DALAPON RESISTANT INDIVIDUALS IN A SUSCEPTIBLE POPULATION OF CHILEAN NEEDLE GRASS

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SUMMARY

An area of Chilean needle grass (*Stipa neesiana*) was treated annually spring and/or autumn with dalapon to prevent the grass seeding. After 3 years of good control, two patches appeared where the plants failed to respond to treatment. Some of these flowering plants were collected from the field and tested for possible resistance to dalapon. Many were unaffected by dalapon at 6.0 kg/ha. Progeny from some of these plants were also tested for dalapon resistance and found to tolerate at least 12.0 kg/ha. Evidence suggests dalapon resistance is inherited and that the tolerance level of resistant plants is more than six times that of susceptible plants.

Keywords: herbicide resistance, Chilean needle grass, dalapon, *Stipa neesiana*.

INTRODUCTION

Chilean needle grass is a perennial grass, native to South America, and classified as a noxious plant in New Zealand, because of the potential for the sharp seeds to cause damage to stock. The grass is of limited distribution in New Zealand being found only in Western Springs (Auckland), Hawkes Bay and Marlborough (Bourdôt and Hurrell 1989). The Hawkes Bay infestation was originally believed to be limited to about 30 ha on seven properties near Waipawa where it had been present for about 30 years. Recently other small infestations have been found in Hawkes Bay (HB Noxious Plants Officers R. Hodgson and S. Bennie pers. comm.).

From research commenced in 1983 by the author, a control programme was established in 1988. Glyphosate proved effective in killing needle grass plants but the high seed burden in the soil led to rapid reinfestation of the newly sown pasture sward. However, dalapon proved very effective at preventing flowering and reduced seed production by 90-99% as well as reducing plant density (Hartley unpublished). It was decided to conduct a dalapon control programme to minimise seed production and thus reduce the soil seed bank before commencing an eradication/renovation programme. Dalapon was applied (generally at 2.2 kg/ha) spring and/or autumn depending on growth stage and weather conditions. In November 1990 after 2 years of apparently good control two isolated patches, about 4 and 20 m² of flowering Chilean needle grass remained in a treated paddock at Waipawa, initially believed to have been spray misses. When the same patches remained the following year, in spite of careful spray application, resistance was suspected and Chilean needle grass material was collected for investigation.

METHOD

Trial 1

Single tiller plants were collected in the autumn 1992 from turves cut from each of the two patches mentioned above, as well as from two other dalapon-treated areas and two areas where dalapon had not be used. Remaining soil from the turves was spread in seed trays and germinating seedlings collected. Two tiller plants and three seedlings from each turf collection were planted in each of 10 plots and two replicates of dalapon (Dowpon 740 sp) applied at 0, 1.0, 2.0, 3.0 or 6.0 kg/ha by precision boom sprayer in 200 litres/ha at 210 kPa in spring 1992. The number of panicles produced by each plant was recorded in November 1992.

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Trial 2

Seed was collected in December 1992 from three plants that were unaffected by 6.0 kg/ha and two plants unaffected by 3.0 kg/ha in Trial 1. These, together with seed collected from four new areas of the Waipawa site where Chilean needle grass was flowering after 4 years of dalapon treatments, and some old seed from untreated plants, were sown in seed boxes in a glasshouse in April 1993 and the resulting seedlings planted out in field plots during the winter.

Only five selections, three from single resistant plants and two from the Waipawa collections, germinated in sufficient numbers to screen. These were planted 1-4 per plot spaced 20 cm apart in rows across 1 x 2 m plots and treated with dalapon at 0, 0.75, 1.5, 3.0, 6.0 and 12.0 kg/ha, applied as before, replicated three times, in a randomised block design, in spring 1993. Panicles were counted and removed three times during November and December 1993 and data expressed as means for each family under each treatment.

RESULTS**Trial 1**

There was no difference in panicle production at various dalapon rates between the two selections from untreated areas so their data are combined in Table 1. Likewise the two lines from the resistant patches behaved similarly and are combined. The two lines from the other treated areas did not differ from "untreated" and are not tabulated. Seedling data are similarly combined and presented in Table 1.

TABLE 1: Tolerance of seedlings and transplanted Chilean needle grass plants to dalapon as measured by panicle production (one harvest - November 1992).

	Dalapon (kg ai/ha)				
	0	1.0	2.0	3.0	6.0
Plants from tillers from untreated areas					
No. plants	8	8	8	8	8
No. with panicles	8	8	6	2	0
No. panicles per flowering plant	18	37	11	5	
SEM	4	7	2	0	
Plants from tillers from areas treated with dalapon for 3 yrs					
No. plants	8	7	8	8	8
No. with panicles	8	7	8	8	7
No. panicles per flowering plant	19	25	17	23	20
SEM	4	4	2	5	4
Plants from seedlings from soil from untreated areas					
No. plants	12	11	12	12	12
No. with panicles	12	9	3	1	0
No. panicles per flowering plant	16	19	2	2	
SEM	2	4	1		
Plants from seedlings from soil under dalapon resistant plants					
No. plants	7	7	7	7	7
No. with panicles	5	7	1	1	2
No. panicles per flowering plant	7	19	3	17	7
SEM	2	3			2

Table 1 shows the number of plants, number flowering and the mean number of panicles produced by the flowering plants. Panicle production by tillers declined rapidly in the untreated susceptible plants as dalapon dose increased, whereas it did not change in the "resistant" plants over the dose range tested. Fig. 1a shows the percentage of plants, grown from tillers, that flowered. The SD_{50} (Suppressive dose at which 50% of plants will not produce panicles) for panicle production in the susceptible population was about 2.5 kg/ha dalapon whereas in the "resistant" population it was well above 6.0 kg/ha. Similarly, panicle production of susceptible seedlings declined rapidly with increasing dalapon dose (Table 1). The SD_{50} for panicle production of susceptible seedlings was about 1.5 kg/ha dalapon (Fig. 1b). Panicle production of seedlings from soil under "resistant" field patches was very variable. One plant produced 17 panicles after treatment with dalapon at 3.0 kg/ha and two flowered at 6.0 kg/ha.

