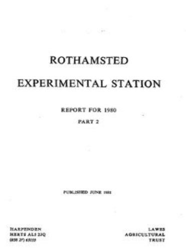
ROTHAMSTED RESEARCH

Rothamsted Experimental Station Report for 1980 Part 2



Full Table of Content

Agricultural Benefits of the Rothamsted Aphid Bulletin

R. Bardner, R. A. French and Maureen J. Dupuch

R. Bardner, R. A. French and Maureen J. Dupuch (1981) *Agricultural Benefits of the Rothamsted Aphid Bulletin ;* Rothamsted Experimental Station Report For 1980 Part 2, pp 21 - 39 **- DOI: https://doi.org/10.23637/ERADOC-1-34237**

Agricultural Benefits of the Rothamsted Aphid Bulletin

R. BARDNER, R. A. FRENCH and MAUREEN J. DUPUCH

Abstract

Since 1968 the *Rothamsted Aphid Bulletin* has been distributed from early spring until late autumn, providing weekly summaries of catches of aerial populations of selected aphids in standardised suction traps. Currently listed are 33 species or species complexes from 22 traps in Britain and Northern Ireland.

The two major uses of these data in advisory work are defining the time and magnitude of aphid movements into crops, and monitoring the growth of aphid infestations in crops. The initial circulation of the *Bulletin* is small, but information derived from it reaches a large number of people in agriculture and related industries, principally through the Agricultural Development and Advisory Service (ADAS) and its Pest and Disease Intelligence Unit. The advent of new methods of rapid data handling and presentation will increase the usefulness of this information. Recipients of the *Bulletin* are most interested in aphids on cereals, potatoes, sugar beet, peas and beans, brassicas and fruit, in that order. Current and future uses of *Bulletin* data in controlling these and other crop aphids are discussed at length.

Quantitative data on aerial populations of aphids can help advisers and growers to make intuitive decisions about the need for control measures and their timing, but the greatest opportunities for improvement are in systematic decision-making, especially where aerial catches can be related to infestations on crops. For these improvements to be achieved considerable further work is needed on economic thresholds and the optimum timing of treatments. However, it is already clear that the cost of the suction trap scheme is small compared with the potential benefits to agriculture.

Introduction

An account of the principles underlying the Rothamsted Insect Survey (RIS) was given in a previous *Rothamsted Report* (Taylor, 1974). There are two separate schemes; one using light traps and the other using suction traps. The light trap survey depends on the cooperation of amateur entomologists who operate most of the traps and identify many of the catches, whereas the suction traps are operated by people who are either professional entomologists or are employed in related fields. Most of the suction trap catches are sorted and identified by Rothamsted staff, and this speeds the collation and distribution of data, especially for aphids. Since 1968 an *Aphid Bulletin* has been compiled at Rothamsted and this is distributed weekly from early spring until late autumn. The present and future uses of this information in agricultural management are the subject of this article.

All important species of crop aphids caught in the suction traps are listed in the *Bulletin*, except those that are difficult to identify as alates (e.g. *Aphis nasturtii* Kalt.) and those that are rarely caught (e.g. *Eriosoma lanigerum* (Haus.)). In addition a few aphids are included because of their ecological interest, even though they are not economically important (e.g. *Drepanosiphum platanoides* (Schrank)). Currently listed are 33 species (or species complexes) from 22 traps in Britain and Northern Ireland (see Fig. 1 in paper by Taylor, French, Woiwod, Dupuch and Nicklen in this *Report*, p. 44).

https://doi.org/10.23637/ERADOC-1-20

Ideally growers and advisers would like to have current information about aphid populations in all fields at risk from aphid attacks. This is an unattainable objective, and even limited field sampling is very expensive in labour costs. Because the variance between crop samples is greater than that between trap samples (Taylor, 1977) fewer trap samples are needed to give the same level of precision. Furthermore, because the trap samples all species in the aerial population at the same time the information collected per man hour is greater than with crop sampling. An additional advantage is that those responsible for the collection and sorting of suction-trap data are not liable to be diverted to other tasks in response to advisory emergencies.

The two major uses of *Aphid Bulletin* data in advisory work are:

1. Defining the time and magnitude of aphid movements into crops.
2. Monitoring the population growth of aphid infestations in crops.

Both uses depend on being able to relate the numbers of aphids in suction traps (the aerial population) to numbers on crops and so far more attention has been paid to (1) than to (2).

A disadvantage of the *Aphid Bulletin* is the 8–14 days which elapse between capturing the aphids and receipt of the *Bulletin*. The postal transmission of catches causes some delay as does the time required to sort the catches and prepare the *Bulletin*; in addition there is further delay as most copies of the *Bulletin* are despatched by post every Friday, and cannot reach recipients until Monday morning at the earliest. Developments in data-handling now make alternative and quicker methods feasible for the collation of data, its presentation and transmission.

Recipients of the *Aphid Bulletin*

At the end of 1978 a questionnaire was sent to the 129 *Bulletin* recipients, to enquire about their needs and their opinions of the Survey; 102 replies were received. These showed that 51% of recipients used the data mainly for advisory work, 42% mainly for research and 7% for other purposes, principally teaching. Sixty per cent were primarily interested in the current pest situation, the remainder being more interested in using the data to explain past events. Eighty per cent of those who had advisory work as their main interest would prefer more rapid data processing and transmission.

Only about 10% of the aphid species caught in the suction traps are listed in the *Bulletin*, though all aphids caught are eventually identified. Nevertheless recipients seem to be satisfied with the species selected for the *Bulletin* and few wished for changes. Listing aphids by the numbers of *Bulletin* recipients expressing interest (Table 1) closely parallels the crops with which recipients are concerned (Table 2), and the relative economic importance of these crops. A notable omission is grassland, which occupies an area greater than all arable crops combined, though few entomologists take an interest in it.

Many people would like information about other groups of insects caught by the suction trap, e.g. other Hemiptera, thrips and entomophagous parasites and predators. Existing staff are too few to provide these data, but retrospective information is sometimes available from other workers collaborating with the Survey who sort and identify groups relevant to their research interests.

Though the initial circulation of the *Bulletin* is small, information from it is passed to an average of 30 colleagues per recipient, and as so many are concerned with advisory work the data eventually reaches a large number of people in agriculture and ancillary industries, particularly through the Agricultural Development and Advisory Service (ADAS) and its Pest and Diseases Intelligence Unit. This article is mostly concerned with the use of the suction traps in pest monitoring and management, but it is worth emphasis-

https://doi.org/10.23637/ERADOC-1-20

TABLE 1

Importance of aphids, ranked by numbers of Aphid Bulletin *recipients expressing interest*

Myzus persicae gp.	66
Sitobion avenae	64
Rhopalosiphum padi	64
Metopolophium dirhodum	53
Macrosiphum euphorbiae	46
Aphis fabae gp.	46
Brevicoryne brassicae	40
Metopolophium festucae	30
Sitobion fragariae	29
Rhopalosiphum insertum	29
Aulacorthum solani	27
Acyrthosiphon pisum	24
Cavariella aegopodi	22
Myzus ascalonicus	15
Rhopalosiphum maidis	19
Phorodon humuli	19
Brachycaudus helichrysi	14
Aphis spp.	14
Pemphigus spp.	10
Myzus ornatus	10
Myzus certus	8
Nasonovia ribis nigri	7
Hyalopterus pruni	7
Amphorophora rubi	6
Pentatrichopus fragaefolii	5
Hyperomyzus lactucae	4
Dysaphis plantaginea	4
Megoura viciae	3
Elatobium abietinum	3
Drepanosiphum platanoidis	3
Phyllaphis fagi	2
Eriosoma ulmi	2
Cinera spp.	1

TABLE 2

Crops of interest to recipients of the Aphid Bulletin

Cereals	334	Brassicas	69
Potatoes	232	Soft fruit	58
Sugar beet	106	Top fruit	58
Peas and beans	101	Other crops	158

ing that data from the Survey have already been utilised in over 70 published papers, and the range of user interests is very wide, from determining when to burn-off seed potato foliage to investigating the relationship between the breeding success of swallows, martins and swifts and the aerial population of insects upon which they feed.

