THE EFFECT OF GRASS GRUB ON THE HERBAGE PRODUCTION OF DIFFERENT PASTURE SPECIES IN THE PUMICE COUNTRY

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Abstract

Small plot mowing trials carried out on central North Island pumice soils have shown that Huia white clover and S170 tall fescue support high grass grub populations, while the resistant legumes Wairau lucerne and Maku Lotus *pedunculatus* suppress grass grub numbers to low levels. Measurement of the effects of grass grub on herbage production has highlighted both the susceptibility of white clover, Nui and Ruanui ryegrasses, and browntop to grass grub attack, and the potential of highly productive resistant or tolerant species (lucerne, tall fescue and to a lesser extent Apanui cocksfoot and Matua prairie grass) for lessening the impact of grass grub on pasture production in this region.

INTRODUCTION

THE severe economic effects of heavy grass grub ***(Costelyfra zealandica*** (White)) infestations in the central plateau region of the North Island were documented by Gordon and Kain (1972). They pointed out that the topography, the marginal economic status of pastoral farming on pumice soils, and the high cost of insecticides greatly limit the scope for chemical control of grass grub. The introduction of high producing species resistant to grass grub could therefore have a major impact on farming profitability in this region.

Studies of the relationships between grass grub and host plant species have identified several resistant species, including lucerne ***(Medicago*** *sativa*) (Kain and Atkinson, 1970) and lotus (*Lotus pedunculatus*) (Farrell and Sweney, 1974), and have shown that clovers (*Trifolium* spp.) are extremely favourable host plants (Kain and Atkinson, 1977). This paper reports some of the major results of a series of small plot mowing trials carried out to determine the effects of botanical composition of pasture on grass grub numbers and the effects of grass grub on herbage production and composition. Other aspects of this work have been reported elsewhere (Kain et ***al., 1978).***

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EXPERIMENTAL

Four trials were conducted. Three trials were sown in September-October 1973 at two sites — Aratiatia (near Taupo) and Kapenga (in the Rotorua district) — and the fourth was sown at Wairakei Research Station in October 1974.

Trial 1 at Aratiatia included two legumes,. 'Grasslands Huia' white clover *(Trifolium repens)* and 'Grasslands Maku' lotus, and three grasses, 'Grasslands 'Nui' ryegrass (*Lolium perenne*), 'Grasslands Apanui' cocksfoot *(Dactylis glomerata)* and 'Grasslands Matua' prairie grass *(Bromus catharticus)*, each sown as a pure species and in all possible 1 : 1 grass-legume combinations.

Trial 2 at Aratiatia included commercial browntop *(Agrostis tenuis)*, browntop/Huia white clover, 'Wairau' lucerne and three lucerne/grass mixtures, the grasses sown with lucerne comprising Nui ryegrass, Apnnui cocksfoot and "Seedmaster" phalaris (*Phalaris aquatica*) .

The third trial at Kapenga included Nui ryegrass, Seedmaster phalaris, Huia white clover and 'Grasslands *4703' Lotus pedunculatus* sown as pure species and mixtures as in trial 1. The lotus treatments at both sites became contaminated with volunteer white clover and their legume component effectively became a lotus/ white clover mixture.

The fourth trial at Wairakei Research Station included "Grasslands Ruanui' ryegrass, S170 tall fescue (*Festuca arundinacea*), Apanui cocksfoot, and Matua prairie grass, each handsown as a pure species and with Huia white clover.

Plot size was 9 x 3 m in the first three trials and 5 x 1.5 m in the fourth trial, with a randomized block design and four replicates. Fensulfothion (2 kg/ha) was applied annually to one-third of each plot (one-half of each plot in trial 4), except for the treatments containing lucerne which was known. to be resistant to grass grub. This insecticide treatment consistently reduced grass grub numbers by more than 90%. Seeding rates, initial fertilizer inputs, and methods of establishment and maintenance of the various treatments in trials 1 to 3 were described by Kain and Atkinson (197.7). Experimental details were similar in the fourth trial, which was handsown, raked in and rolled with tall fescue sown at 20 kg/ha. From October 1975, all treatments received 700 kg/ha of 30% sotassic superphosphate (in six 2-monthly applications) and 200 kg/ha of dolomite annually. The pure grass treatments received nitrolime after each cut at rates proportionate to the mean dry matter (DM) yield of each plot (units of N/ha = 4% of DM/ha) , and grass/legume mixtures received 100 kg N/ha annually (50 kg/ha of N as nitrolime applied in autumn and late winter).

