HGCA

PROJECT REPORT No. 229

APPROPRIATE APHICIDE DOSES FOR SUMMER APHID CONTROL ON WHEAT

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APPROPRIATE APHICIDE DOSES FOR SUMMER APHID CONTROL ON WHEAT

by

J N OAKLEY

ADAS Rosemaund, Preston Wynne, Hereford HR1 3PG

This is the final report of a one year project which started in April 1998. The work was funded by a grant of £129,956 from HGCA (project no. 1714).

Contents

ABSTRACT

Aim. The project aimed to demonstrate the potential of reduced aphicide rates for control of summer aphids in wheat in a range of commercial crops over two seasons.

Conclusions. Sites were established on two commercial wheat crops at or close to each of ADAS Boxworth, Bridgets, High Mowthorpe, Rosemaund and Terrington in both 1998 and 1999. At each site early and later sown crops were used. Each experiment consisted of spray applications with recommended label rate and one-third dose applications of pirimicarb or alpha-cypermethrin and a full rate application of dimethoate at GS 61 compared to an untreated control. More aphids successfully overwintered on crops in the mild winter weather of 1997/98 than have been recorded since 1988/89. Overwintered infestations carried aphid parasitoids and fungal diseases. Wet weather during June further favoured the development of high levels of parasitism and fungal disease. In consequence aphid infestations were controlled naturally before reaching damaging levels at all ten sites. In 1999 grain aphid numbers were reduced by thunderstorms in late May and early June and did not recover to exceed threshold numbers at either GS 61 or 73 at any of the sites. The rose-grain aphid predominated at Terrington and Rosemaund, reaching near damaging levels in one crop at Rosemaund. In the earlier sown crop at Bridgets, a significant yield response was obtained to all the aphicide treatments. This yield increase was obtained despite numbers of aphids remaining below the accepted threshold level of 5 aphids per tiller (equivalent to two thirds of tillers infested with aphids). The crop appeared to be particularly susceptible to aphid damage, due to the combined impact of low soluble stem carbohydrate reserves and a severe attack from wheat blossom midge

Implications for levy payers. A one third rate application of pirimicarb was as effective as the full label rate in controlling moderate aphid infestations. These results confirm earlier findings that a reduced rate can be used as part of an integrated aphid control strategy to tip the balance in favour of the aphids predators. The reduced rate application of alpha-cypermethrin was less effective than the recommended rate. At neither rate was the control of rose-grain aphid infestations on the underside of the leaves as effective as that given by dimethoate or pirimicarb. The results have provided valuable information on the conditions under which natural enemies and wet weather can combine to control aphid infestations. The degree of incidental control of wheat blossom midge was also measured. Dimethoate, pirimicarb and alpha-cypermethrin reduced the proportion of damaged grains by 33, 13 and 28% on average. But at some sites pirimicarb and alpha-cypermethrin increased damage by up to 20%, presumably by killing useful predators when not timed correctly to control the midge.

SUMMARY

The project aimed to demonstrate the potential of reduced aphicide rates for control of summer aphids in wheat in relation to the prevailing levels of natural antagonists in a range of commercial crops over two seasons. A secondary objective was to provide a set of independent data on which to test the models being developed from previous work to enable farmers to predict the outcome of aphid infestations and select the most appropriate control strategy.

Sites were established on two commercial wheat crops at or close to each of ADAS Boxworth, Bridgets, High Mowthorpe, Rosemaund and Terrington in both 1998 and 1999. At each site early and later sown crops were used. Each experiment consisted of spray applications with recommended label rate and one-third dose applications of pirimicarb (P label and P reduced) or alpha-cypermethrin (A label and A reduced) and a full rate application of dimethoate at GS 61 compared to an untreated control. Aphid and natural enemy numbers were monitored at GS 61 and GS 73 and the yields were measured.

Aphid control

More aphids successfully overwintered on crops in the mild winter weather of 1997/98 than have been recorded since 1988/89. Overwintered infestations on some crops not sprayed against BYDV vectors resulted in an early development of aphid infestations together with aphid parasitoids and fungal diseases. Wet weather during June further favoured the development of high levels of parasitism and fungal disease. In consequence aphid infestations were controlled naturally before reaching damaging levels at all ten sites. Numbers declined between GS 61 and GS 73 at seven of the sites and increased somewhat to peak at between 1 and 2.3 aphids per tiller at the other three. At those sites where aphid numbers increased sufficiently to measure the degree of control obtained the reduced rate aphicides performed nearly as well as the recommended label rates (Figure 1).

In 1999 grain aphid numbers were reduced by thunderstorms in late May and early June and did not recover to exceed threshold numbers at either GS 61 or 73 at any of the sites. The rose-grain aphid predominated at Terrington and Rosemaund, reaching near damaging levels in one crop at Rosemaund. This species is more susceptible to aphid parasitoids than is grain aphid, and in years when grain aphid is more frequent is usually controlled by parasitoid

Discussion

The results have provided valuable information on the conditions under which natural enemies and wet weather can combine to control aphid infestations. These measurements will be used to develop a computer based decision support system to decide on the need for aphicide application.