The remaining sections of this article discuss current and future applications of Insect Survey data to the aphid problems of cereals, sugar beet, potatoes, field beans, hops and other crops, with a final section discussing general methods of utilising the data in plant protection.

Cereals

The crop and the aphids. After grass, barley and wheat are the two largest and most valuable crops. In 1978 the United Kingdom grew 2·35 million ha of barley, worth £548 million, and 1·25 million ha of wheat, worth £444 million. There were also 0·18 million ha of oats, valued at £19·5 million, and smaller quantities of mixed corn, rye and maize for threshing.

The aphid fauna of cereals is varied, but amongst the commonest species are *Sitobion*

https://doi.org/10.23637/ERADOC-1-20

avenae (Fab.), which is a serious pest on the ears of cereals, especially wheat, *Metopolophium dirhodum* (Wal.), which is common on the upper leaves of cereals, and *Rhopalosiphum padi* (L.), an important vector of barley yellow dwarf virus (BYDV). The problems caused by each aphid are discussed below, with the information provided by the suction traps.

Sitobion avenae. This species has caused much concern to wheat growers in recent years, but populations vary greatly from season to season (Table 3).

TABLE 3

Catches of S. avenae *at Rothamsted Tower up to week 32 (early August)*

1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
169	171	237	6395	2117	2464	3199	1254	647	483	1523	7589	1784	551	362	710

Populations on wheat increase rapidly about the time of ear emergence, and spraying to control these is recommended at the commencement of flowering or Zadoks growth stage (Tottman, Makepeace & Broad, 1979) GS 60/61 where there is a population of five or more aphids per ear and the numbers are rising. The results of 49 experiments between 1974 and 1977 showed that if this threshold was used to determine the need for a single spray of pirimicarb the mean yield increase of sprayed plots was approximately 12·5% (George & Gair, 1979), whereas the increase for sprayed plots with populations below this threshold was less than 4%.

George and Gair's data show that populations vary considerably between fields. In 1974, when there were 22 experiments, the mean numbers of aphids per ear at GS 60/61 was 7·8 with a maximum of 51·1 and a minimum 0·1. Examination of these data suggests a skew distribution, with only about one-third of fields having populations greater than the arithmetic mean.

Correct timing of sprays is important. George and Gair found that delaying treatment from GS 60/61 to 68/69 (end of flowering) could decrease the mean yield increase from 10 to 4·3%, yet crops often complete their flowering in about a week.

Aphicide use on cereals can be very extensive in years of aphid abundance. In 1977, for example, sprays were applied to an area equivalent to nearly half the winter wheat crop in England and Wales (Steed, Sly, Tucker & Cutler, 1980) though the actual area treated may have been less as some fields were treated more than once.

S. avenae populations developing in cereal fields can be correlated with catches in the nearest suction trap (Dewar, unpublished), allowing traps to be used to give an objective assessment of variations in populations between years and between seasons. To provide information of the same quality from field surveys would require vast resources in manpower to maintain continuous monitoring of very many cereal fields throughout the growing season. Insect survey information is very useful because if few aphids have been caught by the time most crops are at GS 60/61 it is very unlikely that damaging populations of *S. avenae* will develop. Conversely, if very large numbers are caught, crops are obviously at risk. The difficulty is to decide on the advice to be given in the majority of seasons which fall between these two extremes. A possible solution to this problem is described later.

Metopolophium dirhodum. This aphid prefers the leaves to the ears of cereals. Until recently it was thought to have less effect on winter wheat than *S. avenae*, as the latter usually has larger colonies, but in 1979 very large populations of *M. dirhodum* developed. Spraying wheat at GS 60/61 had no effect on yield because of rapid recolonisation, but a

https://doi.org/10.23637/ERADOC-1-20

second spraying at GS 73 (Early milk) gave yield increases similar to those of effective sprays against *S. avenae* (Dean, Dewar, Powell & Wilding, 1980).

M. dirhodum is the predominant species on barley where field conditions apparently do not favour the establishment of large *S. avenae* populations. George (1974) has summarised 12 experiments on spring barley in south Essex in 1970–72 in which *M. dirhodum* was the predominant species. Spraying every 10 days from brairding (GS 21) to ripening (GS 90) increased yields by a mean of 8·8%, the maximum response being +17% and the minimum −2%.

M. dirhodum is abundant in suction traps, and as with *S. avenae* RIS data can be used to give warning of aphids moving into the crop and will also provide information about seasons of unusual abundance, or scarcity. Following the outbreak in 1979, the pest status of *M. dirhodum* is being re-assessed but previously very little spraying of commercial cereal crops seems to have been done to control this aphid. In 1974 and 1977 less than 1% of the area sown to barley was sprayed with aphicide (Chapman, Sly & Cutler, 1977; Steed *et al.*, 1980).

***Rhopalosiphum padi* and other virus vectors.** *R. padi* is important as a pest of young rather than mature plants. In common with *S. avenae*, *M. dirhodum* and other grass aphids such as *Rhopalosiphum insertum* (Walk.), it is a vector of barley yellow dwarf virus (BYDV). Infestations of *R. padi* are often smaller than those of *S. avenae* and *M. dirhodum* but the strains of BYDV this species transmits are particularly damaging.

Cereals suffer more severely from BYDV in the South-west, where both *R. padi* and *S. avenae* can overwinter in an active state on grasses and cereals. Infection occurs in the autumn, when *R. padi* is the cereal aphid most frequently caught in suction traps (Plumb, 1977), and crops sown in September are frequently more at risk than those sown later in the year. Spring-sown crops are also vulnerable, particularly those sown late, which are still in early growth stages when aphids begin to migrate. Oats and barley are more susceptible to the effects of BYDV than is wheat, but it is difficult to make realistic estimates of losses. This is because not only do aphid populations fluctuate greatly from year to year and area to area, but so does the proportion of each species carrying BYDV and the frequency of the various BYDV strains.

Information on aphid virus infectivity can, at present, be obtained only by live trapping and subsequent testing of aphids. The Survey suction traps are unsuitable for this purpose but do give warnings of seasons of unusual aphid abundance. With some testing of live aphids, and with information about sowing dates and growth conditions, some advice on the suitability of insecticide treatments to protect the early stages of crop growth can often be given. Plumb (1977) also makes the point that 'the value of advice not to use chemicals should be seen as at least as important and perhaps in the long run more valuable than the warning that treatment is necessary'. This, of course, is because of the risk of aphids developing resistance to insecticides.

Future improvements. If the recommended threshold for *S. avenae* is to be used effectively each field should be inspected at the correct growth stage. Past experience with similar problems suggests that many growers find insect counts difficult. ADAS staff are able to issue general advice as a result of their field monitoring, but can only sample a small fraction of the fields at risk in the limited time at their disposal. They also have the information provided by the *Aphid Bulletin*, which has the advantage of less variance than field sampling, but is, at present, usually 8–14 days old before it reaches them. However, the ability to relate suction trap catches to field populations should make it possible to use suction trap catches as one of the inputs of the models of *S. avenae* population growth now under development in Britain and Holland (Rabbinge, Anker-

https://doi.org/10.23637/ERADOC-1-20

smit & Pak, 1979; Carter & Dewar, in the press). The main driving component of these models is temperature, so short-term weather forecasts should enable the models to give up-to-date estimates of aphid populations for different stages of crop growth and for each region of Britain. If these hopes are fulfilled, growers need only check the growth stage of their crop, which is much simpler than counting aphids. Information provided by the model would then tell them whether spraying is needed. Such a scheme might also decrease the number of growers using schedule sprays; this would lessen the chances of developing resistant strains of aphids, decrease environmental risks and be less costly for the grower.

