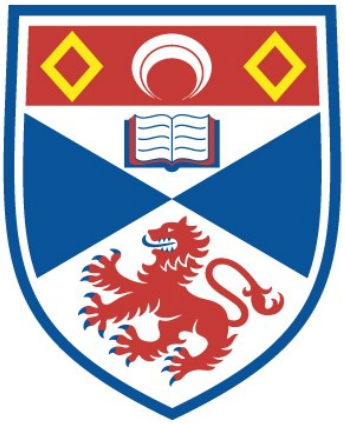
STUDIES IN THE ECOLOGY OF POTATO APHIDS IN EASTERN SCOTLAND WITH SPECIAL REFERENCE TO MYZUS PERSICAE (SULZER)

Alexander Gloag Fisken

A Thesis Submitted for the Degree of PhD/MPhil...
at the
University of St Andrews



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by

A. G. FISKEN

A Thesis submitted for the Degree of

Doctor of Philosophy

in the University of St. Andrews

1957

CERTIFICATE

I certify that Alexander G. Fisken has spent nine terms at research work under my direction, and that he has fulfilled the conditions of Ordinance 16 (St. Andrews) so that he is qualified to submit the following Thesis for the Degree of Doctor of Philosophy.

Supervisor

DECLARATION

I declare that this Thesis records the results of experiments carried out by me; that it is my own composition; and that it has not been previously presented for a higher degree.

This research was carried out at the Scottish Horticultural Research Institute, Invergowrie, by Dundee, under the direction of Dr. C. H. Cadman.

CONTENTS

		Page
I	Introduction	1
II	Materials and methods	6
	1 Aphid traps	6
	i Water traps	6
	ii Suction traps	11
	2 Preparation of aphids for identification	11
	3 Recording aphid populations	13
	i Potato crops	13
	ii Brassica crops	16
III	The overwintering of potato aphids ...	17
	1 Overwintering of Myzus persicae ...	17
	i Peaches...	20
	ii Glasshouses	20
	iii Heated frames	22
	iv Root clamps	28
	v Brassicas	29
	a Causes of decline of aphid populations	49
	b The inter-relationship between overwintered and spring planted crops	51
	2 Overwintering of Macrosiphum euphorbiae	57

3 Overwintering of Aulacorthum solani 59

IV Infestation of the potato crop by aphids 60

i Distribution of potato crops surveyed 60

1 Infestation by Macrosiphum euphorbiae and Aulacorthum solani 65

2 Infestation by Myzus persicae 68

i Midlothian 75

ii Other sites south of the Forth ... 77

iii Fife 80

iv Angus (South) 80

v Angus (North) 82

vi Perth (South) 83

vii Perth (North) 83

viii Moray 84

V Discussion 90

VI References 98

VII Acknowledgments 103

VIII Appendix tables 104

Education and Research Training.

In June 1952 I graduated B.Sc. in Agriculture with First Class Honours in Zoology at Edinburgh University.

I registered as a Research Student in the University of St. Andrews in October 1953, and the work described in this Thesis was completed in October 1956.

I INTRODUCTION

Seed potato growing is one of the most important agricultural industries in eastern Scotland and thrives because aphid-borne virus diseases, the main causes of degeneration of potato stocks, spread only slowly in this area. Table 1 gives a measure of the economic importance of the seed potato crop to Scotland and Table 2 shows that in 1956 sixty-seven per cent of the total acreage of the seed crops was grown in the counties of Angus, Perth, Fife, Midlothian and East Lothian.

Table 1

Tonnage of seed potatoes exported to England and Wales.

Season	Tons
1950/51	374,500
1951/52	356,297
1952/53	346,047
1953/54	310,856
1954/55	315,524
1955/56	285,737

Since 1950 the export of seed to England and Wales has declined. Contributory causes are increasingly effective control of virus spread in the English ware

growing areas tending to decrease the need for annual replacement of stocks; and increasing competition from other seed producing areas where standards of health of seed crops are more rigorously maintained.

Table 2

Acreage of potatoes presented for certification in 1956.

County	Acres
Angus	21,433¼
Perth East	13,493
Perth West	4,192¾
Fife	9,321
Midlothian	2,193
East Lothian	5,144
Total	83,289¾

In Scotland, roguing of virus-infected plants is universally practised and in most years adequately controls virus spread. In exceptional seasons, such as 1945, leaf roll and rugose mosaic spread rapidly and the certification schemes are liable to break down.

Both these diseases are spread by aphids, of which Myzus persicae (Sulzer) is the most important. Macrosiphum euphorbiae (Thomas) and Aulacorthum solani (Kltb.) commonly occur on potatoes but both are inefficient vectors of virus Y and neither seems

This statement is preliminary but there is little doubt that M. Francisco is the most efficient worker.

 (Cadman unpub.)

concerned with the spread of leaf roll. The time and extent to which leaf roll and Y viruses spread in potatoes depends on the time at which aphids arrive on potato crops and on their subsequent activity within crops but these aspects of aphid ecology have received little attention in Scotland. Davies (1939) made a brief survey of potato crops in eastern Scotland and Shaw (1955a) has reported the results of investigations made in the north and north-east of the country. No detailed work has hitherto been done in the seed growing areas of central, eastern and south-eastern Scotland.

The potato crop is, of course, an annual one and becomes infested each season by aphids that spend the winter elsewhere. It has been shown that M. persicae overwinters viviparously in glasshouses, on stored mangolds and fodder beet, on brassicas and on some weed plants. It also overwinters in the egg stage on peach and other Prunus spp. In spring or early summer aphids migrate from overwintering hosts to potato crops and other summer hosts, on which they breed before returning to the winter hosts in autumn. Potato crops near an overwintering site become infested by spring migrants during May and early June, the date and extent of infestation varying with the distance from such sites. If crops escape early

infestation they do not usually become infested until July or August. Because potato plants are most susceptible to infection and are better sources of virus when young (Kassanis,1952), the spring migrants are more efficient in spreading virus than are the more numerous summer migrants.