A one third rate application of pirimicarb was as effective as the full label rate in controlling moderate aphid infestations. These results confirm earlier findings that a reduced rate can be used as part of an integrated aphid control strategy to tip the balance in favour of the aphids predators. The reduced rate application of alpha-cypermethrin was less effective than the recommended rate, at neither rate was the control of rose-grain aphid infestations on the underside of the leaves as effective as that given by dimethoate or pirimicarb.

The results confirm observations made in 1989 that where 2.5% or more of aphids are mummified by aphid parasitoids at GS 61 this is indicative that a sufficient degree or parasitism to prevent economic damage is developing. In such circumstances a decision to apply an aphicide could be deferred for a week to see whether numbers do in fact decline. Where some parasitoids are present, but less than 2.5% of aphids are mummified at GS 61 the use of a reduced-dose selective insecticide, to tilt the balance in the natural enemies favour, may be the most appropriate treatment. The results have shown that some useful incidental control of wheat blossom midges may be given by aphicide application but aphicides applied at the wrong time may kill many of the parasitiods that are important in keeping wbm numbers low. As with the approved wbm insecticides to prevent creating later problems it is important to only treat wbm when sufficient numbers are seen to warrant control and apply any sprays within a week of recording a high level of activity in a crop.

In the earlier sown crop at Bridgets site 13 in 1999 a significant yield response was obtained to all the aphicide treatments. This yield increase was obtained despite numbers of aphids remaining below the accepted threshold level of 5 aphids per tiller (equivalent to two thirds of tillers infested with aphids). The crop appeared to be particularly susceptible to aphid damage. Of the various physiological parameters were measured in the most likely physiological cause of increased sensitivity was low soluble stem carbohydrate reserves at 2.14 tonnes/ha, well below the average of 2.87 recorded for Reaper by NIAB. Wheat blossom midge (wbm) also damaged this crop and the levels of damage to the may have contributed to the yield effect as a secondary sink for carbohydrate. Aphids tend to draw the same level of carbohydrate from the phloem, but the impact of this on the crop depends on whether the crop has spare resources to fill the grain sink, and crops with low stem carbohydrate reserves may be more susceptible to damage.

The provisional conclusion from this and a MAFF study is that crops and varieties low in soluble stem carbohydrate reserves may be more susceptible to damage from summer aphid infestations which act as a late season stress factor in a similar manner to drought.

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Oakley J N, Wratten S D, Dixon A F G & Carter N (1988). *The biology and control of cereal aphids*. HGCA Research Review No 10, 67 pp.

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infestations spreading from grain aphids on the crop. As with previous experiments where rose-grain aphid predominated the pyrethroid alpha-cypermethrin was relatively inefficient compared to dimethoate or pirimicarb, which gave good control. The reduced rate application of pirimicarb gave as effective control of aphids as the recommended label rate, but the reduced rate application of alpha-cypermethrin was less effective than the full rate, especially where rose-grain aphid predominated (Figure 2).

Figure 1. Mean percentage reduction of aphid infestations relative to the untreated control given by the different treatments in 1988.