It may also be possible to develop a similar scheme for *M. dirhodum*. The problem of *R. padi* and other vectors is much more difficult, but the computer mapping system of aphid distributions now available (Taylor, 1974) should enable areas at risk to be identified more readily.

In the last few years about one-third of surveyed winter wheat crops have had populations of *S. avenae* exceeding the thresholds at growth stage 60/61. Assuming a 12·5% yield loss if unsprayed, and a maximum spraying cost of 6·0% of the yield (George & Gair, 1979) the benefits from correct treatment were about £25 ha^{-1} if wheeling damage were avoided. With a wheat crop of 1·25 million ha, the majority of which is winter wheat, the possible savings through correct decision-making for this crop alone are obviously very large, and could be even greater if aphicides become widely used on barley.

Sugar beet

The crop and the aphids. Sugar beet is grown mainly in eastern and to a lesser extent in central and western England. In 1978 there were 204 000 ha, valued at £156 million.

The two aphids of greatest concern to the growers are *Myzus persicae* (Sulz.) and *Aphis fabae* Scop. Both migrate from winter to summer hosts in May and June, with further movements between summer hosts later in the season. *M. persicae* is an effective vector of both beet yellows virus (BYV) and beet mild yellowing virus (BMYV). The proportion of the aphid population carrying viruses is variable and probably small, but because it is the main virus vector, *M. persicae* is considered much more damaging than *A. fabae*. Transmission of viruses by *A. fabae* is considered to be relatively unimportant, but this aphid can form large colonies on plants and damage them by its feeding, whereas feeding by the smaller colonies of *M. persicae* is thought to have little effect on yields. Dunning (1975) used crop inspection records to show that *A. fabae* is second only to *M. persicae* as an arthropod pest of sugar beet, but it is difficult to determine losses caused by *A. fabae* because attacked plants may also be infected with viruses.

Neither BYV nor BMYV are seed transmitted, infection and spread within the crop being entirely due to aphids. The viruses cannot pass transovarially from aphid to aphid, so initial infection of the crop each spring is from aphids which have fed recently on virus-infected plants such as sugar beet ground keepers. BYV can be acquired and transmitted more quickly than BMYV, but the proportion of aphids carrying virus on leaving an infected plant is greater with BMYV (Cockbain & Heathcote, 1965). Heathcote (1978) concluded that 'during the past 30 years, a crop loss (from viruses) of more than 10% has been caused in only 3 years, and of over 5% in only 6 years'. The average annual loss was the equivalent of £2·5 million at 1974 prices or about 3% but in the period 1970–75 losses were greater and Heathcote calculated them to be £4·2 million per annum, or about 5%, despite the use of insecticidal sprays which saved another £3·1 million a year, more than three times their cost. These figures conceal both annual and local fluctuations; losses in 1974 were 18% and Heathcote considered about 30% of the growing area in

https://doi.org/10.23637/ERADOC-1-20

1970–75 required additional control measures to decrease the incidence of infection below the thresholds of economic loss.

Since 1975 the situation has again altered because of the extensive use of systemic insecticide granules applied at planting.

Methods of control. There are now two methods of controlling aphids with insecticides in beet. Systemic insecticide granules can be drilled with the seed, and will also control many other pests, but their effect does not persist long enough to control a late immigration of aphids. These granules only became generally available to growers in 1975 and subsequent years, but were used on 36% of the crop area in 1977 (Steed *et al.*, 1980). The other method is to use insecticide sprays (or more rarely granules) applied to the foliage. These are mainly carbamates or organophosphates and the insecticidal effect is of much shorter persistence than that of granules drilled with the seed. Many populations of *M. persicae* have a proportion of resistant aphids (Devonshire & Needham, 1975; Sawicki, Devonshire, Rice, Moores, Petzing & Cameron, 1978) and this is one reason for the increased use of the carbamate pirimicarb, which was not available in 1974. In that year, when aphid infestations were severe, aphicides were applied to 295 000 'spray hectares'. As the crop area was only 195 000 ha much of the crop was treated twice or more (Chapman *et al.*, 1977). In 1977 the crop occupied 202 000 ha and 160 000 spray hectares were treated, 65 000 ha were treated with aldicarb, 27 000 with pirimicarb and 62 000 with organophosphates. The remaining 6000 ha were treated with organochlorines or other carbamates (Steed *et al.*, 1980). Probably the stimulus for the use of granules was the 'bad' aphid year of 1974, but Heathcote (1978) considers their use solely to control aphids can only be justified in areas where yellows spread in most years.

Before migration occurs it is sometimes possible to predict years when viruses are likely to spread widely using correlations with winter weather (Watson, Heathcote, Lauckner & Sowray, 1975), and it is rather easier to predict seasons when *A. fabae* will be abundant (see section on Field Beans), but for neither pest is it, at present, possible to predict the correct time to spray.

Monitoring the movement of aphids to the crop is essential for the most effective control, indicating the need for sprays and their timing. Hull and Heathcote (1967) found that when sprays were applied at the time warnings were issued there was a 10% greater decrease in yellows incidence compared with sprays applied either 2 weeks earlier or 2 weeks later. Granular treatments gradually lose their effectiveness with time, so a late movement of aphids into crops treated with granules at planting may necessitate spraying.

The British Sugar Corporation Aphid Warning Scheme. As part of their duties, sugar-beet fieldmen make aphid counts on crops each working day. Reports are sent to the local Factory Agricultural Manager and as a result warnings may be sent to growers. These take the form of yellow cards sent by post, and may either recommend spraying, or suggest that growers examine their crops and spray if any aphids are found. Some managers also issue white cards if many black aphids have been found but spraying is not considered generally necessary to control virus yellows. Growers are under no compulsion to follow any of this advice.

The thresholds for issuing cards vary from area to area. One green aphid per 4 plants is often used in southern and central areas, but more aphids are acceptable in the north where there is less virus spread. A common threshold for black aphids is more than 50 per plant or 70% plants infested, but again, this is often modified in view of local experience and conditions.

Factory Agricultural Managers also send a report each Friday to Broom's Barn

https://doi.org/10.23637/ERADOC-1-20

Experimental Station, and on the following Monday a *Bulletin* is compiled which incorporates these reports and Insect Survey data. This is sent to each factory, ADAS, commercial firms concerned with agrochemicals and their application, and local radio.

Uses of the Insect Survey data. The Broom's Barn *Bulletin* forwards information from the RIS to each Factory Agricultural Manager, but this information is already 8–12 days old when it reaches Broom's Barn, and another week elapses before it can influence growers through spray warning cards, although it can reach growers by mid-week through local radio. Information from the Broom's Barn trap is delayed less as this catch is sorted and identified at Broom's Barn, and this trap is very important since it is located in a large beet-growing area.

Is it possible to make more use of Insect Survey data? One obvious way is to speed the flow of data to recipients such as Broom's Barn, and this possibility is now being examined. Some years ago, Heathcote, Palmer and Taylor (1969) showed that suction traps were more effective in detecting the time of the first seasonal immigration of both *M. persicae* and *A. fabae* than was the BSC crop inspection scheme. Since then the usefulness of suction traps has increased because of their greater number and the ability to produce computer-drawn maps of aerial populations. However, catches of early migrants of *M. persicae* in suction traps are very small, and it has not yet been established whether they can be quantitatively related to population densities on sugar beet. There would seem to be a better chance of doing this with *A. fabae*, since such a relationship has been established for *A. fabae* and field beans, and in any case, higher numbers of *A. fabae* can be tolerated on plants, but again, this relationship has not yet been investigated for sugar beet. If traps could be used to provide data on the likely size of populations in crops it might be possible to dispense with some of the laborious field inspections.

