NO.8 EXPERIMENTS WITH BRACKEN IN NON-ARABLE PASTURE

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SUMMARY.

A relatively dense community of austral bracken (Pteridium esculentum (Forst.) Diels) is being subjected to some of the pasture improvement practices that are feasible on non-arable land. Results are assessed mainly in terms of numbers of regrowth fronds. Of the various translocated herbicides that have been applied, only 4-CPA, at 9 lb/ac (acid equivalent) has brought about significant reductions. Successful establishment of oversown species has not yet been achieved, but it is hoped to overcome this problem by the use of a "chemical ploughing" technique.

1. INTRODUCTION.

Reference is made elsewhere (Carnahan 1960) to the need for experimental studies of the effects of pasture improvement practices on weeds of non-arable land. The object of the present work is to help meet this need, by determining the effects of some of these practices on a dense infestation of bracken (Pteridium esculentum (Forst.) Diels). (Wakefield (1955) refers to this South Pacific species by the distinctive common name of "austral bracken".)

2. DESCRIPTION OF COMMUNITY.

The experiment is located at Robertson, N.S.W., in lat. $34\frac{1}{2}^{o}$S., at an altitude of about 2400 ft, and under a mean annual rainfall of about 60 in. The soil parent material is basalt. The original vegetation was rainforest, but this has been cleared, and replaced by pastures of introduced grasses and clovers, notably perennial ryegrass, cocksfoot, and white clover. As can be expected on non-arable land, some of these pastures are running out to such species as creeping fog (Holcus mollis), browntop bent (Agrostis tenuis), and sweet-scented vernal grass (Anthoxanthum odoratum). Bracken is the principal weed, and in some places it has replaced the pasture.

The actual experimental area was fenced off from stock and rabbits in August 1958. At that time, the vegetation within the fence consisted predominantly of bracken fronts. To describe the actual degree of infestation, and also to explain the experimental treatments, it is necessary to consider the details of the seasonal behaviour of this particular community.

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The experimental area was clean burnt in August 1958, and the numbers of new fronds were thereafter determined, at intervals of about one month, in 12 control plots, each of one milacre (10 lk x 10 lk). The first fronds of the season appeared towards the end of September, and the mean number per plot was about 6 by October 1, 1958. The mean then increased fairly steadily to over 70 by the end of December, after which the rate of increase eased off gradually until the maximum of 92 was reached in February 1959. Thereafter, the mean number of living fronds gradually declined to about 34 by the end of July. (At this point, the control plots were cleared, in preparation for observing the pattern of frond production for 1959-60. However, the ultimate fate of fronds produced in the 1958-9 growing season was followed through the winter and spring in another set of plots. The mean number of living fronds had fallen to about 10 by the end of October 1959, and to about one by the end of November, by which time the previous season's fronds had been swamped by the current season's.)

There was a similar pattern of frond production in the control plots in the 1959-60 growing season, except that the first fronds appeared at about the beginning of September, and thereafter the mean numbers of fronds per plot remained about a month in advance of the previous year's values, until a similar maximum was reached. In addition, during the 1959-60 season, counts were also made of the numbers of dead fronds. These first became noticeable at about the time of the frond maximum, and their rate of increase thereafter was found to be roughly comparable with the rate of decrease in the numbers of living fronds. This suggests that, where the community was undisturbed, there was little or no frond production after the maximum number per unit area had been reached.

However, frond production was made to continue later in other plots, by clearing these plots during the growing season. Where this was done, there was a tendency for the mean numbers of regrowth fronds to build up to a second maximum, equivalent to the maximum for undisturbed plots. Whether or not this maximum was actually reached, appeared to depend largely on the date of cutting, since regrowth ceased by about the end of April. Thus, plots cleared when frond numbers for the 1958-59 season were at a maximum had achieved about 60 per cent. regrowth by the time that growth ceased, while those cut three weeks later had only achieved about 10 per cent. regrowth.

When frond numbers were at a maximum for the 1958-9 growing season (as indicated by the control plots), the numbers of fronds were counted in each of the experimental plots. The mean number of fronds for the 152 one-milacre (10 lk x 10 lk) plots of the main experiment was found to be about 87. The standard deviation was about 25, and the

distribution of the plot counts about the mean was approximately normal. This information reflects the fairly even cover of bracken fronds over the experimental area. (It contrasts strongly, for example, with the negative binomial type of distribution that was obtained by Shimada (1958), using plots of similar dimensions.)

