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STRATEGIES FOR ARGENTINE STEM WEEVIL CONTROL: EFFECTS OF DROUGHT AND ENOPHYTE

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ABSTRACT

Herbage production of several ryegrass cultivars was measured over two years at Wairakei and Rukuhia, under conditions of either Argentine stem weevil infestation or insecticide protection.

Argentine stem weevil infestations were similar at both sites and were negatively correlated with incidence of Acremonium loliae infection in ryegrass host plants. Ryegrass yields and tiller densities during periods of larval infestation in spring and summer were greatly Increased by insecticide applications at Rukuhia but not at Wairakei. The weak nature of yield responses at Wairakei, despite highlarval numbers, appeared related todrought conditions. Plant persistence was improved at Wairakei by these insecticide applications.

Surveys of commercial sowings confirmed the correlations between incidence of Acremonium and Argentine stem weevil numbers and damage over a range of soil and management conditions. Between farm differences occurred, however, in the level of tiller damage

These results are discussed in relation to strategies for control of Argentine stem weevil utilising resistant ryegrass cultivars and insecticides.

Keywords: Argentine stem weevil, Listronotus bonoriensis, lolium endophyte, ryegrass, tiller survival, drought, control strategies.

INTRODUCTION

Argentine stem weevil, Listronotus bonariensis (Kuschel) (ASW) is a serious pest of ryegrass (*Lolium* spp) throughout New Zealand. The insect completes two and in northern regions occasionally three generations a year. Larval populations peak in October-November and January-February. Larvae tunnel inside the stems of the ryegrass tillers. Each can kill several tillers during its development. Damage is accentuated by drought stress, when high larval infestations can result in death of whole plants (Pottinger 1961).

Because the effects of ASW on persistence of ryegrass is most pronounced in drought prone areas (eg. Pottinger 1961, Prestidge et al. 1985a), it has generally been assumed that these areas would benefit most from insecticidal control of the insect. Initial studies on ASW infested pastures in the Volcanic Plateau have indicated that insecticides can give small but significant increases in ryegrass and total herbage yields (Prestidge et al. 1984a). In the Waikato ASW damage is more insidious due to the better summer-autumn pasture growth conditions. Preliminary studies (Barker et *al.* 1984a) have indicated, however, that substantial yield increases can result from insecticidal control of stem weevil in these pastures.

A comparison of the Waikato and Volcanic Plateau regions is further explored in this paper, utilising data from two complementary trials, and surveys of commercial sowings. The results are discussed in relation to strategies for control of stem weevil.

MATERIALS AND METHODS

Experimental

Site *1:* Wairakei, Atiamuri gravelly sand. Two seedlines each of 'Grasslands Ruanui', 'Grasslands Nui' and 'Ellett' perennial ryegrass (*Lolium* perenne *L.)*, of differing Acremonium *loliae* Latch, Christensen and Samuels infections, were drilled at 30 kg/ha into glyphosate sprayed pasture in September 1982. The legume component was resident white clover *(Tifolium repens L.)*. There were four replicates of 25 × 30 m plots.

Site 2: Rukuhia, Horotiu sandy loam. 'Grasslands Manawa' *(L. multiflorum × L. perenne)*, 'Grasslands Nui', 'NZ Perennial', and 'Ellett' ryegrasses were broadcast onto a cultivated seed bed at 25 kg/ha in May 1981; each sown with 2 kg/ha 'Grasslands Huia' white clover. Each treatment was replicated six times in 8 × 50 m plots.

Treatments: Insecticides for control of stem weevil were applied to one of the paired subplots (5 × 8 m) within each main plot. In the 1982-83 season the Wairakei plots received a spring application of oxamyl granules at 3.7 kg ai/ha and a split summer application of carbofuran granules at 5.0 kg ai/ha and oxamyl spray at 0.48 kg ai/ha. In 1983-84 ai/ha was sprayed at 10-14 day intervals from September to March.