Potatoes

The crop. In 1978 about 6 million tonnes of potatoes were produced in England, Wales and Scotland from 0·2 million ha of land, the crop being worth about £242 million. The important potato industry of N. Ireland is administered locally and is not discussed in this section. Crop areas are regulated to decrease production fluctuations, but yields and prices vary greatly, mainly in response to weather. Aphids are vectors of the most damaging potato viruses, and also decrease yields directly by their feeding. Methods of growing the crop vary, making it necessary to give separate consideration to the aphid problems of each of the major sub-divisions of the crop.

Potatoes being vegetatively propagated require large areas for the production of 'seed'. Those intended for human consumption are known as 'ware' and are further sub-divided into 'earlies' and 'main crop', the latter being all crops lifted after 2 July, which includes most '2nd earlies'.

These divisions are not rigid, for 'seed' crops which do not meet Certification Scheme requirements are sold as ware, whilst some ware potatoes are retained by their growers for their own use as uncertificated 'once grown' seed. Potatoes which are graded out of ware crops may be fed to livestock; the fraction used in this way being greater in years of surplus.

The proportion of the growing area occupied by the three principal classifications in 1977 is given in Table 4, derived from the data of Steed *et al.*, (1980).

Although some potatoes are grown in all areas, production is generally more intensive on the drier eastern side of Britain. In England the areas bordering the Wash are especially important for the main crop. Certified seed crops in England and Wales are mostly grown in upland areas.

https://doi.org/10.23637/ERADOC-1-20

In Scotland, potato growing of all types is mainly in lowland areas, ware and seed crops being intermingled.

TABLE 4

Relative areas of earlies, main crop and seed potatoes, 1977

	% of total
England and Wales	
Main crop	68·0
Earlies	12·2
Seed	2·6
Scotland	
Main crop	7·2
Earlies	0·7
Seed	9·3

The aphids. Many aphids are found on potatoes, but the commonest and most efficient virus vectors are:

Myzus persicae (*Sulz*). ***The Peach-potato aphid.*** This very polyphagous species is also a serious pest of sugar-beet and other crops. If present in large numbers it can cause damage by its feeding, but is best known as the most important potato virus vector. It can overwinter as apterae on herbaceous plants, but also lays eggs on *Prunus* spp.

Aulacorthrum solani (*Kltb.*), ***the Glasshouse-potato aphid,*** is often a pest of sprouting tubers in chitting houses, as is *M. persicae*. In the field it causes twisting and distortion of foliage, but is a less efficient virus vector than *M. persicae.*

Macrosiphum euphorbiae (*Thomas*), ***the Potato aphid,*** is also a polyphagous species but not as effective as *M. persicae* as a virus vector though it is more common. Large infestations distort the haulm. It overwinters on roses.

Aphis nasturtii ***Kltb. the Buckthorn-potato aphid,*** is not an efficient virus vector, but occasionally multiplies to such an extent that the haulm is killed. It overwinters on Buckthorn, *Rhamnus cathartica.*

Aphid transmitted viruses. Because potatoes are vegetatively propagated viruses are particularly important and infection of the 'seed' crop will result in seed tubers being infested. The two most serious viruses are the 'persistent' potato leaf roll virus (PLRV), and the 'non-persistent' potato virus Y (PVY). PLRV can only be acquired and transmitted by prolonged aphid feeding, the aphids then remain infective for life. Virus Y is acquired and transmitted very quickly, but aphids soon lose their infective ability if removed from a source of virus. Insecticides can decrease infection of crops by immigrant aphids carrying PLRV, but they cannot prevent infection of a crop with PVY, though they are effective in preventing aphid reproduction and hence decrease the spread of PVY within a crop. The effects of each virus on the yield of infected plants is severe, especially if tubers are infected before planting, or if infection occurs early in the season.

Main crop potatoes in England and Wales. Much of the main crop is planted with 'once-grown' uncertified seed saved from the ware crop. In 1975 the proportion of crops planted with such seed varied from 18% in East Anglia to 38% in the North (Anon, 1976). It is important to protect this seed against infection with PLRV and this can be done by using systemic insecticide granules at planting, followed by systemic sprays later in the season. These measures do not protect against PVY carried by immigrant aphids,

https://doi.org/10.23637/ERADOC-1-20

though oil sprays show some promise. However, Govier (unpublished) has found that infection with PVY at Rothamsted is correlated with the Rothamsted suction trap catches of various aphids such as *Brachycaudus helichrysi* that land on potato foliage, a larger group than those which will normally reproduce on potatoes. If this relationship can be shown to hold for other areas, growers could be warned in seasons and districts where the amount of PVY in crops intended for once grown seed is likely to make them unsuitable for this use.

Aphicides are extensively used on main crop potatoes. In 1977, 55% of the crop was treated, often more than once (Steed *et al.*, 1980). In 1974, 9·3% of the treated area received granular insecticides at planting (Chapman *et al.*, 1977) (18·3% in 1977). Because so much of the crop is treated with aphicides it is likely that growers are aware of the potential loss from aphid feeding in addition to the risk of infecting with virus crops intended for once-grown seed. Control of virus spread within a ware crop in the season of infection is not considered important (Carden,1965) though this view might change if there were effective methods of controlling PVY.

Two ADAS studies have shown the benefits of controlling aphids in main crop potatoes. Carden (1965) in 34 experiments obtained a mean increase of 2·64 t ha^{-1}, which was 10% of the mean yield of untreated plots. The dominant aphid in the more severe infestations was *A. nasturtii*. Southall and Sly (1976) found the mean increase in 56 experiments was 1·7 t ha^{-1}, or 1·8 t ha^{-1} when fungicides were also used. Those increases were 4·5–5·0% of the mean yield of untreated plots, and the dominant aphids were *M. persicae* and *M. euphorbiae*.

Carden concluded that if extra wheeling damage was avoided (by treatment at planting or combining aphid and blight sprays), control was justified in 70% of the experiments. Southall and Sly found that control did not increase yields if there were less than 100 aphids per 100 leaves at peak infestation. Although it is clear that the use of aphicides regularly increases yield, there is a dearth of information about threshold levels and the correct timing of sprays, for by the time peak numbers have been reached it is too late to spray. In 1974, only 11% of the total 'spray hectares' had been applied by the middle of June, 63% being applied in late June and early July (Chapman *et al.*, 1977), which was probably rather late for maximum efficiency, and it seems likely that many growers wait until the first blight spray is due, to avoid additional wheeling damage.

The areas treated to control aphids on main crop potatoes are considerably greater than the treated areas of seed crops, though the aphid problems of the seed crop have attracted much more attention. Probably many main crop sprays are being applied as routine treatments, and whilst this situation may be economically justifiable now it may not continue because of the insecticide resistance problem with *M. persicae* (see section on sugar beet).

Selective treatments are preferable. The Insect Survey can be used to warn growers of the time and size of aphid movements to crops, but to make the most effective use of this information more work is needed on threshold numbers justifying aphid control in main crop potatoes, on the effects of the date of treatment on yield and whether catches in suction traps can be related to the growth of aphid populations on potatoes.

Earlies in England and Wales. These are lifted before July, so direct damage by large numbers of aphids is less likely, and only about 20% of the crop is treated with aphicides. There appears to be no information about the necessity for spraying, but it is possible that aphids appear earlier since many earlies are grown in mild districts. Any decrease of yields because of aphid attack will be most serious because of the high value per unit of this crop.

https://doi.org/10.23637/ERADOC-1-20

The seed crop in England and Wales. Use of aphicides on the small seed crop in England and Wales is extensive. In 1977 most of the crop received several aphicide sprays, the average being 4·6 (Steed *et al.*, 1980). In addition, 14% of the area was treated with organophosphate insecticides at planting.