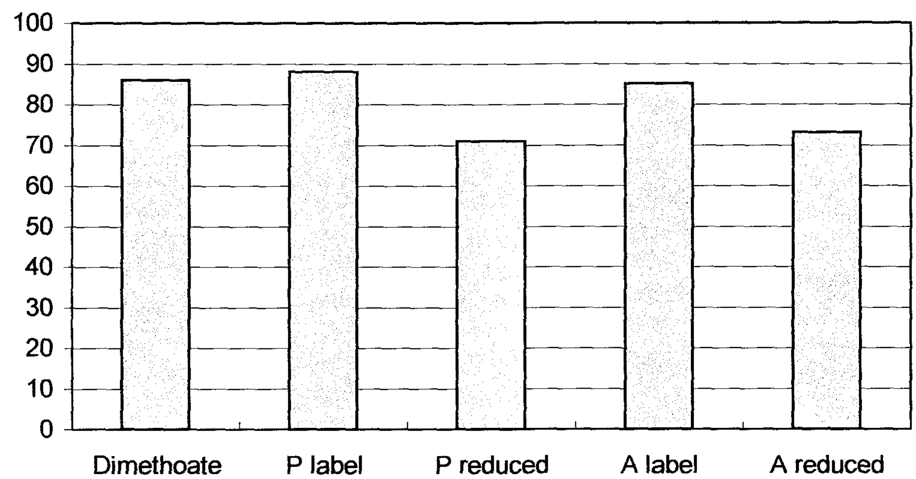
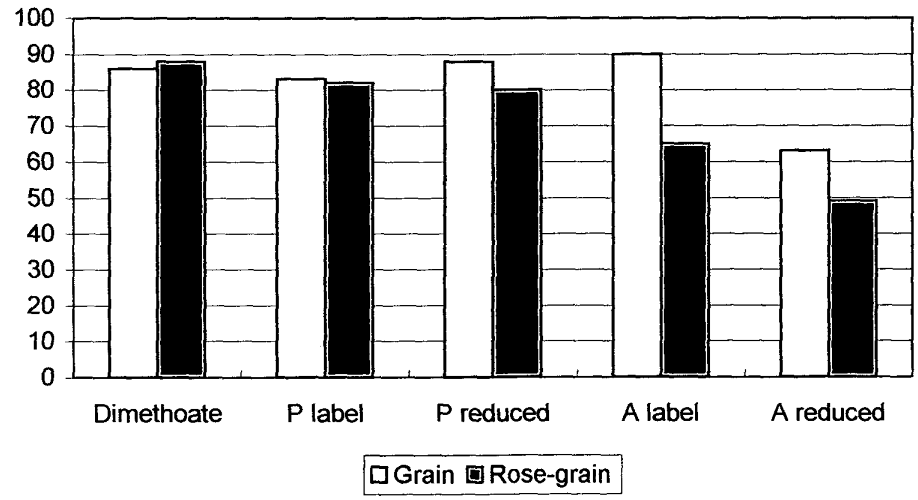
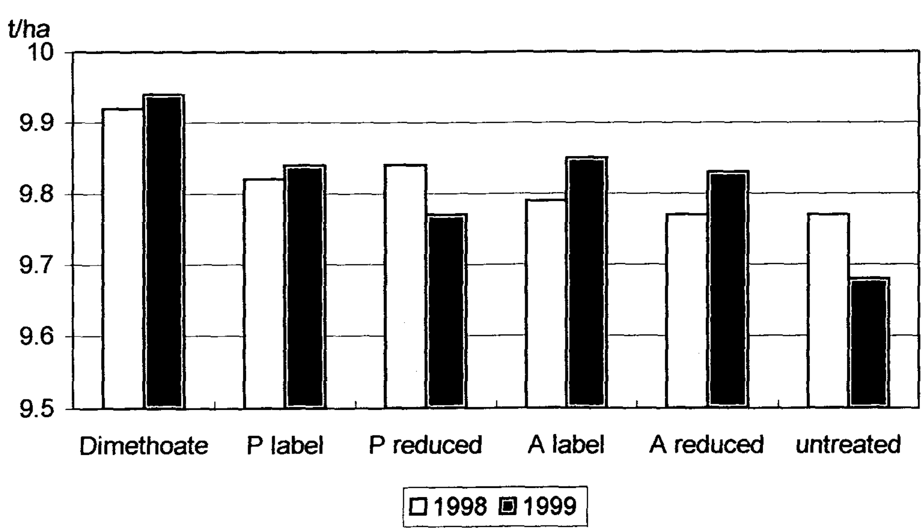


Figure 2. Mean percentage reduction of aphid infestations relative to the untreated control given by the different treatments in 1999, comparing sites with predominantly grain or rose-grain aphid infestations.



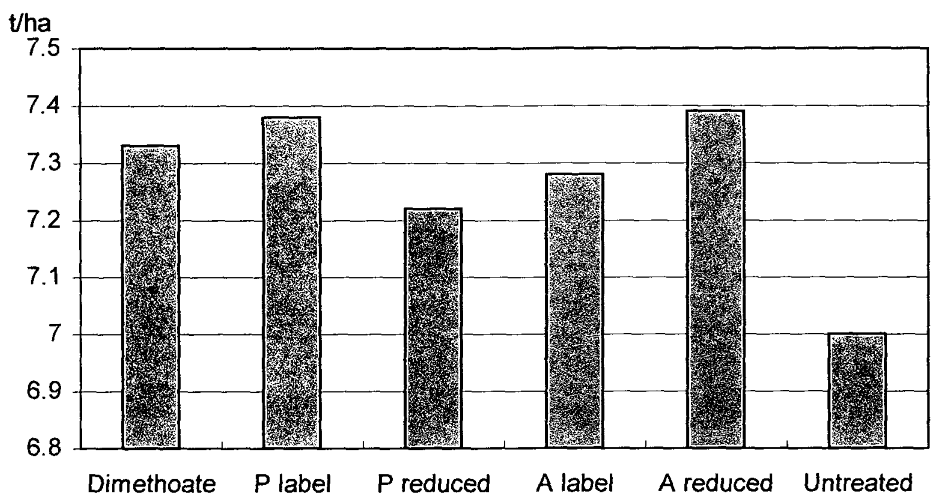
Yields were not significantly affected by treatments at any of the sites in 1998. In 1999 the yields were increased significantly at one site. Taken across all 20 sites there were small increases in yield averaging 0.2 tonnes/ha for dimethoate and 0.1 tonnes/ha for pirimicarb and dimethoate. These increases are probably due to the combined effects of a reduction in sub-economic aphid levels and an incidental control of other pests such as wheat blossom midge, which affected many of the crops (Figure 3).