In the British Isles during the past 30 years, the study of aphids and their importance as vectors of virus diseases in potato crops has been confined mainly to England and Wales, where brassica crops (Davies, 1934, 1939; Jacob, 1941; Staniland, 1943; Fidler, 1949) and glasshouses (Doncaster and Gregory,1948) are the most important overwintering sites for M. persicae, followed by mangold clamps (Broadbent, Cornford, Hall and Tinsley, 1949) and lettuce and spinach crops (Broadbent, Tinsley, Buddin and Roberts, 1951). In some parts of the continent of Europe where winters are usually too severe for viviparae to survive, glasshouses and peach orchards are the main source of M. persicae (Heinze and Profft,1938; Heinze, 1948; Muller, 1949). Broadbent and Heathcote (1955) established that the viviparous M. persicae overwintering on herbaceous hosts provide many more spring migrants than those that develop from eggs laid on peach and other Prunus spp.

The present investigation was begun in October 1953 with the objects of finding how potato aphids,

particularly M. persicae, survive the winter months in eastern Scotland and of following the course of infestation of potato crops by aphids in different areas. The observations therefore fall under two main heads; the overwintering of potato aphids and the colonisation and subsequent infestation of potato crops. The time at which winged migrants arrive on potato crops and the rate of infestation by aphids of plants in crops are of crucial importance because both factors are probably connected with the time and rate of virus spread and hence the relative suitability of different districts for the growing of healthy potato stocks.

The results show that Myzus persicae, Macrosiphum euphorbiae and Aulacorthum solani were distributed throughout eastern Scotland and that the time and severity of infestation of potato crops by M. persicae was closely related to the proximity of a source of overwintered aphids.

Brassica crops, in particular spring cabbage, broccoli and cabbage for seed are the most important overwintering hosts for M. persicae in eastern Scotland, followed by crops in glasshouses and heated frames. Peaches under glass and root clamps seem of little importance.

II MATERIALS AND METHODS

In order to study aphid migration, traps were exposed in selected crops and leaf-sampling techniques were used to follow the progress of infestation of potato and brassica crops by aphids.

1 APHID TRAPS

i Water traps

Water traps (Fig. 1), based on the principle described by Moericke (1951), were used throughout the investigation. Each consisted of a metal tray 18 x 12 x 2 supported on legs of angle iron 27 in. long. The bottom and sides (up to ½ in.) were coated with weatherproof enamel of a yellow shade (New Daffodil) known to be attractive to flying aphids. In one experiment, circular traps of 12 in. diameter were used but in areas where there were few flying aphids the surface area of 119 sq. in. was considered inadequate compared with the 216 sq. in. offered by the redesigned rectangular traps.

The traps were filled to a depth of approximately one in. with water containing a few drops of 98% nicotine to immobilise trapped aphids. On most occasions the traps were cleared every three days. Aphids were removed with a camel's hair and stored in lactic acid-

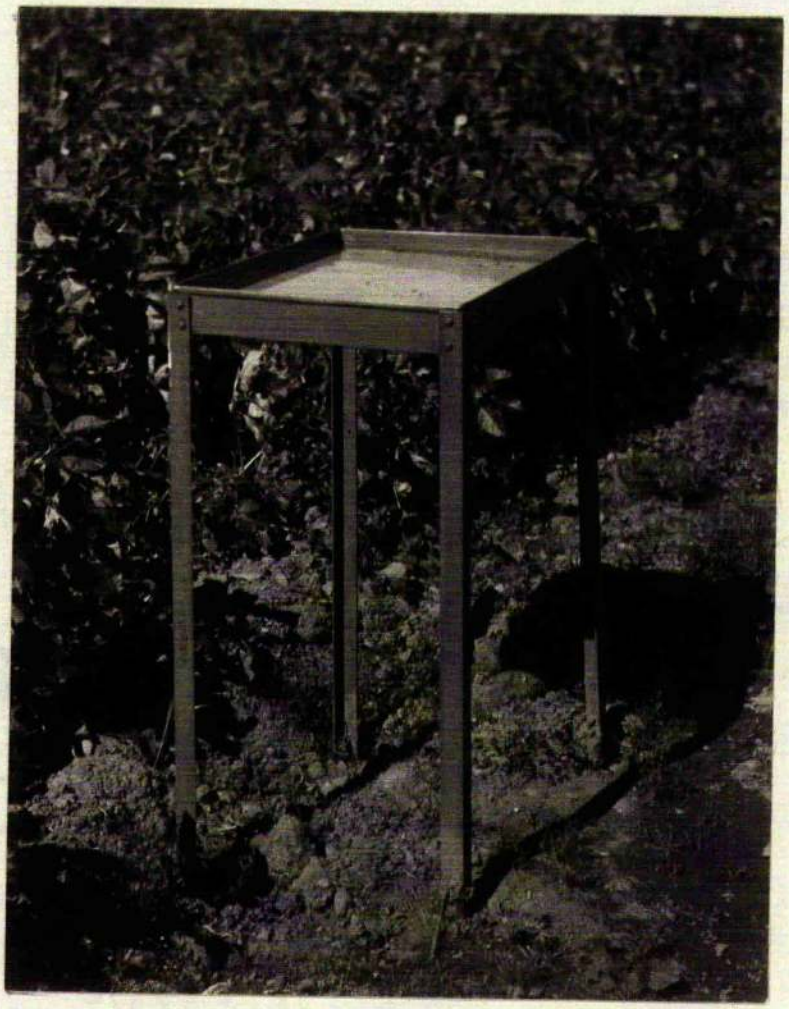


Fig. 1 Water trap

alcohol contained in 2 x ½ in. specimen tubes.

Where traps were attended by farm staff and removal of aphids to specimen tubes was not possible, a modified form of the standard type was employed. The base was constructed with a ¾ in. fall from each side to a central outlet pipe fitted with a rubber stopper. When the latter was withdrawn, a muslin bag held over the lower end of the outlet pipe retained trapped insects. The bags were then stored in jars of lactic acid-alcohol. In the laboratory the aphids were separated from other insects and transferred to specimen tubes for processing and identification at a later date.

In 1954, one trap was exposed per field, placed lengthwise over a drill and at least 50 yards from a headland. In some areas few aphids were caught and the number of traps was increased to four per field in 1955. The traps were placed at the four corners of a rectangle 50 yards long and 50 drills wide and at least 50 yards from a headland. The results (Table 3) show that the total number of aphids caught per trap at any one site varied little although the numbers of M. persicae caught per trap varied considerably. Differences between sites were, however, greater than those within sites and two traps per field seemed adequate to obtain information on the activity of M. persicae in different areas. This was done in 1956 and the figures (Table 4)

show good agreement between trap performances at each of the nine sites.

