-dispersed seed must result in a higher proportion of seeds reaching individual sites suitable for germination and seedling growth, so increasing the chance of establishment. This possibility is further increased when seed is shed throughout the year, because establishment may be able to occur in normally unfavourable seasons as the result of freak favourable conditions. It is noteworthy, however, that the peak seed falls occur when conditions are most likely to be suitable for germination. Year-round seed shed is particularly important in the establishment of a species in which the survival of shed seed on the soil surface for more than a few months is zero.

The ability of manuka seed to germinate at temperatures ranging from 4.5 to 32°C would suggest that in few periods of the year will temperature be limiting to germination. This was demonstrated experimentally when germination was found to occur throughout the winter both on bare plots and in pasture. Summer germination under both conditions was probably limited by low moisture levels in the environment surrounding the seed.

It is also apparent that establishment is favoured by low open cover, relative to establishment on bare ground. This is probably the result of a more sheltered microclimate under such cover. Temperature and moisture extremes are likely to be less but light penetration will still be high.

The results indicate that establishment of manuka would be limited by the requirement of light for germination, and by the effect of increasing amounts of cover reducing seedling survival. The demonstration that seedling survival under various degrees of cover was correlated with light penetration to ground level would indicate that light itself may have been limiting to seedling survival. However, the greater number of slugs and other macro-organisms observed under low light conditions could have been responsible for increased mortality.

Small initial size and subsequent slow growth of seedlings must account in part for reduced seedling survival under increasing amounts of cover.

Open habitats which seem most favourable for the establishment of manuka seedlings include low-fertility pastures where plants may be widely spaced and of low vigour, or where large amounts of moss may occur, providing a suitable substrate for manuka establishment because of a low growth habit and high moisture content. Such pastures may also contain flat weeds which, when grazed, leave a bare patch. Continued grazing of the surrounding plants will maintain these bare patches for considerable periods.

The upright growth habit of manuka must make the seedlings susceptible to grazing damage. Even although the seedlings may be unpalatable, the results suggest that a high proportion are nipped off or pulled out under heavy mob stocking, especially with cattle.

These results have implications in the prevention of reversion of unploughable grassland.

Because of the production of large numbers of readily dispersed seed, manuka plants should not be left alive within a development block. If possible, development should start on the windward side of large areas of scrub. Regrowth should be removed before it sets seed.

It is equally important that a vigorous sward be maintained over as much of the land as possible, thus preventing light reaching ground level.

On newly sown unploughable land, swards are very open and ideal for establishment of manuka. In the prior clearing operations, cutting manuka will cause the seed to be shed. Subsequent burning should destroy all manuka seed in the habitat, leaving no source of infection except from outside. However, if any manuka plants remain alive until burnt, their seed may survive the fire in the protection of the capsule (Burrell, 1963), to be shed in the ash. In a standing burn the amount of viable seed released after the fire may be large.

Manuka entering a pasture at this stage can only be controlled by grazing. Observations have shown that hard grazing in late autumn-winter, especially by cattle, will remove most seedlings. However, if carried too far into the winter, the pugging caused, especially by the cattle, can provide large areas of bare ground on which subsequent crops of manuka or other weeds will establish.

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