In both growing seasons, the average height of the bracken at the time of maximum frond numbers was of the order of 4 ft. By the time that the fronds reached maximum height and density for the season, the only persisting herbaceous species of any importance were waterpepper (Polygonum hydropiper), scrub nettle (Urtica incisa), and scattered spear thistle (Cirsium vulgare).

3. METHODS.

(a) Practices selected.

The plan of the initial experiments combined chemical treatment and pasture establishment.

In the absence of a recognized chemical treatment for bracken, it was necessary to anticipate one. For practical reasons, such a chemical must be able to translocate into, and injure, the bracken rhizome, when applied as a foliar spray. Among the promising substances were: p-chlorophenoxyacetic acid (4-CPA) (Matthews 1956); ammonium sulphamate (AMS) (Conway and Forrest 1956); 3-amino-1,2,4-triazole (amitrol) (West of Scotland Agricultural College 1957); "Killafern" (arsenic trioxide, formulated as sodium arsenite, with cresylic acid for penetrant) (Hart & Co. Pty. Ltd. 1957a, 1957b); and 2,2-dichloropropionic acid (dalapon) (Elliott and Fryer 1958). It was decided to test each of these at the recommended rate, and also at one-third and three times this rate. Sodium arsenite was to be applied with and without cresylic acid. The treatments were to be applied to the fronds when the lamina had unfolded fully, since it appears that translocated herbicides may be most effective against bracken at this stage of growth.

The pasture establishment factor of the experiment was to consist of oversowing a seeds mixture suited to the district, and fertilizing with superphosphate.

(b) Experimental design.

A randomized block design was used. There were 19 chemical treatments, namely: 4-CPA (as an experimental butoxyethanol ester formulation containing 40% w/v 4-CPA) at 1, 3, and 9 lb/ac acid equivalent; AMX (as "Lane's Nocweed

AS": 80% AMX) at 8.33, 25, and 75 lb/ac active ingredient; amitrol (as "Agserv Weedazol": 50% amitrol) at 5, 15, and 45 lb/ac a.i.; arsenic trioxide (with cresylic acid) (as "Hart's Killafern": 40% w/v As_2O_3) at 1.33, 4, and 12 lb/ac a.i.; arsenic trioxide (as "Penite-6 sodium arsenite solution": 113.5% w/v As_2O_3) at the same rates; sodium dalapon (as "Lane's Nocweed Dalapon": 85% sodium salt) at 5, 15, and 45 lb/ac a.i.; and a control.

Each treatment was applied with and without the previous sowing of a seeds mixture, to give a total of 38 treatment plots per block. There were 4 replications. Square plots were used, each with an area of one milacre (10 lk x 10 lk).

(c) Application of treatments.

It has already been noted that the experimental area was clean burnt in August 1958. In October 1958, the appropriate plots were broadcast with a seeds mixture at the rate of 25 lb/ac Victorian perennial ryegrass, 10 lb H1 short-rotation ryegrass, 10 lb S.26 Aberystwyth cocksfoot, 6 lb Mt. Barker subterranean clover, 4 lb N.Z. white clover, and 2 lb red clover (cowgrass). The clover seed was inoculated prior to sowing. The sown plots received superphosphate at the rate of 3 cwt/ac (including 2 oz molybdenum trioxide).

It had been intended to apply the chemical treatments when frond numbers reached a maximum for the 1958-9 growing season. This application should therefore have been made in February 1959 (according to the control plots). However, the weather at Robertson at that time of year proved to be even wetter than usual, with the result that it was not possible to apply the treatments until the last week of March and the first week of April. The chemicals were applied in aqueous solution (or suspension) from a knapsack sprayer. The concentration of each solution was based on a spraying rate of 125 gal/ac, or one pint/milacre.

(d) Assessment.

The first obvious effect of the chemical treatments was some degree of frond injury. This can be important, since too-rapid leaf damage by a herbicide may result in failure to translocate to other parts of the plant. Frond damage was therefore assessed at the end of April 1959. This was recorded for each plot as light (if less than one-third of the total foliage appeared to have been browned), moderate (one-third to two-thirds browned), or heavy (more than two-thirds browned).