Table 3

Number of aphids trapped in 1955.

Site number	Trap number	Myzus persicae	Total aphids
30	1	684	2,884
	2	1,090	3,059
	3	1,295	3,323
	4	1,063	2,892
	Mean	1,033	3,039
32	1	540	1,615
	2	221	1,147
	3	218	1,478
	4	275	1,480
	Mean	314	1,430
33	1	491	1,467
	2	293	1,471
	3	150	827
	4	224	1,050
	Mean	290	1,204
34	1	121	851
	2	112	798
	3	109	847
	4	113	834
	Mean	114	833
46	1	16	697
	2	5	191
	3	23	405
	4	4	315
	Mean	12	398

Table 4

Number of aphids trapped in 1956.

Site number	Trap number	Myzus persicae	Total aphids
2	1	773	1,150
	2	749	1,117
	Mean	761	1,134
7	1	77	270
	2	134	404
	Mean	106	337
17	1	23	448
	2	17	388
	Mean	20	438
18	1	134	552
	2	85	528
	Mean	110	540
19	1	87	620
	2	64	432
	Mean	76	526
21	1	12	130
	2	19	134
	Mean	16	132
22	1	72	461
	2	96	415
	Mean	84	438
28	1	39	382
	2	46	269
	Mean	43	326
46	1	7	388
	2	5	803
	Mean	6	596

ii Suction traps

Two 9 in. suction traps were constructed to the design of Johnson (1950) modified so that insects could be trapped in a wide-necked 18 ml. polythene bottle fitted to the brass collecting tube (Fig. 2). Catches were collected every 24 hours at 9 a.m. and the bottles immersed in lactic acid-alcohol contained in a 32 oz. jar. The preserving fluid entered the bottle through numerous small perforations made in the base and stopper. The perforations in the base also allowed rain water to escape from the bottle when in the collecting position. In the laboratory the insects were separated and stored in the same manner as those from the muslin bags. One trap was operated at Inveresk, Midlothian from 8th May to 5th October 1956, and the other at Mylnefield, Perthshire from 24th May to 13th October 1956.

2 PREPARATION OF APHIDS FOR IDENTIFICATION

All aphids collected either from traps or plants were preserved in a lactic acid-alcohol mixture made up as follows:-

90% ethyl alcohol .. .. .. 2 volumes

95% w/w lactic acid .. .. 1 volume

Aphids were prepared for identification according to the method described by Stroyan (1949).

Many specimen tubes contained large numbers of

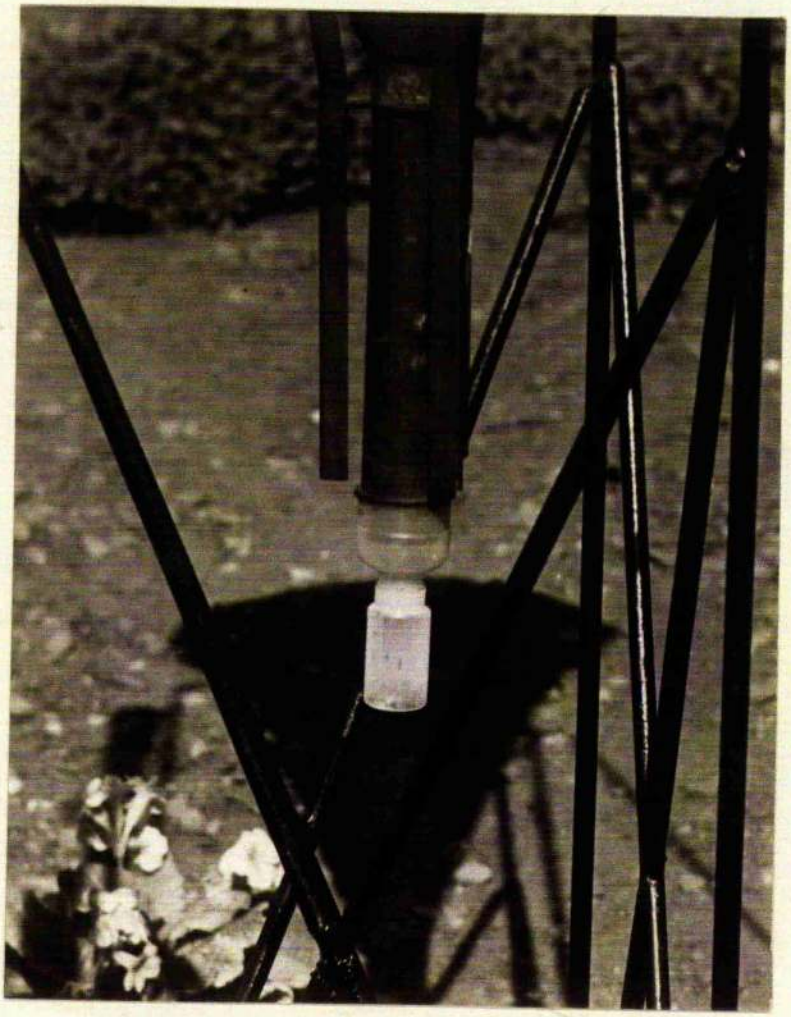


Fig. 2 Suction trap collecting bottle

aphids and a quick method of separating the potato aphids, Myzus persicae, Macrosiphum euphorbiae and Aulacorthum solani from other species was devised. The contents of each sample tube were poured into the left hand compartment of a specially designed sorting dish (Fig. 3) made from polyvinyl chloride (P.V.C.). It consisted of 2 pieces of P.V.C. 4 x 2 x ¼ in. and 4 x 2 x ⅛ in. The compartments were machined out of the thicker piece according to the measurements in Fig. 4. The two pieces were then joined with Tensol 50 cement, the thinner piece forming the base. Under a binocular microscope the potato aphids were sorted into the central compartment and other species into the right hand cell.

3 RECORDING APHID POPULATIONS

i Potato crops

In the past, many methods have been used to estimate aphid populations in potato crops and most workers have recorded their results as numbers of aphids per 100 leaves. By counting the number of aphids per 100 random leaves as the crop was traversed in mid-July, Davies (1934) obtained an estimate which he termed the "index". He pointed out that in seed producing areas the index figure was generally well below 100 and usually below 20 aphids per 100 leaves.