Figure 3. Average yields (tonnes/ha) recorded across all 20 sites.



In the earlier sown crop at Bridgets in 1999 a significant yield response was obtained to all the aphicide treatments. This yield increase was obtained despite numbers of aphids remaining below the accepted threshold level of 5 aphids per tiller (equivalent to two thirds of tillers infested with aphids). The crop appeared to be particularly susceptible to aphid damage. Various physiological parameters were measured in the crops that are thought to impact on the degree of yield loss caused by aphid infestations. In the case of this particular crop the most likely physiological cause of increased sensitivity was low soluble stem carbohydrate reserves at 2.14 tonnes/ha, well below the average of 2.87 recorded for Reaper by NIAB. Wheat blossom midge (wbm) also damaged this crop and the levels of damage to the grain were assessed to check whether a control of wbm had contributed to the yield effect. Control was generally poor, the spray treatments being applied on 10 June when larvae had already hatched and reached the grain from 74% of the eggs laid in the crop.

Figure 4. Yields (tonnes/ha) from Nevada field at Bridgets in 1999.



Aphid prediction

Under the prevailing conditions of adverse weather and parasitism the numbers of aphids found at GS 73 bore almost no relation to the numbers found on unsprayed plots at GS 61. A regression analysis between the counts at the two dates accounted for 0.4% of the variation only, with a probability of a regression of 0.787. The lack of a relationship was strongly influenced by the Terrington site with heavy parasitism in 1999. If this result was excluded from the regression analysis a week correlation was found accounting for 27% of the variation with a probability of 0.023. In the remaining 19 fields aphid numbers increased by an average of 3.74 ($\pm$ 1.49) times between the two growth stages. This contrasts with results from 1994-6 which gave an average multiplication of 17.18 ($\pm$ 3.97) times between the two stages (*P* 0.001, R^2 59%). The results from the current study provide a useful reminder that aphid populations can fall as well as rise during grain filling and that farmers wishing to economise on aphicide should take the weather conditions and numbers of natural enemies in their crops into account when making decisions.

Other pests

In 1998 the mild spring weather followed by a wet June favoured the development of the orange wheat blossom midge (wbm), which caused more damage than had been recorded since the outbreak year of 1993. Levels affecting the experiments were checked in case of any interference with yields. At five of the sites, where levels were high enough to warrant it, wbm damage was assessed on a sub-sample of grain from each plot to measure the incidental impact of aphicide applications on wbm damage. Wheat blossom midge also caused severe damage to the Nevada site at Bridgets in 1999 to the extent that yields were probably depressed and samples were again checked to establish any incidental effects.

Dimethoate provided the most consistent level of control, reducing damage by 33% on average (range 1 – 56%), pirimicarb reducing damage by 14% (range -22 – 56%) and alpha-cypermethrin reducing damage by 28% (range -15 - 60%), with no differences between the label and reduced dose rates. The variation in efficacy of these chemicals appeared to be affected by their timing in relation to the midges' life cycle, being most effective when applied just before the wbm eggs were due to hatch. The young larvae are thought to be vulnerable to a wider range of insecticides when migrating across the ear in search of a feeding site. Increases in damage may be due to the chemical failing to kill the larvae, but affecting predators feeding on the eggs.

Implications for levy payers

The results have provided valuable information on the conditions under which natural enemies and wet weather can combine to control aphid infestations. These measurements will be used to develop a computer based decision support system to decide on the need for aphicide application.

A one third rate application of pirimicarb was as effective as the full label rate in controlling moderate aphid infestations. These results confirm earlier findings that a reduced rate can be used as part of an integrated aphid control strategy to tip the balance in favour of the aphid's predators. The reduced rate application of alpha-cypermethrin was less effective than the recommended rate. At neither rate was the control of rose-grain aphid infestations on the underside of the leaves as effective as that given by dimethoate or pirimicarb.

The results confirm observations made in 1989 that where 2.5% or more of aphids are mummified by aphid parasitoids at GS 61 this is indicative that a sufficient degree or parasitism to prevent economic damage is developing. In such circumstances a decision to apply an aphicide could be deferred for a week to see whether numbers do in fact decline. Where some parasitoids are present, but less than 2.5% of aphids are mummified at GS 61 the use of a reduced-dose selective insecticide, to tilt the balance in the natural enemies favour, may be the most appropriate treatment. The results have shown that some useful incidental control of wheat blossom midges may be given by aphicide application but aphicides applied at the wrong time may kill many of the parasitiods that are important in keeping wbm numbers low. As with the approved wbm insecticides to prevent creating later problems it is important to only treat wbm when sufficient numbers are seen to warrant control and apply any sprays within a week of recording a high level of activity in a crop.