Measurements: ASW populations were monitored on the main plots by sampling at 10-30 day intervals. Tillers were cut at ground level at random points within the plot and 200 representative tillers searched for eggs before heat extraction of the larvae, Adult populations were estimated from 20 7.5 cm diameter soil cores per plot. The insects were extracted by wet sieving and flotation. Populations on the subplots were similarly estimated at appropriate times to assess the effectiveness of insecticide applications. Populations of other potential pests were monitored by appropriate sampling and extraction techniques.

Tiller densities were estimated at 1-3 monthly intervals from 20 (Wairakei) or 30 (Rukuhia) 4.8 cm diameter turf plugs per plot. Herbage yieid was determined by mowing to 25 mm height prior to each grazing. Botanical composition was estimated by dissection of hand clipped herbage at each harvest.

Moisture content of the top 7.5 cm soil was determined gravimetrically weekly throughout the summerautumn period. The incidence of A. *loliae* infection for each ryegrass sown was determined (a) for each seedline by sectioning and staining **25** seeds in lactophenol cotton blue, and (b) by staining tiller sheaths from 40 plants each spring and autumn.

Survey

Two surveys were undertaken to establish correlations between A. *loliae* incidence and stem weevil populations in farmer-sown pastures under a range of soil and mangement conditions. In 1982-83, 63 pastures (sites) on 11 farms (locations) in the vicinity of Hamilton were sampled. The following summer, 45 pastures on 7 farms in the Reporoa-Wairakei area were sampled.

The presence or absence of *A. loliae* were recorded for 40 (Wairakei-Reporoa) or 50 (Hamilton) ryegrass plants per site.

Densities of ryegrass and other grass tillers were estimated in spring and autumn from 40 (Wairakei-Reporoa) or 50 (Hamilton) 4.8 cm diameter turf'plugs per site. The proportion and number of tillers damaged by stem weevil larvae were determined by dissection of a representative sample of tillers.

Populations of adult weevils were estimated in autumn from 80 (Wairakei-Reporoa) or 50 (Hamilton) 7.5 cm diameter soil cores per site.

RESULTS

Experimental

Peak abundance of the larvae, the damaging stage, was similar for the two sites (Table 1).

Larval infestations per tiller were inversely related to *A. loliae* incidence in the respective ryegrass seedlines (Figure 1). Regression lines did not differ significantly between the two sites for the second generation (summer-autumn) but significant ($P < 0.05$) site × year interactions were apparent for the first (spring) generation.

TABLE 1: *Acremonium loliae* infection incidence, peak Argentine stem weevil larval populations and annual herbage yields from insecticide treated (T) and untreated (U) plots for various ryegrass cultivars at Rukuhia and Wairakei.

Cultivar	% A. loliae infection	Larvae/100 tillers Spring	Summer	Total herbage yields kg/ha T	U
RUKUHIA				(May-May)	
1981 82					
Manawa	4	1.9	17.5	7418	6009*
Nui	42	0.7	4.0	905 I	8758*
NZ Perennial	44	0.6	6.0	9620	8680*
Ellett	88	02	2.5	9293	8152*
1982-83					
Manawa	10	2.4	12.4	8986	7092*
Nui	42	2.0	44	9408	8223*
NZ Perennial	58	1.2	3.2	9312	8157*
Ellett	83	0.4	0.7	9122	8334*
WAIRAKEI				(Sept Sept)	
1982~83					
Nui	80	1.5	4.4	2556	2844
Ellett	81	0.7	3.6	2298	2496
Ruanui	7	2.7	10.8	2868	2281
1983~84					
Nui	84	1.0	5.9	6658	6658
Ellett	82	2.7	5.8	6908	6845
Ruanui	13	7.0	12.8	6848	6028*

means sign diff. * $P<0.05$ ** $P<0.01$ *** $P<0.001$

Insecticide applications at Rukuhia resulted in significant increases in ryegrass and total herbage yields (Table 1). Regression analyses confirmed field observations that stem weevil larvae were primarily responsible for losses in ryegrass production in spring (1 September-l December) and summer (1 January-l April) (% ryegrass yield increase = 9.405+14.435 larvae/100 tillers, r= 0.983***). Summer yield responses persisted into winter, reflecting the significant improvement in ryegrass tiller densities caused by insecticide use (Table 2). Early summer tiller densities of Poa *annua*, a favourable host for stem weevil, were similarly increased in all Rukuhia swards with insecticide usage ($P< 0.01$).

