PEST ASSESSMENT STUDIES OF BLUE GREEN LUCERNE AND PEA APHIDS IN THE SOUTHERN NORTH ISLAND REGION OF NEW ZEALAND

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Summary

Studies on mixed species populations of lucerne aphids showed that large losses in lucerne (*Medicago sativa*) herbage production occurred from predominantly blue green lucerne aphid (BGLA) (*Acyrtosiphon kondoi*) infestations in spring-early summer (39 and 60%), a pea aphid (*A. pisum*) dominant infestation in mid to late summer (16 and 48%) and mixed pea aphid-BGLA populations in autumn (6 and 30%). Carry-over effects of autumn aphid damage caused a depression in early spring production of 16 and 20%. Losses in herbage production did not occur below 30 aphids/stem except in autumn when growth was slow. Aphid damage in untreated lucerne caused significant reductions in leaf and stem numbers, stem height, stem to leaf ratios and carbohydrate levels of roots. A reduction (18%) in plant density was recorded in aphid damaged plots in early winter. In these studies herbage quality in terms of protein, carbohydrate, crude fibre, plant pigments, ash and major and trace elements in herbage were not altered to the extent that quality was impaired.

INTRODUCTION

In the autumn of 1976 when BGLA first became established in the southern North Island autumn losses in production from one lucerne meal factory in the region fell by as much as 60% as a result of damage that this pest caused. Symptoms of BGLA damage in lucerne include reduced stem length and leaf size and have been described elsewhere (Kain *et al* 1976). In USA pea aphid is reported to attack several genera of important legumes such as *Vicia*, *Medicago*, *Trifolium* and *Pisum* (Evans and Gyrisco 1956) but in New Zealand damaging infestations have been confined mainly to lucerne (Gaynor *et al* 1978). Pea aphid is known to cause stunting, leaf yellowing and leaf drop in lucerne (Evans and Gyrisco 1956) but apart from leaf-cupping, damaged plants are not usually misshapened or twisted as they are following BGLA attack. Although the pest status of BGLA in terms of losses in herbage production has been studied in New Zealand (Kain *et al* 1977; Gaynor *et al* 1978) no detailed information is available on the effect that this pest has on the lucerne plant and the pest status of pea aphid in this country is largely unknown (Gaynor *et al* 1978).

The present paper reports on studies initiated to determine in more detail the pest status of lucerne aphids both as single and mixed species populations in order to define the level at which crop damage occurs and to provide direction in the choice of control methods. Certain aspects of the early part of these studies and associated studies on aphid seasonality have been published previously (Gaynor *et al* 1978 and Kain *et al* 1979).

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METHODS

Studies were confined to a small plot trial located at Flock House near Palmerston North. The trial was of a randomised block design with two different aphid treatments, sprayed with insecticide (permethrin 0.25 kg/ha) when aphid levels reached, between 5 and 10/stem and greater than 30/stem, and an on untreated control. Plots (3 x 5 m) were divided longitudinally into two equal sub-plots. Each sub-plot was cut 14 days apart at the beginning of the trial. Thereafter lucerne was harvested at the same physiological stage of growth, basal bud movement. This perpetuated a sub-plot difference in harvest time (Harvest A and B). Aphids were sampled weekly by taking at random 10 stems cut at ground level from each sub-plot. Aphids were then extracted by rinsing samples in hot water and collecting them on filter paper for counting and identification. The mean stem length of samples were then measured to determine crop height. The entire trial site was sprayed with permethrin at the end of May to eliminate aphids and allow carry-over effects of damage to be studied.