In a comprehensive review of methods of counting aphids infesting potato crops, Broadbent (1948) concluded

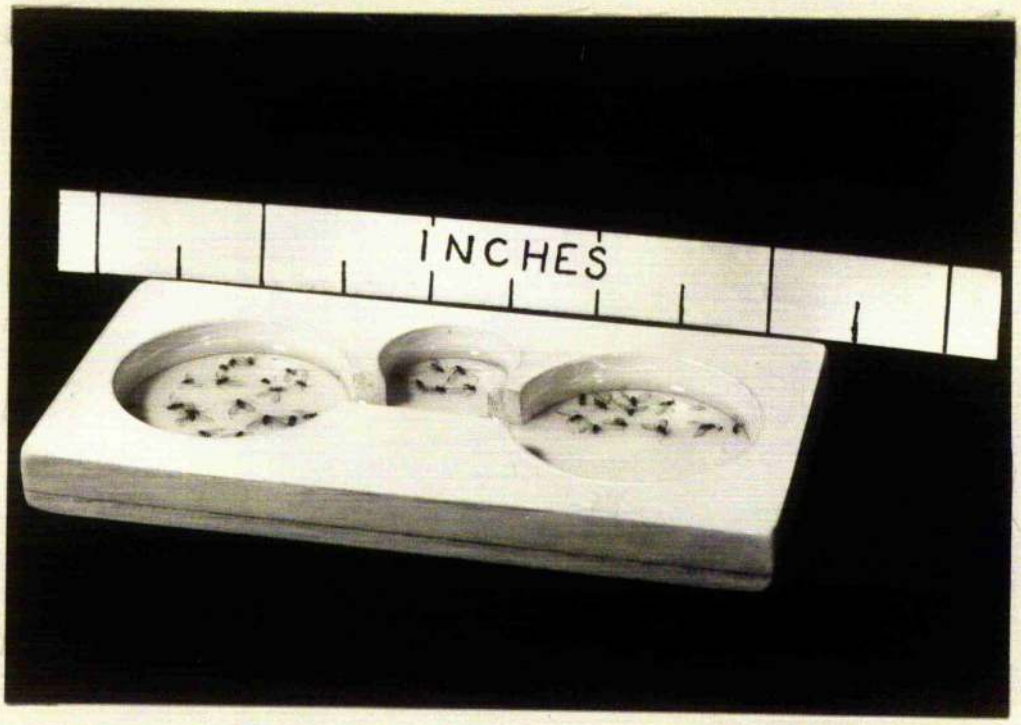


Fig. 3 Aphid sorting dish

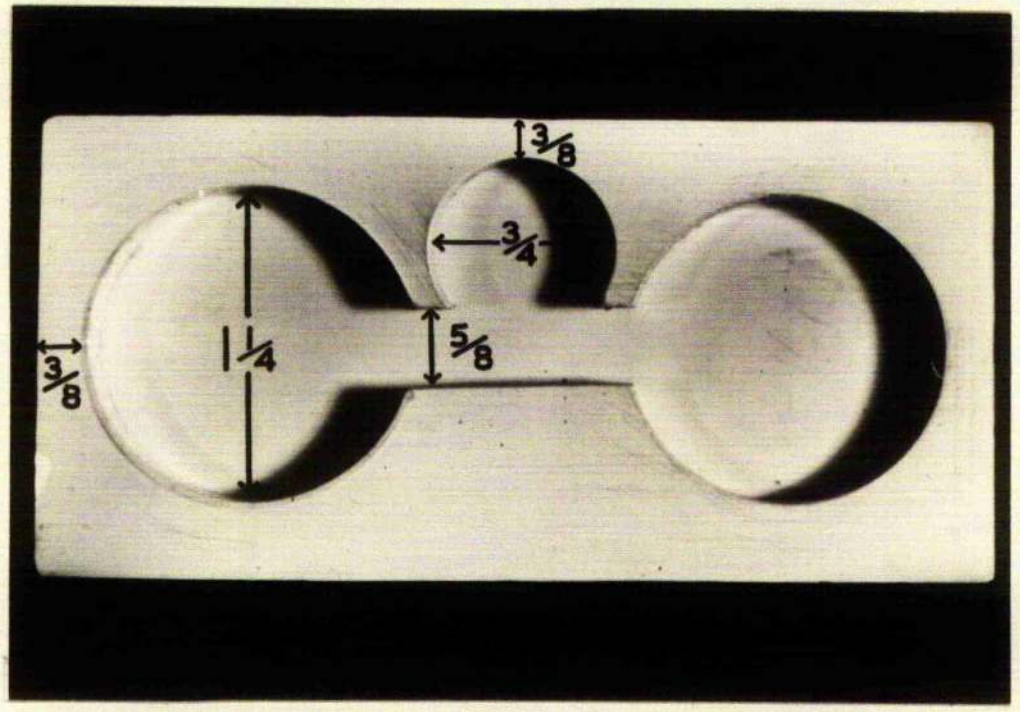


Fig. 4 Dimensions of sorting dish
(inches)

that, for most purposes, an estimate of the number of aphids per plant was better than the number per 100 leaves. He described two methods for estimating the number of aphids per plant. The first method consisted in counting the aphids present on one upper, one middle and one lower leaf from each of forty random plants in a traverse of the field, and the number of leaves at each position on alternate plants of the forty chosen. The mean number of aphids found on upper, middle and lower leaves was calculated and multiplied by the average number of leaves at each of the three levels. The three products summed gave an estimate of the number of aphids per plant. The second method, applicable to the lower populations usually found in seed producing areas, consisted in counting the aphids present on a unit, one upper, one middle and one lower leaf, from each of 33 plants chosen at random. When aphids were found on 60 per cent or less of the 33 units, the estimated maximum population per plant was obtained by adding 10 to the percentage figure. When aphids were found on more than 60 per cent of the units, only the likely upper limit of the population could be estimated.