Grass grub populations were assessed by the methods of Kain and Young (1975) and Kain and Atkinson (1976). Herbage production was measured with a rotary mower (cutting height 5 cm), and botanical composition determined seasonally by herbage dissection. Plots were cut when actively growing species reached an average height of about 15 cm, or at crown bud movement for lucerne treatments between October and April. All clippings were discarded.

RESULTS

GRASS GRUB NUMBERS

Grass grub numbers in areas untreated with insecticide are summarized in Fig. 1. Populations were initially low in all trials, and then followed the typical pattern of increase to reach peak levels under favourable species in the third autumn after sowing. At Aratiatia and Kapenga the effects of pasture composition on grass grub numbers were dominated by the legume component, with the effects of individual grass species insignificant ($P > 0.10$). Grasses have therefore been combined in Fig. 1 (a). White clover and grass/white clover mixtures supported much

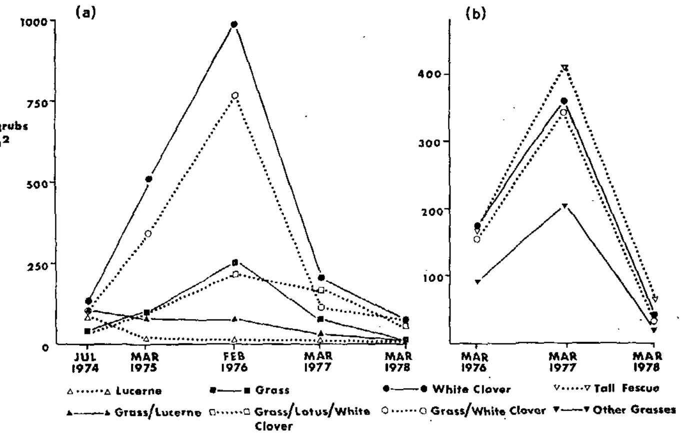

FIG. 1: *Average grass grub population densities under different plant species,* (a) in Aratiatia and Kapengu trials; *(b)* in Wairakei trial.

TABLE 1: TOTAL HERBAGE DRY MATTER PRODUCTION (1 DECEMBER TO 30 NOVEMBER) AND LOSSES CAUSED BY GRASS GRUB

	kg DM/ha T*	*kg DM/ha* U	*% Loss in Production* Sown Grass	*% Loss in Production* Legume	*% Loss in Production* Total
Aratiatia trial 1 1975-6					
Prairie grass/ white clover	10 870a	7 930bc	14*	48**	27’”
Ryegrass/white clover	9 950ab	7 760bc	11’	45**	22”
Cocksfoot/white clover	9 340b	747oc	1 n.s.	37**	20*
Prairie grass/ lotus/white clover	9 740ab	8 960ab	9 n.s.	4 n.s.	8 n.s.
Ryegrass/lotus/ white clover	9 890ab	9 000ab	8 n.s.	10 n.s.	9 n.s.
Cocksfoot/lotus/ white clover	9 610ab	9 510a	0	1 n.s.	1 n.s.
Aratiatia trial 2 1975-6					
Browntop/white clover	8 830	5 470b	22’	57**	38**
Lucerne/grass	—	12 860a			
Lucerne	—	11 590a			
Kapenga 1975-6					
Ryegrass/white clover	9 330a	7 560ab	15*	37**	19’
Phalaris/white clover	8 390a	5 620c	19*	46**	33**
Ryegrass/lotus/ white clover	9 440a	8 400a	5 n.s.	16*	11 n.s.
Phalaris/lotus/ white clover	8 210a	7 060b	15*	13 n.s.	14*
Wairakei 1976-7					
Tall fescue/white clover	11 490a	9 710a	3 n.s.	33**	15*
Prairie grass/ white clover	7 590bc	6 990b	5 n.s.	28**	8 n.s.
Cocksfoot/white clover	7 260bc	7 200b	-8 n.s.	56**	1 n.s.
Ryegrass/white clover	7 400bc	4 15oc	40**	49**	44””
Tall fescue	10 860a	10 780a	2 n.s.	—	1 n.s.
Prairie grass	8 220b	7 930b	6 n.s.	—	4 n.s.
Cocksfoot	7 540bc	7 030b	4n.s.	—	7 n.s.
Ryegrass	7 030c	3 94oc	49**	—	45**
White clover	6 340c	4 15oc	—	37**	35**