TECHNICAL DETAIL

Abstract

The project aimed to demonstrate the potential of reduced aphicide rates for control of summer aphids in wheat in relation to the prevailing levels of natural antagonists in a range of commercial crops over two seasons. A secondary objective was to provide a set of independent data on which to test the models being developed from previous work to enable farmers to predict the outcome of aphid infestations and select the most appropriate control strategy. Sites were established on two commercial wheat crops at or close to each of ADAS Boxworth, Bridgets, High Mowthorpe, Rosemaund and Terrington in both 1998 and 1999. At each site early and later sown crops were used. Each experiment consisted of spray applications with recommended label rate and one-third dose applications of pirimicarb or alpha-cypermethrin a full rate application of dimethoate at GS 61 compared to an untreated control. Aphid and natural enemy numbers were monitored at GS 61 and GS 73 and the yields were measured.

More aphids successfully overwintered on crops in the mild winter weather of 1997/98 than have been recorded since 1988/89. Overwintered infestations on some crops not sprayed against BYDV vectors resulted in an early development of aphid infestations together with aphid parasitoids and fungal diseases. Wet weather during June further favoured the development of high levels of parasitism and fungal disease. In consequence aphid infestations were controlled naturally before reaching damaging levels at all ten sites

In 1999 grain aphid numbers were reduced by thunderstorms in late May and early June and did not recover to exceed threshold numbers at either GS 61 or 73 at any of the sites. The rose-grain aphid predominated at Terrington and Rosemaund, reaching near damaging near damaging levels in one crop at Rosemaund. In the earlier sown crop at Bridgets, a significant yield response was obtained to all the aphicide treatments. This yield increase was obtained despite numbers of aphids remaining below the accepted threshold level of 5 aphids per tiller (equivalent to two thirds of tillers infested with aphids). The crop appeared to be particularly susceptible to aphid damage, due to the combined impact of low soluble stem carbohydrate reserves and a severe attack from wheat blossom midge

A one third rate application of pirimicarb was as effective as the full label rate in controlling moderate aphid infestations. These results confirm earlier findings that a reduced rate can be

used as part of an integrated aphid control strategy to tip the balance in favour of the aphids predators. The reduced rate application of alpha-cypermethrin was less effective than the recommended rate, at neither rate was the control of rose-grain aphid infestations on the underside of the leaves as effective as that given by dimethoate or pirimicarb. The results have provided valuable information on the conditions under which natural enemies and wet weather can combine to control aphid infestations. The degree of incidental control of wheat blossom midge was also measured. Dimethoate, pirimicarb and alpha-cypermethrin reduced the proportion of damaged grains by 33, 13 and 28% on average. But at some sites pirimicarb and alph-cypermethrin increased damage by up to 20%, presumably by killing useful predators when not timed correctly to control the midge.

Introduction

MAFF funded experiments following on from recommendations 14-16 of HGCA Research Review No. 10 "The Biology and Control of Cereal Aphids" have confirmed that reducing the dose of either pirimicarb or alpha-cypermethrin to one third or one fifth of the full rate can be equally or more cost effective than the label recommendation. Yield responses were obtained from 16 of the 30 crops treated, although numbers of aphids were above the action threshold level at only one of these sites at the time of treatment. Identifying those sites where aphid control was actually worthwhile would have generated a profit of £35 per ha compared to the rigid application of a simple threshold. The correct application of a variable control strategy for the 50% of crops requiring treatment would have generated an additional £30 per ha profit compared to a fixed response. (Oakley *et al.*, 1996; Longley & Jepson, 1997)

At the majority of responsive sites the yield increases resulted from controlling populations that subsequently rose above threshold levels, but at some numbers remained below threshold and the yield response was due to the crop being unusually susceptible to aphid damage. A three-fold difference in the degree of yield loss due to aphid feeding was found between the sites (Oakley 1997). This project aimed to demonstrate the potential of reduced aphicide rates for control of summer aphids in wheat in relation to the prevailing levels of natural antagonists in a range of commercial crops over two seasons. A secondary objective was to provide a set of independent data on which to test the models being developed from the previous work to enable farmers to predict the outcome of aphid infestations and select the most appropriate control strategy.

Materials and Methods

Sites were established on two commercial wheat crops at or close to each of ADAS Boxworth, Bridgets, High Mowthorpe, Rosemaund and Terrington in both 1998 and 1999. At each site early and later sown crops were used. Sowing dates varied with local weather conditions, but where possible an earlier sown crop that had recieved a cypermethrin spray to control BYDV vectors was contrasted with a later sown crop that had not been sprayed (Table 1).