In the present investigation the following method, applicable only to M. persicae, was used. The number of aphids present on a unit consisting of one upper, one middle and one lower leaf from each of 33 plants chosen

at random were counted. The average number of leaves per plant was calculated from counts made on 10 random plants. Records showed that upper, middle and lower leaves occurred in the ratio of 2 : 1.2 : 0.92 or approximately 2 : 1 :1, hence the total number of leaves divided by 4 gave the number of complete units per plant. The average population per plant may be calculated thus:-

$$\frac{\text{Total no. of aphids}}{33} \times \frac{\text{Average no. of leaves per plant}}{4} = \text{No. of aphids per plant}$$

This calculation assumes absence of M. persicae from 50% of the upper leaves but the error thus introduced is not very great. Records of the distribution of M. persicae on potato plants showed that, where aphids are few, only about 4 per cent of the total number of M. persicae are found on the upper leaves.

This method gave results, closely similar to those obtainable by Broadbent's first method and also allowed expression of the numbers of aphids per 99 leaves (or for practical purposes 100 leaves) for comparison with results of previous surveys. Further, it was both rapid and allowed reasonably accurate comparisons to be made between infestations on different potato varieties grown at different centres under different conditions. As Broadbent (1948) suggested, it is

doubtful whether the longer time spent on more accurate and elaborate sampling methods is justifiable for this type of work.

The populations of Macrosiphum euphorbiae and Aulacorthum solani were recorded as numbers of aphids per 100 leaves.

ii Brassica crops

The methods of recording populations of aphids on potato crops were not applicable to brassica crops but it seemed best to record aphid populations as numbers per plant rather than as numbers per 100 leaves. On most occasions 50 plants were chosen at random on a diagonal traverse of selected crops and the aphids on each counted, but where populations were extremely high, for example heavily infested savoys, populations per plant could only be estimated. In one instance individual plants were labelled and observed on successive occasions to give information on the relation between leaf abcission and decline of aphid populations.

III THE OVERWINTERING OF POTATO APHIDS

Studies on the overwintering of potato aphids in eastern Scotland were begun in October 1953, and most attention was given to Myzus persicae because it is the most important vector of potato leaf roll and Y viruses.

1 OVERWINTERING OF MYZUS PERSICAE (SULZER)

As stated above, it has been shown that M. persicae overwinters in the egg stage on peach and other Prunus spp. and viviparously in glasshouses, on stored mangolds and brassicas, and that the relative importance of these sites differs between areas.

In eastern Scotland, peaches under glass and in walled gardens, and glasshouses are found fairly evenly distributed throughout the seed-growing districts but mangold clamps are uncommon because turnips and swedes are more extensively grown for stock feeding. Brassica crops are restricted mainly to Mid and East Lothian and Moray. The market garden area of the Lothians is situated between Musselburgh and North Berwick and extends three to four miles inland from the Firth of Forth. That of Moray lies between Forres and Fochabers with Elgin as the main centre and extends two to three miles inland from the Moray Firth.

There is a striking similarity in the climate and situation of the two areas. Although a greater acreage of brassicas is grown in Perth and Angus than in Moray, the crops are much more widely scattered. In the Clyde valley near Lanark a large acreage of lettuce is grown but with the exception of summer cauliflower few brassicas are cultivated.

Table 5 shows the proportions, expressed as percentages, of the total Scottish acreage of green crops and crops in heated frames grown in these areas in 1953. Observations were made in Midlothian, Angus and Perthshire (seasons 1953/54, 1954/55 and 1955/56) and Moray and Lanark (1956) to assess the relative importance of peaches, glasshouses, heated frames, root clamps and brassica crops as sources of the alatae which colonise potato crops annually, and the results will be dealt with under these heads.

Table 5

Percentage of total acreage for Scotland at June 4th 1953.

	Cabbage	Brussels sprouts	Cauliflower	Lettuce	Heated frames
Midlothian	11.45	15.80	12.79	21.79	29.46
East Lothian	48.50	53.71	50.17	21.08	21.72
Moray	3.57	2.24	1.66	0.28	0.32
Perth	3.82	7.69	1.16	4.27	1.31
Angus	5.51	4.48	2.82	1.71	0.62
Lanark	3.94	1.40	15.45	30.77	26.53
Total	76.79	85.32	84.05	79.90	79.96

1 Peaches (Prunus persica L.)

Though not commercially important, peaches are grown in many of the walled gardens of estates in eastern Scotland. In spring 1954,1955 and 1956, a total of 30 such sites was visited periodically and searches for M. persicae made. At 21 of these (Table 6) colonies of aphids were found and in some instances these were large enough to cause premature defoliation of the trees.

Table 6

Frequency of M. persicae on peach.

Year	Number of sites examined	Number at which Myzus persicae found
1954	5	2
1955	14	10
1956	11	9

Although plants such as lettuce, potato and brassicas in the immediate vicinity of such colonies became infested with M. persicae there was no evidence that the aphids migrated to more distant crops. At Glamis Castle on July 28th 1955 for example, Kerr's Pink potatoes grown alongside a glasshouse containing infested peach trees had populations of about 50 M. persicae per plant whilst very few were found on a second plot of potatoes some 25 yards distant. Doncaster and Gregory (1948) reported similar observations.

Borner (1951) showed that winged M.persicae (fundatrigeniae) that develop on primary hosts (Prunus spp.) are morphologically distinguishable from those (virginogeniae) that develop on secondary hosts such as brassica and potato plants. On this basis, Martini (1953) in Germany (cited by Broadbent and Heathcote, 1955), Meier and Keller (1955) in Switzerland and Hille Ris Lambers (1955) in the Netherlands have shown that most of the M. persicae colonising potato crops in the spring are fundatrigeniae. Broadbent and Heathcote (1955) found that, of a total of 238 winged M.persicae trapped before the end of June in England mainly in the south, only two were fundatrigeniae.

No fundatrigeniae were found were found among the first alatae collected from potatoes in Angus and Perthshire in 1954, 1955 and 1956 or among those trapped by the end of July in the same years; the totals examined were 36, 55 and 51 respectively.

No M.persicae overwintered successfully on outdoor peaches at three sites in Angus and Perthshire in 1955 or1956 and it seems unlikely that peaches are important sources of infestation in this area.

ii Glasshouses.

It has been well established that glasshouses provide shelter for M. persicae during the winter and these sources of spring migrants are particularly

important in northerly latitudes where the long periods of low temperature in winter kill aphids outdoors. Muller (1949) reported that in a survey of 62 glasshouses in central Germany between mid January and March 1949, M. persicae was absent from five and that this aphid was present on 45 out of 74 ornamentals examined in a glasshouse at Naumberg. In England, Doncaster and Gregory (1948) found carnations and chrysanthemums the crops most frequently infested.