T* = Insecticide-treated; U = Untreated; % losses calculated as 100 (T-U) /T.
Significance of losses: ** $P < 0.01$; * $P < 0.05$; n.s. $P > 0.05$.
Figures in a column without a common letter differ significantly ($P < 0.05$)

higher grass grub populations than all other treatments in 1975 and 1976 ($P < 0.01$). Populations remained at relatively low levels in the pure grasses and in treatments containing the resistant legumes lotus and lucerne, with populations of the lucerne treatments significantly less than all others ($P < 0.05$) in 1976. Kain *et* al. (1978) showed that within years grass grub populations of grass/white clover and grass/lotus/white clover mixtures declined exponentially from high to low levels as the lotus content (% DM in autumn) increased from zero to 40%.

The population crash in the white clover and grass/white clover treatments in 1977 (Fig. la) reflects very high late autumn-winter mortality in these treatments in 1976 following severe pasture damage caused by the peak populations. The low numbers in all treatments in 1978 probably resulted from a very severe late summer-autumn drought in that year, since droughts are known to be a major cause of grass grub population decreases (Kain, 1975).

At Wairakei, grass grub numbers (Fig. lb) fell into two significantly different ($P < 0.05$) groups in both 1976 and 1977, with higher numbers in the tall fescue, white clover and grass/white clover treatments than in pure cocksfoot, ryegrass and prairie grass, and no significant differences ($P > 0.10$) within these groups.

HERBAGE PRODUCTION

Grass grub damage (assessed as the difference in production between insecticide-treated and untreated subplots) was generally greatest in each trial in the year of peak populations. Damage was most apparent in autumn and early winter when the root-pruning activity of larvae is greatest. Kain et al. (1978) presented average yields from the Aratiatia and Kapenga trials for the groups of treatments in Fig. la, which showed that both autumn production in 1976 and annual production (December 1975 to November 1976) were more severely affected by grass grub in the white clover-based treatments than in the pure grasses or grass/lotus/white clover mixtures, reflecting the differences in grass grub numbers. This effect is shown in more detail for individual grass/legume treatments in Table 1.

In the absence of lotus, grass grub caused significant losses in the annual production of the legume component, the grass component in Nui ryegrass, prairie grass, phalaris and browntop mixtures, and the total sward where these components occurred.

The addition of lot& reduced most of these losses to a non-significant level. The effects of grass grub on individual grass/legume mixtures varied with the relative proportions of the different species present and their 'susceptibility to grass grub attack. Kain et *al.* (1978) showed that grass grub damage declined with increasing lotus content, and they calculated that lotus must comprise at least 30% of the total autumn DM production of a grass/lotus/white clover mixture to reduce grass grub damage to a tolerable level. Differences in total annual production of insecticide-treated grass/legume mixtures at Aratiatia and Kapenga were mostly not significant in 1975-6 (Table 1) or in other years. In contrast, average annual production of grass/white. clover mixtures in untreated subplots in 1975-6 was significantly lower ($P < 0.05$) than that of grass/lotus/white clover mixtures. The effects of grass grub damage on grass/white clover treatments in 1976 did not persist into the subsequent 2 years, with the exception that the yield of the white clover component failed to recover completely, with a compensatory increase in the production of grasses (both sown and unsown species) and weeds.

The yields of the lucerne and lucerne/grass mixtures in trial 2 'at Aratiatia (Table 1) illustrate the high productivity of lucerne on pumice soils in comparison to grass/white clover pastures, in the presence of grass grub. Total annual DM production of the treatments containing lucerne in this trial averaged 14 800 kg/ha in 1974-S and was about the levels shown in Table 1 in the subsequent 3 years, with no significant differences ($P > 0.05$) between individual lucerne/grass mixtures and lucerne alone in any year.

Although peak grass grub populations in the Wairakei trial were lower than in the other trials (Fig. 1) , grass grub damage to white clover was of the same order (Table 1). This may reflect the drier late summer-autumn in 1977 (January to April rainfall 23% below average) than in 1976 (January to April rainfall 43% above average) and the coarser, more drought-prone pumice soil at the Wairakei trial site, since plants under moisture stress are more susceptible to grass grub damage (e.g., East and Pottinger, 1975). Ruanui ryegrass suffered greater production losses from the peak grass grub population at Wairakei than Nui ryegrass in the other trials (Table 1), both sown with white clover and as a pure species. Annual. production of tall fescue, cocksfoot and prairie grass at Wairakei was unaffected by grass grub. As in the other trials, total annual production of grass/white clover mixtures was reduced markedly by grass grub, with the exception of cocksfootjwhite clover and prairie grass/white clover which were both very grass dominant. Tall fescue out-produced all other species at Wairakei both as a pure species and with white clover and in the insecticide-treated and untreated subplots (Table 1).