Table 1. Details of crops used for the experiments

Site	Field	Variety	Sowing date	BYDV spray
1998				
1 Boxworth	Samsons West	Riband	16 Sept	11 Nov
2	Samsons East	Soissons	22 Oct	none
3 Bridgets	Georgia	Reaper	22 Sept	28 Oct
4	Nevada	Reaper	22 Oct	none
5 Mowthorpe	Smithfield	Brigadier	23 Sept	none
6	Skipwith	Consort	23 Oct	none
7 Rosemaund	Town	Riband	10 Oct	16 Feb
8	Titley	Rialto	23 Oct	none
9 Terrington	Tebbs	Riband	25 Sept	12 Nov
10	Rail	Riband	29 Oct	none
1999				
11 Boxworth	Samsons East	Madrigal	16 Oct	none
12	Long Eleven	Rialto	7 Dec	none
13 Bridgets	Nevada	Reaper	11 Sept	
14	Michigan	Reaper	2 Dec	none
15 Mowthorpe	Warren	Hereward	19 Oct	none
16	Homefield	Savanagh	4 Nov	none
17 Rosmaund	Holbach	Consort	15 Oct	20 Mar
18	Bigyard	Claire	21 Oct	none
19 Terrington	Warren	Riband	11 Oct	24 Feb
20	Grove 5	Equinox	18 Dec	none

Plots of 3 by 24 m with 0.5 m paths were burnt out of the standing crops in May each year.

Treatments were applied at GS61

1. dimethoate at 850 ml/ha of 400g ai/l formulation (as BASF Dimethoate 40)
2. pirimicarb at 280 g/ha of 500 g/kg formulation (as Aphox)
3. pirimicarb at 93 g/ha
4. alpha-cypermethrin at 150 ml/ha of 100 g/l formulation (as Fastac)
5. alpha-cypermethrin at 50 ml/ha
6. untreated control

Numbers of aphids and fertile tillers were assessed before the sprays were applied. Samples for soluble stem carbohydrate measurement were collected in June. Aphid numbers and green leaf area were assessed in July at GS73 Plots were harvested for assessment of yield and sub-samples of grain assessed for moisture level, specific weight and thousand grain weight. . Where crops suffered a significant degree of damage from orange wheat blossom midge larvae 1000 grain sub-samples from each plot were assessed for damage.

Results

Initial aphid levels were below threshold levels at all sites, with the highest numbers found at site 20 (Table 2).

Table 2. Date and results of pre-treatment aphid assessment

Site	Date	% tillers attacked	aphids/tiller
1998			
1	12 June	6.0	0.14
2	19 June	4.0	0.16
3	16 June	6.8	0.02
4	16 June	8.2	0.05
5	25 June	22.8	0.81
6	4 July	15.2	0.36
7	12 June	10.2	0.10
8	18 June	16.5	0.71
9	8 June	5.0	0.17
10	8 June	18.1	0.38
mean 98		11.3	0.29
1999			
11	15 June	15.7	0.48
12	21 June	7.7	0.16
13	10 June	5.8	0.18
14	26 June	3.7	0.08
15	24 June	6.0	0.16
16	5 July	2.0	0.18
17	15 June	26.7	0.87
18	17 June	5.6	0.10
19	10 June	19.0	0.57
20	18 June	62.2	3.28
mean 99		15.4	0.61

Crops represented the desired range of physiological parameters with fertile tiller counts ranging from 239 to 600 per square metre and soluble stem carbohydrate reserves from 1.61 to

5.52 tonnes per hectare (Table 3). The majority of crops equalled or bettered the average soluble stem carbohydrate reserves quoted for the variety grown in the NIAB Cereals Variety Handbook 2000, although sites 1, 2, 7, 13, 19 and 20 had lower reserves. Crops tended to be thicker, but have lower carbohydrate reserves, in 1998 than in 1999.

Table 3. Results of physiological assessments

Site	fertile tillers /m^2	soluble stem carbohydrate (t/ha)
1998		
1	700	2.87
2	650	1.79
3	421	3.47
4	396	2.85
5	600	3.82
6	545	2.70
7	357	1.61
8	330	4.06
9	391	2.54
10	590	3.56
mean 98	498	2.93
1999		
11	496	3.42
12	392	5.02
13	412	2.14
14	470	2.57
15	475	3.80
16	464	5.52
17	327	3.37
18	372	3.30
19	239	2.10
20	286	2.04
mean 99	393	3.33
overall mean	446	3.13

Aphid control

More aphids successfully overwintered on crops in the mild winter weather of 1997/98 than have been recorded since 1988/89. Overwintered infestations on some crops not sprayed against BYDV vectors resulted in an early development of aphid infestations together with aphid parasitoids and fungal diseases. Wet weather during June further favoured the development of high levels of parasitism and fungal disease. In consequence aphid infestations were controlled naturally before reaching damaging levels at all ten sites. Numbers declined between GS 61 and GS 73 at seven of the sites and increased somewhat to peak at between 1 and 2.3 aphids per tiller at the other three. At those sites where aphid numbers increased sufficiently to measure the degree of control obtained the reduced rate aphicides performed nearly as well as the recommended label rates (Table 4).