Figure 1: Percentage of plants flowering in response to dalapon dose; a. tiller derived plants (Trial 1); b. seedling plants (Trial 1 & 2).
 * wild-type; ■ resistant; ◆ parent 1; ■ parent 2; ● parent 3.
 The upper plotted line on right is mean of all three single parent selections.

Trial 2

Table 2 shows panicle production from progeny of three single parent selections, where the parent was resistant, and two selections (data combined) collected from plants showing resistance in the field. Only at the highest rate of dalapon (12 kg/ha) was there any significant reduction in panicle number per flowering plant among the progeny of the single plants and there was no change between 1.5 and 12.0 kg/ha amongst the field collection. Progeny of Parent 2 had an SD_{50} for panicle production of about 9 kg/ha (Fig. 1b). The other single parent lines had SD_{50} s in excess of 12.0 kg/ha (Fig. 1b). The plotted line in Fig. 1b is the mean of the three single parent selections. The field collection from Waipawa showed no clear correlation with dose and is not plotted.

DISCUSSION

Repeated use of dalapon to prevent Chilean needle grass seeding appears to have induced or, more probably, selected for dalapon resistance in this species. Unfortunately only old seed from the untreated line was available in 1993 and this did not germinate well. Thus, no direct comparison can be made between resistant and susceptible progeny in 1993. Comparison, therefore, has been made between resistant seed lines in 1993 and susceptible seedlings in 1992. Panicles were only counted once in 1992 whereas they were counted and removed three times in 1993, thus counts in

1993 were substantially higher than in 1992. The SD_{50} for panicle production gives comparisons regardless of panicle numbers. Comparison of the SD_{50} for panicle production of susceptible seedlings tested in 1992 with the three single parent selections in 1993 indicate a minimum six-fold greater resistance but it may be much higher. Rates of dalapon above 12.0 kg/ha were not tested as these levels would be quite impractical in pasture situations. Plants with tolerance to dalapon above this rate can be considered resistant in an agricultural context. Seedlings from field collections, from the soil and field plants, showed a wide range of sensitivities to dalapon as would be expected in an unrelated population. The one-parent selections were far more uniform with few progeny failing to flower below the 6.0 kg/ha rate and most producing similar panicle numbers within their families.

TABLE 2: Tolerance of seedling Chilean needle grass to dalapon as measured by panicle production (three harvests November-December 1993).

	Dalapon (kg ai/ha)					
	0	0.75	1.5	3.0	6.0	12.0
Plants from seed of one plant from Trial 1 resistant to dalapon at 6 kg ai/ha						
No. plants	12	11	12	12	12	12
No. with panicles	12	11	12	11	8	7
No. panicles per flowering plant	70	50	39	32	42	12
SEM	10	6	7	7	9	3
Plants from seed of one plant from Trial 1 resistant to dalapon at 6 kg ai/ha						
No. plants	11	11	11	11	11	11
No. with panicles	11	11	10	10	8	4
No. panicles per flowering plant	40	40	36	35	35	17
SEM	8	9	6	7	6	5
Plants from seed of one plant from Trial 1 resistant to dalapon at 3 kg ai/ha						
No. plants	9	9	9	9	9	9
No. with panicles	9	8	9	7	8	7
No. panicles per flowering plant	55	46	27	36	43	9
SEM	8	8	8	8	7	4
Plants from seed of ca. 20 field plants flowering after 4 years dalapon treatment						
No. plants	15	15	16	16	16	16
No. with panicles	14	13	12	15	11	9
No. panicles per flowering plant	45	49	28	26	17	29
SEM	7	7	4	4	6	5

The few seedlings collected from soil under dalapon resistant plants in the field did not produce many panicles per plant in the absence of dalapon (Table 1). This might suggest resistant plants are less fit than susceptible plants but numbers are insufficient to draw any firm conclusions especially as the trend was not supported by the tillers from the same source. Seed germination among the potentially resistant lines was, however, very low. Four of the nine lines, three single parent selections and one field collection, produced 30-40% emergence, one (field collection) 12% and the other four (2 single parent, 2 field) 0-10%. Fresh susceptible seed would be expected to have a germination of about 60% (Bourdôt pers. comm.). Again this suggests a lower fitness among some dalapon resistance strains of needle grass.

It is not known whether the dalapon resistance reported here resulted from selection of a naturally resistant proportion of the population or whether repeated use of dalapon has induced genetic mutations in the population. The fact that two patches noticed after 3 years repeated use of dalapon, and subsequently found to be dalapon

resistant, were 4-20 m² in area, suggests they were natural “families” within the population rather than induced mutants. Had the resistance occurred as a result of recent dalapon treatment it is unlikely the area would have been so extensive so soon. Whatever the origin of the resistance, the problem appears to be increasing. In 1992 about 10 patches were observed to be flowering following dalapon treatment. In 1993 extensive areas of a third paddock, where dalapon had been used repeatedly since 1988, failed to respond (Bennie pers. comm.). Alternative control measures will be necessary for effective control of the Waipawa Chilean needle grass population.

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REFERENCES

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