The seasonal losses in pasture production resulting from grass grub attack were greater than the annual losses recorded in Table 1. For example, 1976-7 production of the pure species at Wairakei is divided into four 3-month seasons in Table 2, with summer commencing on 1 December. Production of all treatments was unaffected by grass grub in summer, before the onset of significant larval root pruning. The susceptible species ryegrass and white clover suffered the greatest losses in autumn and winter, coinciding with larval feeding, and recovered only partially in the subsequent spring, after larval development had been corn-pleted. Cocksfoot and prairie grass were less severely affected by grass grub but suffered significant losses in either autumn or winter. Tall fescue was very tolerant of grass grub attack, with production not significantly affected in any season despite the presence of high numbers of grass grub (Fig. lb) . Production of tall fescue was greater than all other treatments in summer and autumn, and in the presence of grass grub was equalled only by prairie grass in winter and spring (Table 2). Sown species comprised 85 to 97% of these seasonal yields, but intensive hand

TABLE 2: SEASONAL HERBAGE PRODUCTION AND LOSSES CAUSED BY GRASS GRUB AT WAIRAKEI (1 DECEMBER 1976 TO 30 NOVEMBER 1977)

	kg DM/ha T*	kg DM/ha U	% Loss	kg DM/ha T*	kg DM/ha U	% Loss
Summer				*Autumn*		
Tall fescue	4 820a	4 850a	-1 n.s.	2 470a	2 200a	11 n.s.
Cocksfoot	3 550b	3 230b	9 n.s.	1 500b	1420b	5 n.s.
Prairie grass	3 450b	3 330b	3 n.s.	1 730b	1 200b	31'
Rvegrass	2 45oc	2 21oc	10 n.s.	1 460b	22oc	85**
White clover	2 600bc	2 360c	9 n.s.	95oc	21oc	78**
Winter				*Spring*		
Tall fescue	710ab	670a	6 n.s.	2 860a	3 060a	-7 n.s.
Cocksfoot	630b	34Qb	46"	1 860b	2 040bc	-10 n.s.
Prairie grass	790ab	840a	-6 n.s.	2 250ab	2 560ab	-14 n.s.
Rvenrass	1 020a	300b	71**	2 100ab	1 210c	42*
White clover	750ah	290b	61**	2 040ab	1 29oc	37*

*See footnote to Table 1.
Significance of losses: ** $P < 0.01$; * $P < 0.05$: n.s. $P > 0.05$.
Figures in a column without a common letter differ significantly ($P<0.05$).

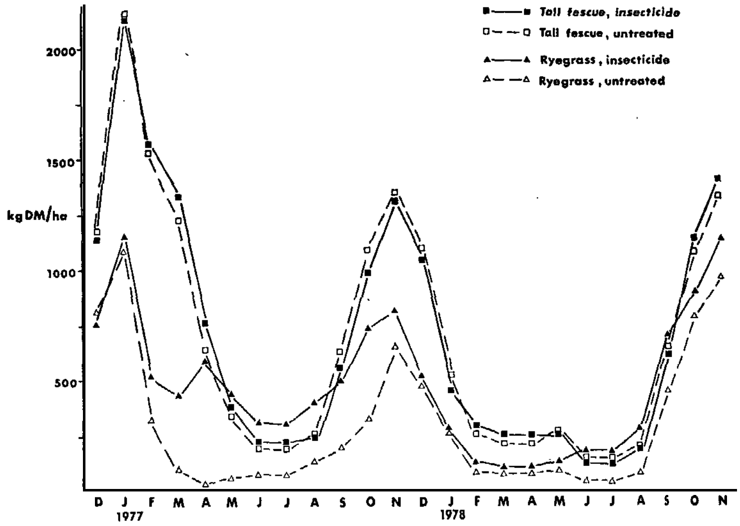

FIG. 2: *Herbage production of S170 tall fescue and Ruanui ryegrass sown us pure species in insecticide-treated and untreated subplots at Wuirakei.*

weeding was necessary in spring to maintain this degree of purity in the untreated ryegrass and white clover subplots.