Populations of other insect pests at Rukuhia were absent or were present in insufficient numbers to cause significant pasture losses. Nematode populations were significantly reduced by oxamyl applications (Yeates and Barker 1984), but numbers of plant feeding species were generally low. White clover did not repsond to insecticide application.

At Wairakei, ryegrass yield responses to insecticide were highly variable and rarely significant. Only at high larval infestations in Ruanui plots did insecticides consistently increase ryegrass yield but responses were always relatively small and transient (Table 1). Insecticide use at Wairakei did not increase ryegrass tiller densities (Table 2) but significantly improved ryegrass plant persistence (Table 3).

Populations of other insect pests were low at Wairakei. The insecticides used resulted in small but significant increases in white clover content and yield, associated with reductions in plant feeding nematode populations (Yeates and Prestidge, in prep.).

Figure 2 is a summary of the soil moisture data for both sites. At Wairakei the period

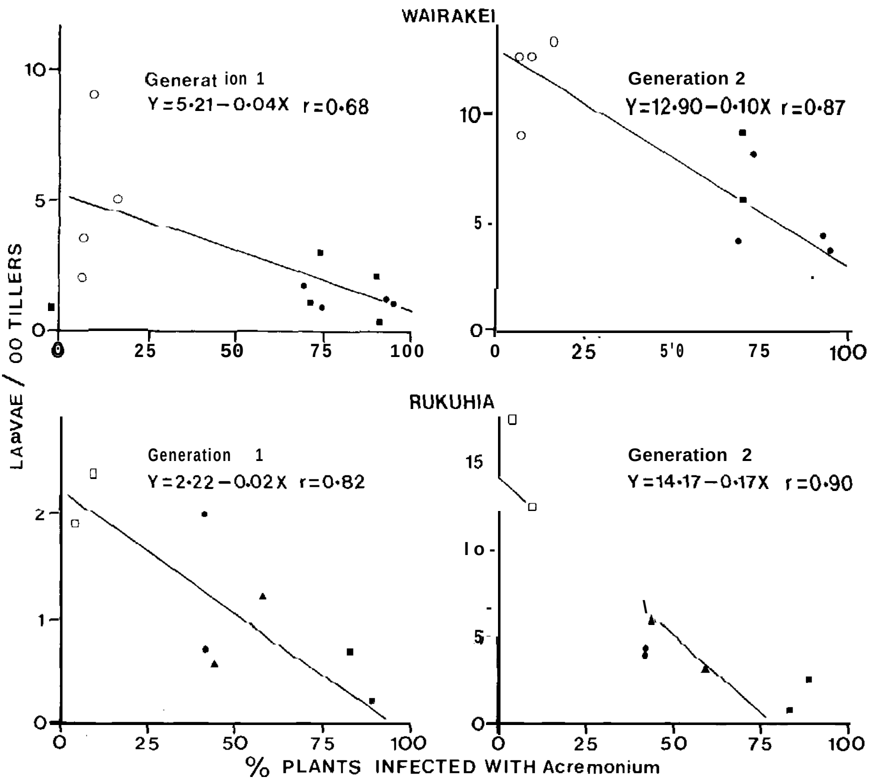

FIGURE 1: Relationships between incidence of Acremonium loliae and stem weevil larval infestations in ryegrass cultivars at Wairakei and Rukuhia. For each site, data from two years have been pooled.