In 1999 grain aphid numbers were reduced by thunderstorms in late May and early June and did not recover to exceed threshold numbers at either GS 61 or 73 at any of the sites. The rose-grain aphid predominated at Terrington and Rosemaund, reaching near damaging levels in one crop at Rosemaund. This species is more susceptible to aphid parasitoids than is grain aphid, and in years when grain aphid is more frequent is usually controlled by parasitoid infestations spreading from grain aphids on the crop. As with previous experiments where rose-grain aphid predominated the pyrethroid alpha-cypermethrin was relatively inefficient compared to dimethoate or pirimicarb, which gave a good control. The reduced rate application of pirimicarb gave as effective a control of aphids as the recommended label rate, but the reduced rate application of alpha-cypermethrin was less effective than the full rate, especially where rose-grain aphid predominated (Table 4).

Table 4. Post treatment aphid numbers at GS 73 detransformed from (log10 number per 25 tillers +1).

Site	dimeth	pirimicarb		α-cypermethrin		control	*P*
		label	low	label	low		
1998							
1	0.00	0.00	0.00	0.00	0.00	0.00	0.451
2	0.00	0.00	0.00	0.00	0.00	0.00	0.451
3	0.00	0.00	0.02	0.02	0.06	0.03	0.410
4	0.08	0.02	0.66	0.23	0.58	1.20	0.046
5	0.00	0.00	0.06	0.01	0.06	0.06	0.046
6	0.02	0.03	0.14	0.03	0.03	1.04	<0.001
7	0.01	0.00	0.01	0.01	0.03	0.01	0.495
8	0.24	0.49	0.31	0.32	0.36	3.32	0.068
9	0.06	0.06	0.34	0.04	0.14	0.14	0.031
10	0.34	0.14	0.29	0.28	0.46	0.49	
mean 98	0.075	0.074	0.183	0.094	0.172	0.629	
1999							
11	0.48	0.53	0.06	0.36	0.45	0.66	<0.001
12	0.02	0.02	0.05	0.01	0.13	0.38	<0.001
13	0.05	0.11	0.04	0.07	0.13	0.48	0.063
14	0.21	0.17	0.02	0.02	0.78	2.43	0.004
15	0.16	0.03	0.06	0.05	0.02	0.07	0.025
16	0.16	0.2	0.27	0.23	0.23	0.26	0.450
17	0.90	1.19	1.48	2.20	3.63	7.92	0.003
18	0.17	0.62	0.52	1.24	1.56	2.40	<0.001
19	0.02	0.04	0.03	0.07	0.07	0.13	<0.001
20	0.15	0.06	0.08	0.11	0.08	0.03	0.050
mean 99	0.224	0.253	0.29	0.442	0.734	1.51	
overall mean	0.15	0.16	0.24	0.27	0.45	1.07	
as % of control	84	85	78	75	58		

Yields were not significantly affected by treatments at any of the sites in 1998. In 1999 the yields were increased significantly at site 13. Taken across all 20 sites there were small increases in yield averaging 0.2 tonnes/ha for dimethoate and 0.1 tonnes/ha for pirimicarb and dimethoate. These increases are probably due to the combined effects of a reduction in sub-economic aphid levels and an incidental control of other pests such as wheat blossom midge, which affected many of the crops (Table 5).

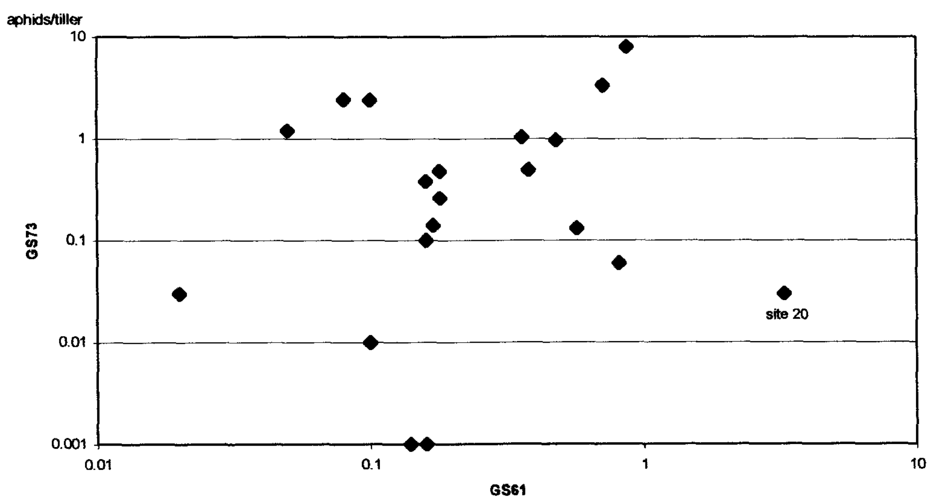
Table 5. Yields of grain (Tonnes/ha @ 85% dry matter).