The experimental area was again clean burnt in the winter of 1959, and the results of the treatments were assessed during the 1959-60 growing season, in terms of the numbers of new fronds in each plot. Two assessments were made, the first being in December 1959, and the second in February 1960, when frond numbers had reached their maximum for the season (according to the control plots).

4. RESULTS.

The foliar injury caused by the chemical treatments within a month of application is shown in Table 1. The foliage was in much the same condition at the end of May.

The results of the chemical treatments, in terms of numbers of fronds produced in the following growing season, are also shown in Table 1. The results for each chemical treatment are expressed as the adjusted means of the numbers of fronds that were recorded for each treatment plot in December 1959 and February 1960. Significant differences have been calculated by the methods of Snedecor (1956).

The results of the second assessment only, also show a probably significant effect for the sowing and fertilizing treatment. (Adjusted mean for sown plots, 86; for unsown plots, 92; 5% sig. diff., 4.5). This effect can hardly be due to the pasture species, since they never became properly established. The sowing and fertilizing treatment was repeated in September 1959 (while the treatment plots were clear after their second burn), but this was no more successful.

There were no significant interaction effects.

TABLE 1 - FOLIAR DAMAGE ONE MONTH AFTER CHEMICAL TREATMENT, AND ADJUSTED MEANS OF FROND NUMBERS PER TREATMENT PLOT IN SEASON FOLLOWING TREATMENT.

Chemical	Dosage (lb/ac)	Foliar Damage	Regrowth	
			Dec.1959	Feb.1960
4-CPA	1	light	66	84
"	3	light	58	81
"	9	moderate	43	60
AMS	8.33	light	70	90
"	25	moderate	61	80
"	75	heavy	75	105
Amitrol	5	light	64	91
"	15	light	70	96
"	45	moderate	63	88
As_2O_3 (cresylic)	1.33	moderate	62	85
"	4	heavy	68	88
"	12	heavy	67	82
As_2O_3	1.33	heavy	66	90
"	4	heavy	65	82
"	12	heavy	75	96
Sodium dalapon	5	light	79	98
"	15	light	73	99
"	45	moderate	77	107
Control	-	-	64	87
	5% SD		27	26

5. DISCUSSION.

The only reduction in frond numbers that appears to be of any significance is associated with the application in the previous season of 4-CPA at 9 lb/ac (acid equivalent). This finding is in accordance with results recently reported for the treatment of British bracken (Conway and Forrest 1959). The results as they stand may not appear to be of much practical importance, but it must be recognized that the application may have been too late in the season to give optimum results.

Two factors that may have been involved in the failure of the sown species are the total lack of cover at the time of sowing (following clean burns), and the probability that the plants did not have a chance to become properly established before they were subjected to strong competition from the new season's bracken fronds. However, although the sowings failed, the sowing and fertilizing treatment is associated with a probably significant reduction in frond numbers. If this is a real effect, it may be related to the 6 cwt/ac of superphosphate that has been applied to the sown plots.

6. CONCLUSION.

As far as chemical treatments are concerned, it may be desirable to concentrate of 4-CPA, as being the most promising. The effectiveness of this chemical might be enhanced by better timing of application, and possibly by the use of different formulations.

In view of the failure of the spring sowings, the question of autumn establishment of pasture species in non-arable bracken country requires further investigation. Autumn sowing calls for autumn clearing, and this must be delayed until frond regrowth is unlikely. Further, it is desirable that the fronds should have dried up enough by the autumn to carry a fire. If the fronds will not burn standing, they must be laboriously cut by hand, and left to dry before burning. This problem might be overcome by using chemical defoliation as a substitute for cutting. In fact, it may be possible to clear the bracken sufficiently by the use of a chemical defoliator alone, without subsequent burning. The sown species might become established more successfully in the resulting litter than on the bare ground that results from burning a dense stand of bracken. (Matthews (1959) has claimed that the effects of minor variations of climate on oversown seeds may be overcome if "chemical ploughing" has provided adequate litter.)

A promising chemical for this purpose is 1,1'-ethylene-2,2'-dipyridylium dibromide (diquat). In a preliminary trial, diquat was applied at 2.5 lb/ac at about the time of maximum frond numbers. This concentration gave a more or less complete frond kill within a month.

Finally, it may be desirable to check the effect of applying superphosphate by itself to the bracken community.

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