0 Ruanui, • Nui, ▮ Ellett, A NZ Perennial, □ Manawa

of moisture deficit was protracted, from November through the period of larval infestation into February or later. At Rukuhia, periods during which soil moistures were below wilting point, were relatively brief and occurred after the peaks in larval infestations.

Survey

On-farm sampling confirmed that stem weevil density and tiller damage were significantly correlated with the incidence of A. *loliae* infections in ryegrass. Numbers and proportions of ryegrass tillers damaged by ASW, and density of the insects were positively correlated with abundance of favourable hosts, ie. the number of Acremonium-free ryegrass tillers. Similarly, ASW numbers and tiller damage were negatively correlated with the proportion of tillers in the sward infected by the fungus. These correlations are summarised in Figure 3.

Covariance analyses conducted on the Waikato survey data showed significant (P 0.05) locality (farm) differences in intercept values in the regressions in figure 3. Slope values did not differ significantly. These results suggest that, while the correlations held true, the actual level of tiller damage at a given incidence of *Acremonium* infection may vary substantially from one farm to the next. Sample distributions for the Wairakei-Reporoa survey prevented any meaningful analysis of locality differences over the full range of *Acremonium* incidences.

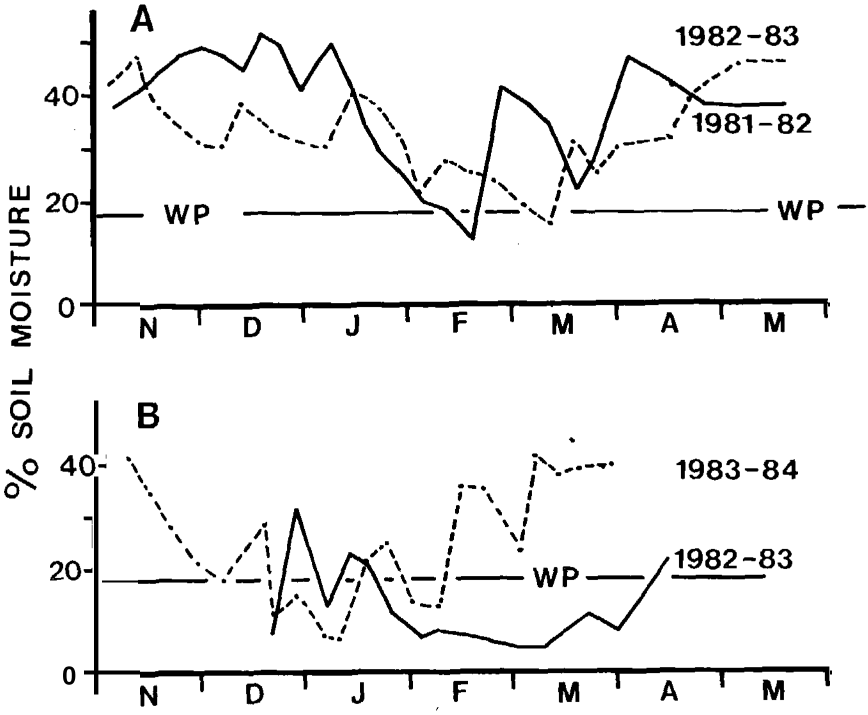

FIGURE 2: Soil moisture levels at A Rukuhia and B Wairakei. WP = Wilting point

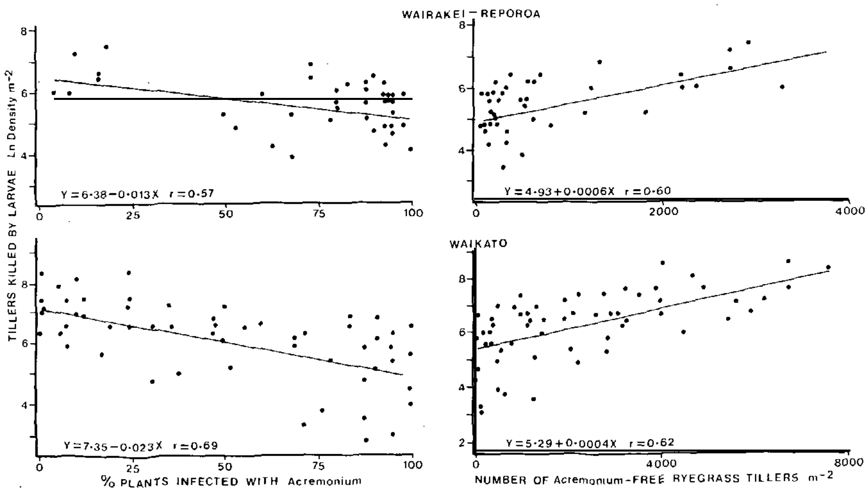

FIGURE 3: Relationships between incidence of *Acremonium loliae* and stem weevil damage from on-farm surveys in the Waikato (1982-83) and Wairakei-Reporoa (1983-84).

TABLE 2: Tiller densities of various ryegrass cultivars at Rukuhia and Wairakei, with (+) and without (-) insecticide applications.

		Tillers m 2					
Rukuhia		Manawa	Nui	NZ Perennial	Ellett	SED	Main effects
28.10.81		3 380	5 010	5 850	4 830	880	cultivar **
10.0582		450	2 490	3 720	4 400	380	cultivar ***
	+	1 830	3 970	5 500	6 900		insecticide *