Selected plants were marked in two replicates of the untreated and 5 - 10 aphids/stem spray treatment in Harvest A and B in early spring. Nine plants were marked in each sub-plot in Harvest A and 18 in Harvest B. The plants were stratified on a height basis at the basal bud movement stage of growth and three or six representative short, medium and tall plants were selected from each sub-plot at random. At each harvest all plants in Harvest A and half the plants in Harvest B were harvested individually and stem numbers, length and weight and internode number and lengths together with leaf number and weight were recorded. In late summer the plants which had not been individually harvested in Harvest B were dug up and the remaining plants were dug up in mid-winter. The roots of dug plants were washed clean of soil, severed from the foliage and the diameter of crown and roots at 5 and 10 cm from the crown were measured and root volume estimated by displacement. Roots were freeze dried soon after harvest for starch and soluble sugar analyses. At the end of autumn plant numbers were counted from two 1 m² quadrats sited at random in each sub-plot in Harvest B at the beginning of the study. All herbage harvested from the trial was dissected into lucerne and weeds. Harvest dates are given in Table 1. Following severe BGLA damage in December (Harvest A) and pea aphid damage in February (Harvest B) herbage harvested from a number of the 5 - 10 aphids/stem and untreated sub-plots was freeze dried and analysed for minerals and other constituents listed in Tables 4 and 5.

The methods used for analysing plant constituents are essentially the AOAC standard methods (Anon 1975). Starch and soluble sugar analyses of root tissue were analysed by the enzymic methods developed by Hazeldore and Roughan (1976) and mineral analyses of herbage by methods published by the Ministry of Agriculture and Fisheries (Anon 1979).

RESULTS AND DISCUSSION

It is difficult in studies on mixed pest populations involving two species of aphids which cause almost identical types of damage and, in the case of BGLA, carry over effects (Kain *et al* 1977) to apportion damage to one pest species or the other. An indication of the propensity of each aphid to damage lucerne can be gained from monitoring losses in herbage production at times when one species is very dominant over the other. In late spring-early summer when BGLA dominant infestations were present (Fig. 1) losses in herbage production of 39% and 60% were recorded whereas in mid-summer when pea aphid numbers were higher than BGLA numbers herbage production was depressed by 16% and 48%. It is likely

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TABLE 1: Effect of insecticide control of blue green and pea aphids on lucerne production* (kg DM/ha/100).

Harvest A						
Harvest date	5 Dec	6 Jan	15 Feb	20 March	19 May	18 Sept
Treatment						
5-10 aphids/stem	33	18	23	18	11	11
30 aphids/stem	32	20	22	18	10	11
untreated	13	13	17	17	9	9
LSD (P = 0.05)	4.7	2.1	3.5	1.6	2.0	1.6
% Loss	60	28	26	6	18	19

Harvest B						
Harvest date	7 Nov	24 Jan	28 Feb	10 April	13 June	18 Sept
Treatment						
5-10 aphids/stem	26	33	19	17	10	11
30 aphids/stem	28	33	15	16	7	10
untreated	16	28	10	16	7	7
LSD (P = 0.05)	3.8	2.3	1.4	1.4	1.1	1.7
% Loss	39	16	48	6	30	36

* Only lucerne herbage.

that the carry-over effects of earlier BGLA damage and the effects of low but significant numbers of BGLA present over this period particularly in Harvest A confounded losses attributed to pea aphid. The same is also true with respect to carry-over effects of previous damage for losses recorded in autumn-early winter lucerne production (18 and 30%) which occurred in the presence of mixed pea aphid-BGLA populations.

The debilitating effect of aphid damage on subsequent production even in the absence of aphid infestations was most apparent in these studies in January (16 and 28%) and again in winter and early spring (19 and 36%) (Table 1 and Fig. 1). Losses in herbage production in treatments in which aphid densities were not allowed to rise far above 30 /stem were only significant in late autumn-early winter. This indicates that in seasons in which lucerne growth is most rapid losses in productivity only occur at levels higher than 30 aphids/stem but outside these seasons substantial losses may occur at aphid levels lower than this. A similar trend has previously been reported by Kain *et al* (1977) who showed that aphid damage is a function of pest density and time that infestations are present, and is markedly influenced by the crop growth rate. It should be remembered that in these studies lucerne was inspected weekly and treated when populations reached the prescribed levels. In these studies damage was most pronounced in regrowth periods when high aphid infestation levels occurred on young growth (Table 1 and Fig. 1). Hence it would seem that aphid control during the early regrowth stage is most important if severe damage is to be avoided (Kain and Atkinson, 1977; Kain *et al* 1978).