The seasonal patterns of tall fescue and Ruanui ryegrass growth at Wairakei were similar, but with tall fescue showing a greater late spring/early summer peak (Fig. 2). The marked effects of grass grub on ryegrass growth in 1977 had disappeared by the 1977-8 summer. In the severe late summer-autumn drought of 1978 (January to April rainfall 64% below average), summer and autumn production of tall fescue was again significantly greater than that of ryegrass ($P < 0.05$). In 1978, ryegrass did not respond significantly to the insecticidal removal of grass grub until winter, when production was reduced by 66% in untreated areas ($P < 0.01$). This delay in grass grub damage until winter reflects both the impairment of grass grub feeding by a drought which extended into the autumn and the susceptibility of rye-grass to damage by low numbers of grass grub (Fig. 1) following severe drought. Nui ryegrass sown as a pure species at Aratiatia suffered a similar production loss (64%) from grass grub attack in winter 1978, whereas in previous years this treatment had not suffered significant autumn and winter losses. When sown in combination with white clover, which resulted in a marked increase in grass grub numbers compared with pure rye-grass (Fig. la), Nui had shown production losses of 34% (Ara-tiatia) and 38% (Kapenga) in autumn 1976. In 1978, winter and spring production of tall fescue and insecticide-treated Ruanui ryegrass did not differ significantly but was greater ($P < 0.05$) than the production of untreated ryegrass (Fig. 2).

DISCUSSION

These studies have confirmed the sensitivity of grass grub populations to the botanical composition of pastures, and the findings are in general agreement with earlier work (Kain and Atkinson, 1977). Tall fescue is an exceptionally favourable host plant, supporting similar numbers of grass grub to white clover.

The resistant legumes lucerne and lotus offer scope for manipulating grass grub populations to insignificant levels, although it should not be overlooked that these species are susceptible to other insect pests such as lucerne aphids and Lepidoptera (East et al., 1978). Lucerne already makes a significant contribution to pastoral production in the pumice country, but its potential is partly limited by practical problems associated with its establishment and management on hill country. In this study, the annual and seasonal herbage yields of luceme and lucerne/grass mixtures were similar to those observed by Baars and Cranston (1978). The agronomic limitations of presently available lotus cultivars (Brock and Charlton, 1978) suggest that the realization of the potential of this species for grass grub control in areas such as the pumice hill country will depend on further breeding programmes .

The resistant grass phalaris does not suppress grass grub populations when sown in combination with white clover (Kain and Atkinson, 1977). Nevertheless, it was surprising that phalaris sown in mixtures with legumes at Kapenga suffered significant production losses when not protected with insecticide (Table 1). Since grass grub ‘larvae feed actively on phalaris roots (Kain, unpublished), it is possible that the toxic effect of phalaris may be reduced by dilution in a mixture with a favourable food plant such as white clover, particularly as the larvae tend to aggregate around the clover roots (Kain and Atkinson, 1977). The pure phalaris plots at Kapenga contained low grass grub populations and showed no production response to the removal of grass grub with insecticide.

This work, and that of, Kain et *al.* (1979) in Hawke s Bay, highlights the susceptibility to grass grub attack of ryegrass and white clover, the two major pasture species sown in New Zealand, and browntop, a widespread species in lower fertility pastures. There is clearly a need for alternative cultivars or species which are less susceptible to grass grub attack. In both this study and that of Kain *et al.* (1979), 5170 tall fescue has shown a remarkable ability to produce at a high level in the face of attack by large numbers of grass grub. Cocksfoot (Aratiatia and Wairakei) and prairie grass (Wairakei only) showed a lesser degree of tolerance (Tables 1 and 2) . The increase in prairie grass. yield in the untreated plots at Wairakei in winter and spring (Table 2) also reflects the ability of this species to re-establish from natural seedfall in swards opened up by grass grub attack in autumn.

The high productivity of tall fescue in New Zealand has been noted before (e.g., Watkin, 1975). Figure 2 illustrates the ability of tall fescue to outproduce ryegrass under the conditions of this study in the presence of two of the most severe constraints to pasture production in the pumice country, drought and grass grub. The yields of tall fescue on a coarse pumice soil at Wairakei (Tables 1 and 2) underline rhe potential of this species for lifting pasture production in the central North Island hill country. Further research is required on the establishment of tall fescue and other tolerant species on pumice soils, and their persistence under different grazing regimes, before the practical value of these findings can be assessed.

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