07 10.82		1 830	5 080	7 420	6 110	760	cultivar ***
26 04.83		620	2 770	4 550	5 230		cultivar ***
	+	2 080	3 740	4 890	4 850	385	insecticide NS
							cult × insect *

Wairakei		Nui	Ellett	Ruanui	SED	Main effects
29.11.82		3 360	3 470	4 900	380	cultivar *
25.05.83		4 240	4 630	5 230	1 200	cultivar NS
	+	4 650	3 430	7 140		insecticide NS
15.11.83	-	2 820	2 900	2 770	610	cultivar NS
29.05.84	-	3 710	3 560	3 990	1 000	cultivar NS
	+	2 850	3 320	2 830		insecticide NS

TABLE 3: Plant densities for three ryegrass cultivars at Wairakei, with (+) and without (-) insecticide applications.

		Plants m 2				
		Nui	Ellett	Ruanui	SED	Main effects
21.10.82		474	545	581	69	cultivar NS
19.05.83		319	283	257	15	cultivar **
	+	362	355	316		insecticide***
28.08.84		322	370	320	47	cultivar NS
	+	366	372	370		insecticide*

DISCUSSION

Successful on-farm management of insect pests is dependent on reliable measurement of their populations; farmer awareness of potential production losses; prediction of infestations, and formulation of control strategies, eg. combination of short term insecticidal controls with longer term cultural methods such as the utilisation of resistant/tolerant plant cultivars.

ASW has long been recognised as a major pest of pastures in drought prone areas. Even before the demonstration that resistance in perennial ryegrasses is due to endophytic fungal infections (Prestidge et al. 1983; Barker et. al. 1984c), farmers in these areas had identified the superior cultivars (Prestidge et. al. 1985b). This preference resulted primarily from the superior persistence of Acremonium infected plants in the face of ASW attack. Quantification of the losses due to stem weevil in these drought prone areas has, however, been neglected until these studies.

effects of stem weevil are not as apparent, unless susceptible and resistant cultivars are sown in adjacent paddocks. There has however, been an increase in the use of resistant, Acremonium infected, ryegrass cultivars in such districts as farmer awareness of their greater persistence increases (Goold 1984).