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Fig 1. Pea aphid □ and bluegreen lucerne aphid ■ levels in untreated sub-plots and crop height of the 5-10 aphids/stem treatment (-----) and untreated lucerne (—).

As Gaynor *et al* (1978) noted, the ability of pea aphid to damage lucerne at periods when the drought resistant properties of the crop are most in demand, places the pest status of this species in the same category as BGLA, although crop losses, at least in these studies, were less severe. Pea

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TABLE 2: Effect of aphid control on weed content (% DM) and Lucerne plant density (No/m²).

Harvest	A (19 May) % DM	B (13 June) % DM	B (21 May) No/m ²
Treatment			
5-10 aphids/stem	13.0	13.0	22
30 aphids/stem	14.5	29.0	20
untreated	22.6	32.3	18
LSD (P = 0.05)	7.3	4.2	2.7

aphid population levels recorded in these studies however were much lower than those recorded for BGLA (Fig. 1 Kain *et al* 1979).

The severe aphid damage experienced in these studies caused a marked increase in the weed content of lucerne in late autumn-early winter and a significant loss in plant density (18%) by May in Harvest B (Table 2). The response of individual plants to aphid damage showed in a marked reduction in stem numbers, numbers of leaves /stem, number of internodes and internodal length (represented by the length of the top and bottom internode) (Table 3). An increase in % leaf in herbage DM (Table 3) from aphid damage was reflected in a depression in % crude fibre and an increase in % carbohydrate (Table 4). Decreased levels of carotene and xanthophyll and K were recorded in aphid damaged herbage (Tables 4 and 5). Crude fibre, xanthophyll and K were found to be positively correlated with herbage production (Tables 4 and 5 and Fig. 2). Small but significant increases in S,P,Zn and Cu occurred in aphid damaged herbage whereas large increases were recorded in Mn, B and Mo levels (Table 5). With the exception of Zn, all trace elements were negatively correlated ($P < 0.05$) with herbage production in at least Harvest A or B (Table 5 and Fig. 2). Increased levels of trace elements found in aphid damaged herbage did not approach those considered to be toxic to livestock but in the case of Mn and B were large enough to confuse detection of plant nutrient deficiencies by chemical analyses of herbage. The elevation in levels of these two elements spanned the range between levels regarded as deficient or barely sufficient and excessive (Anon 1979). In spite of changes in plant constituents in aphid damaged herbage these did not adversely affect herbage quality and if anything, improved quality at the expense of production.

The persistent aphid damage recorded in these studies reduced root volume and the cross sectional area of crowns and roots measured at 5 cm and 10 cm from the crown (Table 6). Roots of aphid damaged plants were found to contain lower carbohydrate levels caused by a 37% reduction in starch (Table 7). Mean stem weights were found to be correlated with carbohydrate root reserves in February (Fig. 2) but following persistent aphid damage this relationship in July was only significant for undamaged plants.

Trends shown in foliage and roots of aphid damage plants were similar to those found in lucerne stands mismanaged through frequent premature defoliation and suggests that severe and persistent aphid attack reduces plant vigour through the depletion of root reserves (Kain *et al* 1978). As a consequence immediate post aphid damage management should be aimed at increasing root reserves as quickly as possible by utilising herbage at an advanced stage of growth (basal bud movement stage) and ensuring

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TABLE 3: Effect of aphid damage on lucerne foliage in Harvests A and B.

	% stem gain or loss				No. leaves/stem			
	Dec		May		Feb		April	
	Feb	April	June	June	Feb	April	June	June
5-10 aphids/stem untreated	A	B	A	B	A	B	A	B
LSD (P = 0.05)	+1	-10	62	53	50	45	21	21
	-45	-30	47	39	42	37	19	16
	23	18	9	9	7	7	5	5
No. internodes								
	Feb	April	June	June	Feb	April	June	June
5-10 aphids/stem untreated	A	B	A	B	A	B	A	B
LSD (P = 0.05)	59	61	65	66	12.2	10.8	10.5	7.3
	58	68	71	51	9.6	8.9	9.5	7.7
	3.2	4	4	4	0.8	0.8	0.9	1.3
Bottom internode length (cm)								
	Feb	April	June	June	Feb	April	June	June
5-10 aphids/stem untreated	A	B	A	B	A	B	A	B
LSD (P = 0.05)	0.98	0.91	0.57	0.58	0.37	0.37	0.55	3.1
	0.48	0.43	0.49	0.51	0.23	0.23	0.43	5.5
	0.15	0.15	0.08	0.10	0.06	0.06	0.50	2.4
							0.49	0.53
							0.50	0.50

TABLE 5: Effect of aphid damage on chemical composition of lucerne herbage.