Site	dimeth	pirimicarb		α-cypermethrin		control	SEM	*P*
		label	low	label	low			
1998								
1	8.18	8.11	8.44	8.12	8.21	8.21	0.135	0.580
2	7.51	7.62	7.52	7.49	7.60	7.60	0.136	0.969
3	10.01	9.88	9.81	9.82	9.57	9.76	0.410	0.698
4	10.01	10.20	10.12	10.15	10.11	9.97	0.276	0.073
5	13.35	13.13	13.12	13.17	13.14	13.16	0.093	0.533
6	10.67	10.30	10.88	10.59	10.62	10.29	0.183	0.241
7	12.18	12.14	12.15	11.98	11.75	12.21	0.367	0.946
8	4.39	3.99	4.01	4.09	4.17	3.97	0.176	0.543
9	11.74	11.94	11.68	11.68	11.69	11.78		
10	11.14	10.93	10.71	10.81	10.86	10.72		
mean 98	9.92	9.82	9.84	9.79	9.77	9.77		
1999								
11	11.04	10.81	10.69	10.46	10.55	10.72	0.215	0.503
12	8.13	7.85	7.72	7.96	7.97	8.10	0.136	0.320
13	11.53	11.35	11.65	11.52	11.59	11.33	0.086	0.103
14	7.33	7.38	7.22	7.28	7.39	7.00	0.052	0.003
15	12.33	12.36	12.25	12.14	11.97	12.12	0.117	0.235
16	10.39	10.52	10.36	10.56	10.26	10.32	0.118	0.540
17	8.97	8.69	8.73	8.99	9.00	8.83	0.170	0.657
18	11.10	10.73	10.96	10.76	10.75	10.55	0.150	0.207
19	10.90	10.51	10.30	10.61	10.58	10.53	0.123	0.081
20	7.69	8.16	7.83	8.24	8.23	7.32	0.265	0.151
mean 99	9.94	9.84	9.77	9.85	9.83	9.68		
overall mean	9.93	9.83	9.81	9.82	9.80	9.72		
as % of control	102.2	101.1	100.9	101.0	100.8			

Aphid prediction

Under the prevailing conditions of adverse weather and parasitism the numbers of aphids found at GS 73 bore almost no relation to the numbers found on unsprayed plots at GS 61. A regression analysis between the counts at the two dates accounted for 0.4% of the variation only, with a probability of a regression of 0.787. The lack of a relationship was strongly influenced by the Terrington site 20 with heavy parasitism in 1999. If this result was excluded from the regression analysis a week correlation was found accounting for 27% of the variation with a probability of 0.023. In the remaining 19 fields aphid numbers increased by an average of 3.74 (± 1.49) times between the two growth stages. This contrasts with results from 1994-6 which gave an average multiplication of 17.18 (± 3.97) times between the two stages (*P* 0.001, R^2 59%). The results from the current study provide a useful reminder that aphid populations can fall as well as rise during grain filling and that farmers wishing to economise on aphicide should take the weather conditions and numbers of natural enemies in their crops into account when making decisions.

Figure 1. Relationship between GS 61 and GS73 aphid numbers on untreated plots.



Other pests

In 1998 the mild spring weather followed by a wet June favoured the development of the orange wheat blossom midge (wbm), which caused more damage than had been recorded since the outbreak year of 1993. Levels affecting the experiments were checked in case of any interference with yields. At five of the sites, where levels were high enough to warrant it, wbm damage was assessed on a sub-sample of grain from each plot to measure the incidental impact of aphicide applications on wbm damage. Wheat blossom midge also caused severe damage to the Nevada site at Bridgets in 1999 to the extent that yields were probably depressed and samples were again checked to establish any incidental effects (Table 6)..

Table 6. Percentage of grains visibly damaged by wheat blossom midge larvae.

Site	dimeth	pir lab	pir low	alpha lab	alpha low	control	SEM	*P*
1	0.8	1.4	1.1	0.8	0.9	0.8	0.20	0.303
2	1.1	0.7	1.0	1.4	0.8	1.2	0.27	0.441
3	6.8	7.5	7.1	7.3	6.3	10.0	0.50	0.002
4	4.0	4.4	4.3	5.2	4.6	6.1	0.57	0.164
7						1.3		
8	5.1	8.2	8.0	4.5	5.9	8.0	0.76	0.010
9						2.8		
10						1.5		
13	11.7	19.1	20.1	12.9	12.7	16.5	1.11	<0.001
14	3.0	3.6	3.1	3.1	3.5	3.0	0.35	0.758