In spring 1955 and 1956 a total of 20 species of ornamental and crop plants including carnations, chrysanthemums, lettuce, Azalea, Cineraria, Hydrangea, Lilium and Solanum capsicastrum were periodically examined in 31 glasshouses in eastern Scotland. M. persicae was found on six occasions;- twice on lettuce, twice on chrysanthemums, once on carnations and once on Solanum capsicastrum. Although only 20 percent of the glasshouses examined were infested with M. persicae, the large number of glasshouses throughout the country, especially in urban areas, are probably of some importance as sources of alate M. persicae capable of infesting potato crops in early summer. In mid April 1956, no M. persicae was found in six commercial glasshouses in the Clyde valley.

iii Heated frames

Heated frames containing host plants of M. persicae might be expected to offer conditions suitable for overwintering. Accordingly observations were made from 1954 - 1956 on two large blocks of frames (Fig. 5), each covering some 12 acres, in the Musselburgh area of Midlothian.

The growing seasons of the four crops commonly grown, namely lettuce, carrot, turnip and cauliflower and the two field crops, early potatoes and summer cauliflower, usually grown near the frames, is illustrated in Fig. 6.

In each of the three years, the infestation and population increase of M. persicae on the frame crops, followed a similar pattern. Isolated colonies of apterae were found on lettuce between mid-March and mid-April. By mid-May, when most of the lights were removed and the growth of the crops was strong (Fig. 7), a few winged migrants were found and aphids were more widely distributed. From this time, the populations on turnip, carrot and cauliflower increased steadily until the maximum was reached in late June to early July. At this time populations of 200 - 300 aphids per plant on turnip and up to 1,000 per plant on cauliflower were recorded. Predators and parasites including fungi of the order Entomophthorales combined to reduce drastically

Fig. 5 Heated frames at Musselburgh

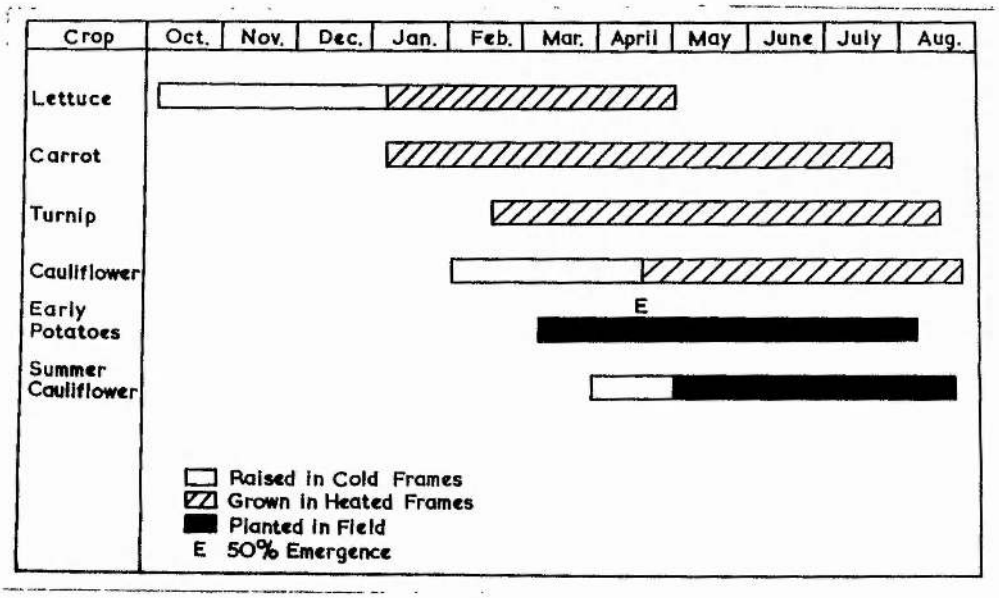


Fig. 6 Growing season of heated frame and adjacent field crops at Musselburgh

Fig. 7 Section of heated frames at Musselburgh showing turnip and cauliflower, May 18th 1956

the populations of the remaining plants, and by the beginning of August, when the frames had been almost cleared of plant material, few aphids could be found.

The course of infestation of field crops, early potatoes and summer cauliflower, grown near the frames in 1955 and 1956, is illustrated by the following observations.

1955

Early potatoes, (Epicure), planted March 18th, 600 yards from frames.

Infestation started about June 16th when a few alatae were found on the crop, and by July 7th an average population of 48 per plant was recorded.

Summer cauliflower, planted May 3rd, adjacent to frames.

Infestation commenced about May 20th but by June 15th small populations of M. persicae were found. By July 8th, however, the populations had increased to 120 aphids per plant.

Four 12 in. diameter water traps were set up in this crop at the edge nearest to the frames, and the total numbers of aphids caught are shown in Table 7.

1956

Early potatoes, (Epicure), planted March 6th, 200 yards from frames.

A few alate M. persicae were first found on this crop on May 18th. On June 11th the population was still

small, but on July 4th there were 313 M. persicae per plant.

Table 7

Total catch from four water traps in cauliflower crop adjacent to heated frames.

Date	M. persicae	M. euphorbiae	A. solani	Other species	Total
9/6	0	0	0	23	23
13/6	0	0	1	5	6
17/6	0	0	1	23	24
21/6	0	0	0	96	96
25/6	3	0	4	105	112
29/6	18	1	9	113	141
2/7	26	0	13	132	171
6/7	187	18	180	644	1,029
11/7	44	1	30	34	109
15/7	146	0	65	192	403
19/7	387	0	180	846	1,413
22/7	36	1	12	68	117
29/7	27	0	36	37	100

Summer cauliflower, planted May 8th, adjacent to frames.

No aphids were found on this crop on May 18th. On June 11th the population averaged five M. persicae per plant and by July 5th 160 per plant were found.

Although no aphids were found in the frames before mid March, it is concluded, from consideration of the cropping sequence, that the few aphids necessary to start the spring infestation were introduced into the frames on the young lettuce plants.