Harvest A (5th Dec)	Major elements % DM						Trace elements ppm DM					
	S	P	Mg	Ca	Na	K	Mn	Zn	Cu	B	Mo	
5-10 aphids/stem untreated	3.1	3.3	0.23	1.4	0.084	3.1	29.2	30.1	13.1	49.5	0.81	
r (8) =	3.6	3.2	0.24	1.6	0.094	2.8	41.7	33.5	14.4	67.7	1.14	
	NS	NS	NS	-0.66*	NS	0.64*	-0.82**	NS	NS	-0.88**	-0.72**	
Harvest B (27th Feb)												
5-10 aphids/stem untreated	3.4	2.5	0.28	1.6	0.066	2.8	28.8	29.4	11.4	57.2	0.67	
r (14) =	3.7	2.8	0.30	1.8	0.057	2.6	40.2	29.2	11.8	73.3	0.91	
	-0.40*	-0.40*	-0.56*	NS	NS	0.47*	-0.72**	NS	-0.55*	-0.78**	-0.79**	
LSD (P = 0.05)	0.2	1.5	0.02	1.0	0.012	0.2	2.7	1.6	0.61	3.9	0.01	

r = correlation coefficient of x on herbage production
* = P < 0.05
** = P < 0.01

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protection from aphids through the use of insecticides rather than premature grazing or harvesting (Kain and Atkinson 1977) which are known to deplete root reserves (Langer 1967) reduce crop vigour (Dunbier pers comm) and aggravate carry-over effects of aphid damage (Stiefel pers comm).

TABLE 4: Effect of aphid damage on some constituents of lucerne herbage.

	Moisture	% DM Protein	Crude Fibre	Carbo- hydrate	Fat	ppm DM Car†	Xanth†
Harvest A (5th Dec)							
5-10 aphids/stem	9.13	24.0	21.7	31.9	2.78	150	379
untreated	8.88	23.5	19.5	35.1	2.94	135	333
r (8) =	-	NS	0.69*	NS	NS	NS	0.84*
Harvest B (27th Feb)							
5-10 aphids/stem	10.12	22.6	19.8	36.2	2.11	141	398
untreated	10.33	23.5	17.2	37.6	2.06	127	359
r (14)	-	NS	0.62*	- 0.49*	NS	NS	0.55*
LSD (P = 0.05)	0.71	2.4	0.80	0.90	0.16	12	28

† Car = carotene Xanth = xanthophyll

r = correlation coefficient of x on herbage production or, for xanthophyll, on stem length with degrees of freedom ()

TABLE 6: Effect of aphid damage on root development of lucerne sampled in July.

Treatment Harvest B	Root volume ml	Cross section area (cm ²)		
		Crown	5 cm†	10 cm†
5 aphids/stem	56	10.3	5.2	2.9
untreated	38	6.2	2.8	1.8
LSD (P = 0.05)	10.6	1.58	0.73	0.42

† root depth

TABLE 7: Effect of aphid damage on carbohydrate content of lucerne† roots in February (Harvest B).

Constituent % DM	5-10 aphids/stem	untreated	LSD (P = 0.05)
starch	7.2	4.5	2.4
soluble sugars	7.2	7.0	0.42
total carbohydrate	14.4	10.8	2.61

† only tall plants were analysed six samples in each treatment to minimise effects of disease.

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Fig 2. Correlations between plant constituents, Mo, B, Mn and xanthophyll, and herbage production (Harvest A), or crop height (cm) (Harvest B) and % root carbohydrate and stem weight (Harvest B, † only 10 samples chemically analysed).

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