In outlying seed-producing areas, such as North Yorkshire, Fidler, Neild and Murdoch (1967) and Rogerson and White (1969) concluded that the chief hazard of virus infection is not aphid multiplication within the crop, but the migration of aphids into the crop from adjacent ware-producing areas. Perhaps RIS data could be used to monitor the likelihood of this in different seasons, as the problem seems similar to that highlighted in Govier's work with PVY. The Survey data are already used to help in determining dates for burning-off (Ebbels, unpublished).

Main crop and seed in Scotland. In Scotland there is often little difference between pest control practices on main crop and seed potatoes, the ultimate use of the crop being determined by the grading achieved in the Certification Scheme and the demand for seed. Scottish certified seed was used in 55% of the British main crop in 1975 (Anon, 1976), so it is extremely important to decrease virus infection to the lowest practical levels. Aphids in Scotland infest the crop later than in England or Wales, but although potential seed crops are 'rogued' to remove virus-infected plants this is not always completely effective and the presence of such plants can cause down-grading or even rejection. There have been increased virus infections of seed crops in recent years, causing much concern. Woodford, Shaw, McKinlay and Foster (1977) suggested that mild winters had increased the aphid problem. Until about 1973 aphicides were little used and in 1974 aphicides were applied to only about 6% of the crop (Chapman *et al.*, 1978). In 1976 a survey showed 80% of grower dealers sprayed aphicides, and 15% used granular insecticides at planting, while by 1977 it was difficult to find untreated fields in many areas (Woodford *et al.*, 1977). These authors also give details of the warning system now in operation which is based on crop inspection for aphids. They believe this is a more reliable method of detecting primary aphid migrants in the spring than the use of suction traps, however, Turl (1980) concludes that the dates of the first catches in suction traps can be related to spring temperatures, and that this could form the basis of a predictive system for aphids infesting potatoes.

Earlies in Scotland. These occupy a very small area—only 0·7% of the total area of the British potato crop. In 1974, no aphicides were used (Chapman *et al.*, 1977). The combination of a northern latitude and early lifting is unfavourable to the development of aphid populations.

Chitting houses. In 1975 41% of the British main crop acreage was planted with chitted seed (Anon, 1976). *A. solanii* and *M. persicae* can reproduce on potato shoots in chitting houses and are often controlled by fumigation. Chitting houses are a potential source of alate aphids migrating into potato crops where they may also cause virus problems, especially if the chitted seed is once grown.

Future improvements. It is evident that the aphid problems of potatoes are as varied as the purpose for which the crop is grown. The problems of the certified seed crop have received most attention in recent years, but it is likely that further research will show that there is considerable potential for use of RIS data in the management of the English and Welsh main and once-grown seed crops, on which most aphicides are now used.

https://doi.org/10.23637/ERADOC-1-20

Field beans

The crop. Thirty-eight thousand ha of field beans (*Vicia faba* L.) were grown in the UK in 1978, valued at £8 million. About one-third of the crop was autumn sown and two-thirds was spring-sown.

The aphids. *A. fabae* is the most serious pest, and uncontrolled infestations may completely destroy spring-grown crops; autumn-sown beans are not often damaged. *A. fabae* is also a pest of sugar beet and will colonise several annual weeds, especially in late summer.

The commonest 'green' aphids infesting beans are *Acyrthosiphon pisum* (Harris) and *Megoura viciae* Buck. Neither species form large colonies on beans so their feeding has little direct effect on the yield. *A. pisum* is much more abundant than *M. viciae* and is a vector of bean leaf roll and other viruses. Green aphids often infest bean crops before *A. fabae* but at present little is done to control them.

Losses caused by *A. fabae*. The yields of beans are extremely variable, even in crops unattacked by *A. fabae*. This is partly due to climatic effects, but also to variations in attacks by other pests and diseases (Bainbridge, Bardner, Cockbain, Day, Fletcher, Hooper, Legg, McEwen, Salt, Webb & Wilding, 1977). Cammell and Way (1977) calculated that if control measures had not been used in the period 1970–75, losses caused by *A. fabae* would have averaged £16·1 ha^{-1}, using crop values then current. This is equivalent to 12% of the mean yield but there were large variations in the incidence of attack between seasons and between fields.

Methods of control. All chemical methods of control for *A. fabae* rely on systemic insecticide sprays, or granules, applied to the foliage. Before the introduction of the bean aphid forecasting scheme, described below, there were two recommended control measures (Anon, 1974). Either an annual preventative treatment could be applied to the crop in early June, when small and inconspicuous numbers of aphids are usually present, or an eradicant treatment could be applied later when the infestation became obvious. Both methods have disadvantages. In some years and in some areas preventative treatments are unnecessary, because of the small number of primary migrants from spindle (Way, Cammell, Alford, Gould, Graham, Lane, Light, Rayner, Heathcote, Fletcher & Seal, 1977), and with eradicant treatments, the late applications result in smaller yield increases (Bardner, Fletcher & Stevenson, 1978).

An alternative method is now available (Way & Cammel, 1973; Way *et al.*, 1977; Way, Cammell, Taylor & Woiwod, 1981), based mainly on the examination of overwintering stages on *Euonymous europaeus* L. (Spindle), but also on RIS data on the autumn movement of *A. fabae* to the winter host and the spring movement back to annual crops. Forecasts of likely levels of infestation are made available to ADAS entomologists for 18 separate areas south of the Humber. In 1970–75, the net annual loss with no treatment would have been £16·1 ha^{-1}, with a routine preventative treatment £8·5 ha^{-1}, and with treatments based on forecasts £4·7 ha^{-1} (Cammell & Way, 1977).

Although forecasts are distributed to ADAS staff, there are no quantitative data about the number of growers receiving this information, or the use they make of it. Surveys of pesticide usage on field beans were done in 1974, a year of severe *A. fabae* infestations, and 1977, when infestations were small; these suggest that growers do respond to annual variations in aphid abundance by altering the quantity of insecticide used. Aphicides were used on 40 089 spray-hectares in 1974, equivalent to 77% of the spring-sown crop, but only on 8876 spray-hectares in 1977, equivalent to 35%. In both years there was

https://doi.org/10.23637/ERADOC-1-20

little spraying of the autumn-sown crop; only 390 spray-hectares in 1974 and 1096 in 1977 (Chapman *et al.*, 1977; Steed *et al.*, 1980).

The RIS and the bean aphid forecast. The forecast scheme has been in operation since 1970, and with the additional information from suction traps the following measurements are now available (Way *et al.*, in press):

1. Autumn migration of aphids to spindle (from suction traps)
2. Overwintering eggs on spindle
3. Spring populations of aphids on spindle
4. Spring migration to annual crops (from suction traps)
5. Aphids on bean crops in June
6. Secondary migration of aphids to other summer hosts (from suction traps).

The autumn migration provides the earliest indication of the potential risk to the next year's bean crop, suction trap catches accounting for 28% of the variance in the percentage of infested bean stems in early to mid-June of the following year. Later counts of eggs or spring aphid populations on spindle account for a greater percentage of the variances in infested bean stems but suction trap catches of aphids caught during the spring migration from spindle are better still, accounting for 64%.

Ideally, insecticides should be used at the end of primary migration, when the catch of aphids in the trap has passed its peak, and there is a 'trough' in catches before secondary migration becomes conspicuous. Suction traps are designed to catch aphids migrating from distant sites as well as local ones, and secondary migration can start in some districts before primary migration has finished in others, so frequently the trough is not evident. In these circumstances, a measurement which is influenced by local phenology is necessary. Inspection of individual bean crops can be done by growers themselves, but for advisory purposes treatment is recommended about two weeks after aphid populations on the most heavily infested spindle bushes begin to collapse (Way *et al.*, 1977). These authors comment that corrcet recommendations for the application of insecticides have always been made as a result of following this procedure, even in 1976, when migration was exceptionally early.