Undoubtedly frame crops are important sources of the early summer migrants which infest neighbouring early potato and brassica crops.

iv Root clamps

Between March and May, 1955, fifty mangolds were examined from each of 12 clamps, three in Angus and nine in Mid and East Lothian. One alate and one apterous M. persicae were found on lightly topped mangolds in a clamp in the Musselburgh area where aphids had been numerous the previous summer. No aphids were found on the other 11 clamps. These results confirm those of Broadbent et al (1949) who found few aphids in root clamps in Scotland in 1947. In contrast, 54, 12 and 60 per cent of clamps examined in England between March and June 1946, 1947 and 1948 respectively were infested. They found that M. persicae was introduced on the leaves and thus the number of aphids on the crop when lifted, and the method of topping and clamping the roots influenced the infestation.

At Inveresk, a clamp of Redskin potatoes, opened on May 3rd, 1956 was found heavily infested by aphids. These were Rhopalosiphoninus latysiphon (Davidson) an aphid commonly associated with stored potatoes (Rademacher, 1949 and Haine, 1950); there was no M. persicae present.

These results suggest that root clamps are of no importance as overwintering sites for M. persicae.

V Brassicas

Except in climates where prolonged periods of low temperature are experienced in winter, for example in northern Germany (Heinze, 1948), brassicas and in particular savoys frequently carry populations of M. persicae throughout the winter months (Davies, 1934; Jacob, 1941; Staniland, 1943; Fidler, 1949; Maine, 1950).

To assess the importance of brassicas as over-wintering hosts for M. persicae in the Lothians, Angus and Perthshire, crops in these areas were observed and fluctuations in aphid populations recorded in three successive seasons 1953/54, 1954/55 and 1955/56. Brief observations were made in Moray in 1956. Casual observations on many other crops confirmed that the situation represented by the results given below was typical for each of the areas.

Except when estimated figures are given, the tables in the text are condensed from the figures given in the appendix.

Lothians area

Table 5 shows the importance of brassica growing in the Lothians. In 1953, 60 per cent, 69 per cent and 63 per cent of the total Scottish acreage of cabbage, brussels sprouts and cauliflower respectively was grown there.

The majority of the crops observed in this area were situated near Musselburgh and Inveresk.

1953 - 54

In this winter, observations were made on nine crops. These comprised one each of broccoli, cabbage for seed, brussels sprouts and three each of savoys and spring cabbage. M. persicae was found throughout the winter on all these crops. The broccoli, brussels sprouts and two of the savoy crops were cleared in early spring before winged migrants were produced. A few alatae were found at the end of April on the remaining savoy crop just before it was cleared. The seed cabbage and spring cabbage crops persisted well into the summer and by the middle of June quite large populations of aphids were found on them; a considerable proportion of the aphids were alatae capable of migrating to potato and spring planted brassica crops.

1954 - 55

Detailed observations were made on seven crops; four of spring cabbage (B1, B2, B3 and B4), two of savoys (B5 and B6) and one of broccoli (B7) and the results are given in Tables 8, 9 and 10.

Observations on another broccoli crop in the same locality showed that populations were similar to those recorded on B7.

These results show that on each of the crops

Table 8

Spring cabbage 1954/55

Total number of Myzus persicae per 50 plants

Date of count	Crop number B1	B2	B3	B4
November 5th	94	4	111	21
December 12th	7	1	13	2
January 31st	1	0	0	2
March 10th	3	1	0	0
April 14th	0	1	7	0
May 20th	4	4	26	15
June 17th	1302	1174	697	201

Table 9

Savoys 1954/55

Average population of Myzus persicae per plant

Date of count	Crop number B5	B6
September 29th	80	400
December 14th	7	50
January 31st	4	6
March 10th	1	1
	Cleared	Cleared

Table 10

Broccoli 1954/55
Total number of Myzus persicae per 50 plants

Date of count	Crop number B7
November 6th	225
December 13th	61
February 1st	12
March 11th	0
April 15th	0
May 20th	1
June 18th	1400

examined, aphid populations declined rapidly after November and aphids were few in January, February, March and early April. From mid-April populations increased and large numbers of aphids, a proportion of which were alate, were found in the spring cabbage and broccoli crops in mid-June.

On each sampling occasion the largest populations were found on the two savoy crops. No alate aphids were found at the last count before these crops were cleared in mid-March, but one alate was found on each of three of 50 plants examined in crop B6 on January 31st 1955.

Although detailed counts were not made, observations

on two crops of brussels sprouts showed that high summer populations of the order of 1,200 aphids per plant were reduced to about 50 per plant by November 5th 1954. From this time onwards small numbers of apterous aphids were found, mainly on the loose unsaleable sprouts, until the crops were cleared in the second week of March, 1955.

These results show that aphids successfully overwintered on spring cabbage and broccoli and detailed figures in the appendix show that alatae developed on these crops in early summer. The spring and early summer of 1955 were warm and dry and provided favourable conditions for aphid development and multiplication, and populations of 340, 180 and 64 M. persicae per plant were estimated on the spring cabbage crops B1, B3 and B4 respectively on July 7th 1955. Furthermore, owing to unfavourable marketing conditions, spring cabbage crops were grown on for longer than usual. The combination of these two factors resulted in the development of a much larger number of migrant alatae from spring cabbage than would be expected in an average season.

1955 - 56

Detailed observations were made on ten crops; four of spring cabbage (B9, B10, B11 and B12), two of savoys (B21 and B22), one of broccoli (B23), two of brussels sprouts (B24 and B25) and one of cabbage

saved for seed (B13). The results are given in Tables 11, 12, 13, 14 and 15.

The hot dry summer of 1955 favoured aphid multiplication and autumn populations on most crops tended to be higher than in 1954. However the sharp decline in population from November to February followed a similar pattern to that of 1955.

Due to market demands, the spring cabbage crops were cut at earlier dates than comparable crops in the 1954 - 55 season, and alatae developed on only two of the crops (B9 and B10) which persisted later than mid-May. The largest populations of M. persicae per plant were again recorded on the savoy crops as in 1955, and although small numbers of alatae were found on January 12th only apterae were found before the crops were cleared in March. Aphids were found at each time of examination of the broccoli crop (B23) and similar populations were recorded on another broccoli crop in the same locality. On May 18th a few alate nymphs were found on crop B23 and by June 13th there was an average of about 10 alatae per plant. The majority of aphids on the brussels sprouts were found on the lower stem leaves and on the loose unsaleable sprouts. Three alatae were found on a total of 50 plants of crop B25 when examined on January 12th but only apterae were found just before the crops were cleared in March.