Acremonium loliae infected plants possess a high degree of deterrency to adult ASW feeding and oviposition and activity is mostly concentrated on grasses lacking the fungus (Barker et *al.* 1983, 1984c). Furthermore, larval survival is reduced when confined to Acremonium infected plants (Barker et *al.* 1984b). These authors suggested that population size and hence the degree of damage, is determined by the abundance of endophyte-free ryegrass and alternative favourable hosts. Surveys of commercial sowings and field experiments reported in this paper have confirmed that the level of stem weevil infestation and damage is correlated with incidence of A. loliae in the swards (Figs. 1 and 3). The concept of weevil numbers being deterimined by abundance of favouable plant hosts (carrying capacity) is supported. Larval Infestations were linearly correlated with numbers of Acremonium-free ryegrass tillers, and with the proportion of tillers infected. Regressions between tiller damage and A. *loliae* incidence (Fig. 3) were non-linear however, suggesting more tillers were damaged per larvae at low endophyte incidence.

Ryegrass in grazed swards at Rukuhia produced substantial increases in yield and tiller densities in response to insecticide in both spring and summer. The degree of yield response was significantly correlated with stem weevil larval infestations, which reflected Acremonium infections. Pastures at Wairakei exhibited a high degree of variability in yield. Only under high larval infestations (viz., low incidence of A. loliae) were ryegrass yield responses to insecticide significant. Wairakei and Rukuhia swards had similar larval infestations for any given incidence of A. loliae but Rukuhia swards responded more readily to insecticide use.

A number of factors may have contributed to the disparity of responsiveness of the two sites to insecticides. Both regions studied have a similar mean annual rainfall (11.50 mm) but the lower moisture retaining capacity of Atiamuri gravelly sand ensures a moisture deficit occurs over summer in most years.

Reduced leaf expansion and tillering by ryegrass during drought can be considered an adaptive mechanism for survival (Korte and Chu 1983, Barker *et al.* 1985). Insecticides are unlikely to increase growth of plants in this "dormancy" state. Korte and Chu (1983) found that drought had little effect on survival of tillers established prior to the stress period and that high tiller densities enhanced plant survival, During infestations of ASW however, both established and replacement tillers can be destroyed. Therefore, in drought prone areas, such as the Central Volcanic Plateau. ASW infestations can be expected to reduce ryegrass plant survival (Percival and Duder 1983; Prestidge et al. 1985a; this study) but may yield no short term benefits from insecticide applications. The low contribution of winter growth to annual yields (Baars ef al. 1975, McQueen and Baars 1979) is likely to restrict any carry-over of insecticidal effects. In contrast, insecticide applications at Rukuhia ensured high tiller numbers at the beginning of the moisture deficit period. The brevity of the deficit allows realisation of the prodction differential established in tiller numbers.

The surveys of commercial sowings indicated between farm differences in levels of ASW populations and damage. These results indicate an interaction between soil type and grazing management of the expression of ASW infestations. Batten (1964). among others, has commented on the role of management in reduction of the impact of ASW. Assessment of ASW damage under a particular set of management circumstances would be useful in highlighting potential losses. Such assessments however, may be of little value in predicting losses due to ASW, and the need for application of controls on specific farms. Much more finite information is required on the interactions between ASW numbers, grazing management, tiller dynamics and moisture stress. Gross underestimations of the extent of ASW damage in drought affected pastures may result when insecticides are used as experimental tools.

The use of resistant, Acremonium infected ryegrass cultivars and use of insecticides represent the two basic approaches to stem weevil control. The resistance conferred by the presence of A. loliae in some cultivars offers the most economic way to reduce the impact of ASW. Because of the stock disorders associated with A. loliae infected ryegrasses however, considerable effort has been directed toward development of insecticidal controls as alternatives (Prestidge et al. 1983, 1984b, Pottinger et al. 1984). The implication of the present research is that insecticides will assist plant survival in drought affected pasture, but the costs of application are unlikely to be recouped in yield responses, at least in the short term. By contrast, insecticidal control of ASW larvae infesting pastures on soils, with adequate summer moisture levels, should give economic yield increases.

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