The weekly *Aphid Bulletin* also provides data on *A. pisum* and *M. viciae*. Correlations between numbers in traps and numbers in the field have not yet been established, but if there are few aphids in the traps, field infestations are usually small (Cockbain, personal communication), so the trap data are of use to research workers concerned with these pests, and especially those concerned with *A. pisum* as a vector of Bean leaf roll and other viruses.

Conclusions. The warning system seems to be working well. The *Aphid Bulletin* is available to all ADAS entomologists who request it, but in addition, all data relevant to *A. fabae* forecasts are co-ordinated by Imperial College entomologists at Silwood Park, and transmitted by them to ADAS advisors. Postal delays in the transmission of autumn counts of *A. fabae* from Rothamsted traps are not important, as no immediate action is required. However, this is a problem with spring counts, though the timing of early summer applications of insecticides to the bean crop is usually fixed by the local disappearance of aphids from spindle bushes rather than their appearance in suction trap catches.

Hops

The crop and its pest disease problems. Hops occupied 29 064 ha in 1879, but the area devoted to this crop is now much smaller and is still contracting. In 1969 it was 6769 ha and

https://doi.org/10.23637/ERADOC-1-20

in 1979 5695 (Thresh, 1979). The same author says that in 1979 the crop was worth £15 million, i.e. about £2500 ha^{-1}, so it is a high value crop. It is now grown only in Southern England and the West Midlands. The major pests and diseases of hops are the damson-hop aphid (*Phorodon humuli* Schrank), red spider mite (*Tetranychus urticae* Koch.), wilt (*Verticillium albo-atrum* Reinke & Berth), powdery mildew (*Sphaerotheca humuli* (D.C.)) and downy mildew (*Pseudoperonospora humuli* (Miyabe & Takah)). There is a lavish use of insecticides and fungicides and in 1975 figures provided by Nix (1976) show that the cost of these materials and their application amount to 15·5% of the input costs. In 1977 30 t of insecticides (active ingredient) were used, 3 t acaricides, 0·03 t of molluscides and 187 t of fungicides (including 120 t sulphur) (Umpelby & Sly, 1978). There was also an extensive use of tar oil.

Control of aphids. Damson hop aphid, which overwinters on *Prunus* sp. is considered to be a much more serious pest than red spider. The first winged migrants are usually produced in the second half of May, but migration from *Prunus* to hops continues into July, or even August (Anon, MAFF, 1979). Hence repeated sprays or drenches are necessary to control the continued influx of aphids into hop gardens.

If uncontrolled, aphids can cause complete loss of yield. Apart from the effects of their feeding on the growth and survival of the foliage the aphid honeydew fouls the hop cones and encourages the growth of sooty mould, which results in down-grading. Aphids also transmit Hop Mosaic Virus, to which the variety Goldings is susceptible (Thresh, 1979). Figures published by Umpelby and Sly (1978) show that in the years 1973–77 the average number of applications of insecticides per season varied between 4·9 and 6·6. Cultivated hops are the major summer host for the aphid, though it can also be found on wild or feral hops. Because most of the aphid population is exposed to aphicides the selective pressure is high and the first confirmed record of resistance in Britain was in 1965 (Anon, 1966). Hop aphids are resistant now to a wide range of organophosphates and to some carbamates, though with both groups the level of resistance varies considerably between the different compounds. There are also low levels of resistance to endosulfan and permethrin (Muir & Cranham, 1979). A wide variety of pesticides is currently recommended for aphid control, at concentrations which should ensure 95% kill if the spray contacts the aphids. Because of the dangers of developing greater resistance to the insecticides currently in use there is considerable interest in integrated control, using a decreased number of insecticide applications and placing more reliance on natural enemies, especially anthrocorids, and this work is still being developed (Muir & Cranham, 1979).

The beginning of migration can vary by 2–3 weeks and the end by up to 7 weeks. Insecticide treatments must be effective when aphids arrive on hops, but if control is efficient, further applications of insecticide are not usually needed after migration ends because natural enemies will kill the few remaining aphids.

Use of RIS data. Assessment of the need for treatment is mainly through crop examination by growers, but suction traps are a valuable source of additional information.

In the spring, aphids are usually caught in the traps a few days before they are first detected on hops. Growers can then be alerted provided this information can be distributed quickly. Suction traps are also useful for monitoring the end of migration; this is very difficult to ascertain from crop examination. Unfortunately, traps are unlikely to be useful in monitoring the growth of aphid populations on hops, because, unlike cereal aphids, alate hop aphids are not produced from crowded populations, but only in response to the physiological state of the plants at the end of the growing season.

Collaborative work between Wye College and Rothamsted has shown recently that

https://doi.org/10.23637/ERADOC-1-20

correlations exist between mean air temperatures and catches of both the first and last aphids moving to hops at Wye and Rosemaund (Hereford), providing growers with a valuable additional aid to monitoring movement.

In the S. East the most useful trap is at Wye, although the Writtle trap catches more hop aphids. In the West Midlands the Hereford trap is nearest to the crop.

The benefit of the Survey to hop-growers is obvious but difficult to evaluate economically. There are no recent estimates of the losses that hop aphids cause, or the effects that better treatment timings have on control costs or on losses. Using Nix's figures and the current value of the crop it seems that about £1 million is spent on the control of pests and diseases (not weeds), and perhaps 40–50% of this is spent on aphid control. If the Survey could decrease the cost of aphid control by only 10% (i.e. less than one spray round), the saving would be roughly equal to the entire annual cost of the suction trap scheme—or 0·3% of the value of the crop.

Other crops

Crops for which there is generally less information about aphid problems are considered here, including grassland, vegetables, fruit and forests.

Grassland. In the UK the area under grass is greater than that of all arable crops combined. In 1978 there were 2·0 million ha of temporary grass, 5·0 million ha of permanent grass and 5·1 million ha of rough grazing. The aphids which occur on cereals also infest grasses, but their effects on growth and yield are difficult to assess. Aphids such as *R. padi* can cause severe damage at high densities (Gair, 1953) and are also virus vectors. Henderson and Clements (1977) obtained yield increases of 0–32% when insecticides were applied to ryegrass swards and it is probable that part of the increase was the result of aphid control. The economics of applying dimethoate were analysed by Henderson and Clements (1976). If treatment is applied frequently enough to control pests (including aphids) the costs cannot be justified. Little or no grass land is treated to control aphids, and though it might be possible to use Insect Survey data to monitor risks to grassland from aphid feeding, aphids would still need testing to assess virus infection risks.

Vegetables. Vegetables grown in the open occupied 210 000 ha in 1978, valued at £431 million. Brassica crops accounted for about one-third of the value and one-quarter of the area. Aphicides are frequently applied to brassicas, mostly against *Brevicoryne brassicae* (L.) and usage is particularly heavy on late-maturing crops such as sprouts and winter cabbage, fouling by aphids making them unacceptable to buyers. Catches of *B. brassicae* in suction traps reach their maximum in late autumn, when numbers are increasing in the crop, so traps can probably be used to monitor risks. Some ADAS entomologists consider that trap catches do not always reflect crop infestations, especially in early summer when catches are small but dispersal is starting from the brassica crops on which aphids have overwintered. Early treatment can be important as both *B. brassicae* and *M. persicae* are vectors of cauliflower mosaic virus. It would seem desirable to investigate the use of Insect Survey data for this crop.

Peas are another valuable crop, occupying 100 000 ha and worth £53 million in 1978. A substantial portion of the crop is sprayed with aphicides, though these are often intended as broad spectrum treatments active against aphids and various other pests. The commonest aphid, *A. pisum* a vector of several viruses, is also common in suction traps and it is probable that RIS data could be used for monitoring and forecasting; further work is needed to investigate this possibility.

Carrots are attacked by the Willow-carrot aphid, *Cavariella aegopodi* (Scop.), a vector

https://doi.org/10.23637/ERADOC-1-20

of carrot motley dwarf virus, and common in suction traps. Doubts have been expressed about the ability of traps to give adequate information about the time of arrival on carrots, though apparently parsley-growers find the information useful.

The lettuce crop was worth about £40 million in 1977. About half is grown under glass. Several species of aphids attack lettuce, including *Nasonovia ribis nigri* (Mosley), *Hyperomyzus lactucae* (L.) and *Pemphigus bursarius* (L.). Some are virus vectors. Much aphicide is used and advisors find the Insect Survey data useful for estimates of aphid abundance.

Orchard fruit. In 1978 there were 50 000 ha of orchards worth £88 million. Aphicides are used extensively, especially on apples. which comprise 75% of the crop, though often applications are broad spectrum treatments to kill other pests as well. Of the eight species of aphid attacking apples, *Dysaphis plantaginea* (Passerini) is probably the most damaging species, but it is not common in suction traps and is difficult to identify. The only species caught in large numbers is the apple-grass aphid, *Rhopalosiphum insertum* (Wlk.), and numbers caught in the autumn, when leaving the grass summer hosts, are correlated with egg-laying aphids found on apple (Taylor, 1977). Unless very abundant, this aphid causes little damage; growers are still advised to examine trees for this and other aphids before deciding to spray. Monitoring of all pests on the trees is becoming more important with the increased use of integrated control methods rather than schedule sprays.

Pears, plums and cherries also have aphid problems, but so far Insect Survey data seem to be utilised only as an aid to a general impression of pest abundance.

Soft fruit. There were 16 000 ha worth £45 million in 1978. Strawberries were by far the most valuable, the production from 6500 ha being worth £28 million. Aphicides are used on an extensive scale. *Pentatrichopus fragaefolii* Cock. is an effective virus vector, but is only caught in small numbers by the traps. *Myzus ascalonicus* Doncaster causes distorted growth in strawberries and is caught in suction traps in large numbers; it is likely that trap data could be used for monitoring populations and warning growers. Raspberries, currants and gooseberries are less valuable than strawberries and have fewer aphid problems. Only moderate amounts of aphicides are used. Little use seems to have been made of RIS data.

Forestry. Several tree aphids are listed in the *Aphid Bulletin*, but the only one of economic importance in forestry is the Spruce Aphid, *Elatobium abietinum* (Walk.). This can have a severe effect on the growth of spruce (*Picae*) (Carter, 1977). The aphid is anholocyclous in Britain, dispersal flight taking place only in early summer (Carter & Cole, 1977), and severe infestations occur about one year in three. There is little development of new populations from these aphids until the following autumn, so trap catches can be used to give early warning of potentially damaging infestations.

Future improvements. In the crops discussed in this section there are some whose most damaging aphids, particularly those without common wild hosts, are only caught in small numbers by suction traps, or where some of the important aphids are difficult to identify (e.g. apples). Other aphids may be important as vectors of plant viruses early in the season, when catches of alates are small (e.g. brassicas and carrots). In all these cases RIS data may be of limited use (though with viruliferous aphids similar difficulties occur on potatoes and sugar beet). However, there are many situations where aphids could be monitored, and their numbers predicted in advance, as with *R. insertum* on apple. With this exception there has not been any attempt so far to correlate aphids on the crops reviewed in this section with suction trap catches, and indeed very little use of RIS data except in the most general way. In many cases the criteria growers use for aphicide

https://doi.org/10.23637/ERADOC-1-20

application are also unclear and there would seem ample opportunity for making applications more selective, with the aid of RIS data.

General conclusions

Taylor (1973) observed that the justification for aerial sampling with suction traps is not that it is ideal, but that it is practical. In contrast to field sampling, large amounts of data are produced per man-hour, and no subjective element is involved. The information is strictly quantitative, enabling relationships between catches, weather conditions and host-plant development to be investigated.

From the discussion of individual crop problems it is clear that the data can either be used to assist advisors and growers to form an intuitive impression of the development of an aphid attack, or it can be used as a source of data for systematic pest management, incorporating threshold levels for control decisions. So far the main use of the Survey in advisory work has been for the first purpose, the *Bulletin* data being used to supplement data from grower's reports and ADAS field sampling. Answers to our questionnaire revealed that 72% of Bulletin recipients also obtained information from other methods of sampling aphids. Over half thought that these methods were not comparable with *Bulletin* data, those that ventured an opinion were evenly divided as to whether data from the *Bulletin* were better or worse, though nearly all found the information useful.

Intuitive decisions about pest control based on available information is the normal practice for most pest situations, and current efforts to improve the presentation and rapid distribution of suction trap data should improve such decisions. Nevertheless, the real opportunities for improvement are in the use of the data for decision thresholds, and serious attempts to exploit these possibilities have begun only recently, making it easier to point to opportunities rather than successes. The most rewarding situations are likely to be those where trap catches can be related to population growth in the crop, as with cereal aphids, but even when this is not so, correlation between trap catches and weather conditions may enable better timing of treatments, as with hop aphids. A difficulty is that in many cases we do not know what population levels justify control, or what is the optimum time of treatment. Furthermore, with viruliferous aphids, live trapping and subsequent testing is also needed. It is to be hoped that the availability of quantitative data from suction traps may stimulate interest in rationalising the decision-making process for more aphid problems. This will require further collaborative work between Rothamsted staff, ADAS and others concerned with these crops. Closer links are already being established, particularly with the ADAS Pest & Disease Intelligence Unit. What is clear already is that the costs of the Survey are small compared with the opportunities for gain, for even the elimination of one spray round in a minor crop, such as hops, would pay for the entire annual cost of the suction trap scheme.

Acknowledgements

We acknowledge with thanks the help of *Bulletin* recipients and numerous colleagues in ADAS and Rothamsted who answered our many questions. Particular thanks are due to those who allowed us to quote from unpublished results or who read through sections of this manuscript.

References

ANON (1966) *East Malling Research Station Annual Report for1965*.
ANON (1974) Black bean aphid—*Advisory leaflet* No. 54, Ministry of Agriculture, Fisheries and Food.
ANON (1976) Report on the survey of maincrop potato production 1975–1976. Potato Marketing Board.
ANON (1979) Plum aphids. *Ministry of Agriculture, Fisheries and Food Advisory Leaflet* No. 641.

https://doi.org/10.23637/ERADOC-1-20

BAINBRIDGE, A., BARDNER, R., COCKBAIN, A. J., DAY, J. M., FLETCHER, K. E., HOOPER, D. J., LEGG, B. J., MCEWEN, J., SALT, G. A., WEBB, R. M. & WILDING, N. (1977) Recent work at Rothamsted on factors limiting yield of field beans. Proceedings of the symposium on the production, processing and utilisation of the field bean (*Vicia faba* L.). *Scottish Horticultural Research Institute. Bulletin* No. 15, 28–38.

BARDNER, R., FLETCHER, K. E. & STEVENSON, J. H. (1977) Pre-flowering and post-flowering insecticide applications to control *Aphis fabae* on field beans: their biological and economic effectiveness. *Annals of Applied Biology* **88**, 265–271.

CAMMEL, M. E. & WAY, M. J. (1977) Economics of forecasting for chemical control of the black bean aphid, *Aphis fabae* on the field bean *Vicia faba*. *Annals of Applied Biology* **85**, 333–343.

CARDEN, P. W. (1965) Economics of aphid control of ware potatoes. *Proceedings of the 3rd British Insecticides and Fungicides Conference*, 308–316.

CARTER, C. I. (1977) Impact of green spruce aphid on growth: can a tree forget its past? *Forestry Commission Research and Development Paper* No. 116.

CARTER, C. I. & COLE, J. (1977) Flight regulation in the green spruce aphid (*Elatobium abietinum*) *Annals of Applied Biology* **86**, 137–151.

CARTER, N. & DEWAR, A. M. (1981) The development of forecasting systems of cereal aphid outbreaks in Europe. *Proceedings of the 9th International Congress of Plant Protection* (In the press.)

CHAPMAN, P. J., SLY, J. M. A. & CUTLER, J. R. (1977) Pesticide usage survey report 11—arable farm crops 1974. Ministry of Agriculture, Fisheries and Food.

COCKBAIN, A. J. & HEATHCOTE, G. D. (1965) Transmission of sugar beet viruses in relation to the feeding, probing and flight activity of alate aphids. *Proceedings of the 12th International Congress of Entomology*, 521–523.

DEAN, G., DEWAR, A. M., POWELL, W. & WILDING, N. (1980) Integrated control of cereal aphids—*International Organisation for Biological Control West Palearctic Regional Section Bulletin* No. III–4, 30–47.

DEVONSHIRE, A. L. & NEEDHAM, P. H. (1975) Resistance to organophosphorus insecticides of peach-potato aphid (*Myzus persicae*) from sugar beet in 1975. *Proceedings of the 8th British Insecticides and Fungicides Conference*, 15–19.

DUNNING, R. A. (1975) Arthropod pest damage to sugar beet in England and Wales, 1947–74. *Rothamsted Experimental Station. Report for 1974*, Part 2, 171–185.

FIDLER, J. H., NEILD, J. R. A. & MURDOCH, G. (1967) Aphids and the increase of potato leaf roll virus in seed potatoes on the Wolds of the East Riding of Yorkshire. *Plant Pathology* **16**, 97–103.

GAIR, R. (1953) Observations on grass aphids in Derbyshire, 1950–52. *Plant Pathology* **2**, 117–121.

GEORGE, K. S. (1974) Damage assessment aspects of cereal aphid attack in autumn- and spring-sown cereals. *Annals of Applied Biology* **77**, 67–74.

GEORGE, K. S. & GAIR, R. (1979) Crop loss assessment on winter wheat attacked by the grain aphid, *Sitobion avenae* (F.), 1974–77. *Plant Pathology* **28**, 143–149.

HEATHCOTE, G. D., PALMER, J. M. P. & TAYLOR, L. R. (1969) Sampling for aphids by traps and by crop inspection. *Annals of Applied Biology* **63**, 155–166.

HEATHCOTE, G. D. (1978) Review of losses caused by virus yellows in English sugar beet crops and the cost of partial control with insecticides. *Plant Pathology* **27**, 12–17.

HENDERSON, I. F. & CLEMENTS, R. O. (1976) The effect of a short-persistence systemic insecticide on the yield of perennial ryegrass. *Journal of the British Grassland Society* **31**, 15–17.

HENDERSON, I. F. & CLEMENTS, R. O. (1977) Grass growth in different parts of England in relation to invertebrate numbers and pesticide treatment. *Journal of the British Grassland Society* **32**, 89–98.

HULL, R. & HEATHCOTE, G. D. (1967) Experiments on the time of application of insecticide to decrease the spread of yellowing viruses of sugar-beet 1954–66. *Annals of Applied Biology* **60**, 469–478.

MUIR, R. C. & CRANHAM, J. E. (1979) Resistance to pesticides in damson-hop aphid and red spider mite on English hops. *Proceedings of the 1979 British Crop Protection Conference—Pests and Diseases*, 161–166.

NIX, J. (1976) Farm management pocketbook, 7th Edition. Wye College, School of Rural Economics, Farm Business Unit.

PLUMB, R. T. (1977) Aphids and virus control on cereals. *Proceedings of the 1977 British Crop Protection Conference—Pests and Diseases*, **3**, 903–913.

RABBINGE, R. ANKERSMITT, G. W. & PAK, G. A. (1979) Epidemiology and simulation of population development of *Sitobion avenae* in winter wheat. *Netherlands Journal of Plant Pathology* **85**, 197–220.

ROGERSON, J. P. & WHITE, J. H. (1969) Aphids and the spread of leaf-roll virus in seed potatoes in the North Riding of Yorkshire, 1964–66. *Plant Pathology* **18**, 156–163.

SAWICKI, R. M., DEVONSHIRE, A. L., RICE, A. D., MOORES, G. D., PETZING, S. M. & CAMERON, A. (1978) The detection and distribution of organophosphorus and carbamate insecticide-resistant *Myzus persicae* (Sulz) in Britain in 1976. *Pesticide Science* **9**, 189–201.

SOUTHALL, D. R. & SLY, J. M. A. (1976) Routine spraying of potatoes to control aphids and potato blight during 1969–73. *Plant Pathology* **25**, 89–98.

STEED, J. M., SLY, J. M. A., TUCKER, G. G. & CUTLER, J. R. (1980) Pesticides Usage Survey Report 18—Arable Crops. MAFF.

TAYLOR, L. R. (1974) Monitoring change in the distribution and abundance of insects. *Rothamsted Experimental Station. Report for 1973*, Part 2, 202–237.

TAYLOR, L. R. (1977) Aphid forecasting and the Rothamsted Insect Survey. *Journal of the Royal Agricultural Society of England* **138**, 75–97.

https://doi.org/10.23637/ERADOC-1-20 *pp 19*

TAYLOR, L. R., FRENCH, R. A., WOIWOOD, I. P., DUPUCH, M. J. & NICKLEN, J. (1981) Synoptic monitoring for migrant insect pests in Great Britain and Western Europe. I. Establishing expected values for species content, population stability and phenology of aphids and moths. *Rothamsted Experimental Station. Report for 1980*, Part 2, 41–64.

THRESH, J. M. (1979) Recent changes in the health status of English hop plantings. *Proceedings of the 1979 British Crop Protection Conference—Pests and Diseases*, 169–175.

TOTTMAN, D. R., MAKEPEACE, R. J. & BROAD, H. (1979) An explanation of the decimal code for the growth stages of cereals, with illustrations. *Annals of Applied Biology* **93**, 221–234.

TURL, L. A. D. (1980) An approach to forecasting the incidence of potato and cereal aphids in Scotland. *EPPO Bulletin* **10**, 135–141.

UMPELBY, R. A. & SLY, J. M. A. (1978) Pesticides usage survey report 16—Hops 1973 to 1977. Ministry of Agriculture, Fisheries and Food.

WATSON, M. A., HEATHCOTE, G. D., LAUCKNER, F. B. & SOWRAY, P. A. (1975) The use of weather data and counts of aphids in the field to predict the incidence of yellowing virus of sugar-beet crops in England in relation to the use of insecticides. *Annals of Applied Biology* **81**, 181–198.

WAY, M. J. & CAMMELL, M. E. (1973) The problem of pest and disease forecasting—possibilities and limitations as exemplified by work on the bean aphid, *Aphis fabae*. *Proceedings of the 7th British Insecticide and Fungicide Conference 1973* 933–954.

WAY, M. J., CAMMELL, M. E., ALFORD, D. V., GOULD, H. J., GRAHAM, C. W., LANE, A., LIGHT, W. I. St G., RAYNER, J. M., HEATHCOTE, G. D., FLETCHER, K. E. & SEAL, K. (1977) Use of forecasting in chemical control of black bean aphid, *Aphis fabae* Scop., on spring-sown field beans, *Vicia faba* L. *Plant Pathology* **26**, 1–7.

WAY, M. J., CAMMELL, M. E., TAYLOR, L. R. & WOIWOD, I. P. (1981) The use of egg counts and suction trap samples to forecast the infestation of spring-sown field beans, *Vicia faba* by the black bean aphid, *Aphis fabae*. *Annals of Applied Biology* **98**, 21–34.

WOODFORD, J. A. T., SHAW, M. W., MCKINLAY, R. G. & FOSTER, G. N. (1977) The potato aphid spray warning scheme in Scotland, 1975–1977. *Proceedings of the 1977 British Crop Protection Conference—Pests and Diseases* 247–254.

https://doi.org/10.23637/ERADOC-1-20