Table 11

Spring cabbage 1955/56

Total number of Myzus persicae per 50 plants

	Crop number			
Date of count	B9	B10	B11	B12
October 27th	950	367	309	592
December 1st	302	559	451	cut
January 11th	7	20	31	
March 2nd	0	0	5	
April 11th	0	0	cut	
May 18th	48	1		
June 12th	cut	8		
July 7th		2500		

Table 12

Savoys 1955/56

Estimated number of Myzus persicae per plant

	Crop number	
Date	B21	B22
August 5th	900	-
September 10th	600	80
October 28th	300	200
December 2nd	250	800
January 12th	180	350
March 2nd	8	cut
March 15th	cut	

Table 13

Broccoli 1955/56

Estimated number of Myzus persicae per plant

Date	Crop number B23
October 28th	200
December 2nd	180
January 12th	56
March 2nd	1
April 11th	1.2
May 18th	7
June 13th	140
July 6th	450

Table 14

Brussels sprouts 1955/56

Estimated number of Myzus persicae per plant

Date	Crop number B24	B25
June 17th	1.5	-
July 8th	200	-
August 5th	1200	-
September 8th	300	75
October 27th	55	120
December 1st	35	120
January 12th	10	26
March 2nd	Cleared	1
March 11th		Cleared

Table 15

Cabbage for seed 1955/56
Total number of Myzus persicae per 50 plants

Date	Crop number B13
October 28th	8750
December 2nd	3500
January 12th	600
March 2nd	2
April 11th	3
May 18th	30
June 13th	320
July 6th	10000
August 3rd	3500

In the seed cabbage crop detailed counts were made on March 2nd, April 11th and May 18th. The figures shown against the other dates in the table were estimated. From mid-January the aphid populations declined sharply and did not increase until mid-April. On May 18th only apterae were found on 50 plants examined. From this time populations increased rapidly until the maximum was recorded on July 6th.

Angus and Perthshire.

In 1954 just over 200 acres of cabbage, brussels sprouts and cauliflower for human consumption were

grown in Angus and Perthshire, representing 7¾, 14 and 3½ per cent respectively of the total Scottish acreage. In contrast, 35,098 acres of turnip and swedes were grown for stock feed. In view of their possible importance as overwintering hosts for M. persicae a representative sample of turnip and swede crops were examined along with other brassica crops.

1954 - 55

Observations were made on a total of twenty crops comprising five of spring cabbage, three of savoys and brussels sprouts, two of broccoli, four of turnip and three of swedes.

Between April 29th and May 30th, 50 plants were examined from each of the five spring cabbage crops (three near Dundee, one near Forfar and one near Kirriemuir). No M. persicae was found.

At Mylnefield near Dundee detailed records were made throughout the winter of aphid populations on one each of the crops of savoys (B15), broccoli (B16) and brussels sprouts (B17), and the results are given in Tables 16, 17 and 18.

Populations on the savoy crop (B15) declined steadily from mid-November until the end of December and no aphids were found from January until the crop was cleared on March 25th. No M. persicae was found on the two other savoy crops examined near Dundee on April 6th.

Table 16

Savoys 1954/55

Total number of Myzus persicae per 50 plants

Date	Crop number B15
October 14th	252
November 10th	205
December 3rd	110
December 30th	16
January 26th	0
March 4th	0
March 18th	0
March 25th	Cleared

Table 17

Broccoli 1954/55

Total number of Myzus persicae per 50 plants

Date	Crop number B16
October 19th	2142
November 9th	960
December 6th	164
December 29th	77
January 25th	5
March 2nd	1
March 18th	0
April 1st	0
April 15th	0

Table 18

Brussels sprouts 1954/55
Total number of Myzus persicae per 50 plants

Date	Crop number B17
October 12th	242
November 10th	685
December 10th	38
January 6th	0
January 31st	0
March 4th	0
March 18th	0

Although higher populations were found on the broccoli (B16) than on the savoy crop (B15) in November, the population decline followed a similar pattern and no aphids were found from mid-March until the crop was cleared. No M. persicae was found on the other broccoli crop examined at Inchture, Perthshire on May 30th.

On the brussels sprouts crop (B17) at Mylnefield no aphids were found between early January and the end of March when the crop was cleared. No M. persicae was found on the two other brussels sprout crops examined at Bridge of Earn and Inchture, Perthshire on March 14th. At Bridge of Earn, however, small populations of Myzus ascalonicus (Doncaster) were found on four of the 50

plants examined.

On most farms turnips and swedes are left in the ground all winter and lifted as required; some are not lifted until mid-April. By January most of the older leaves are lost in both crops so that the only shelter for aphids is provided by the compact crown of small leaves which begin to grow in early spring. From September 1954 to February 1955 observations were made at monthly intervals on the four turnip and three swede crops which were situated in the Dundee district of Angus. In September small populations, averaging 5 M. persicae per plant, were found on all crops. These populations gradually declined and in December, January and February no aphids were found on any of the crops.

1955 - 56

A total of eight crops was examined; three of spring cabbage, two each of savoys and broccoli and one of winter cabbage. Detailed counts were again made at Mylnefield, Perthshire, on one each of the crops of spring cabbage (B18), broccoli (B19) and winter cabbage (B20) and the results are given in Tables 19, 20 and 21.

The spring cabbage at Mylnefield (B18) was the only crop examined in Angus and Perthshire on which aphids overwintered successfully. The large populations recorded on November 23rd declined rapidly and between January and April very few aphids were found. From

Table 19

Spring cabbage 1955/56

Total number of Myzus persicae per 50 plants

Date	Crop number B18
September 27th	235
October 18th	607
November 23rd	829
December 29th	42
January 30th	0
February 28th	4
March 26th	0
April 19th	0
May 22nd	5
June 21st	8

Table 20

Broccoli 1955/56

Total number of Myzus persicae per 50 plants

Date	Crop number B19
September 6th	16793
September 30th	19323
November 10ht	9435
December 15th	1659
January 12th	399
February 23rd	3
March 23rd	2
April 19th	0
May 25th	0

Table 21

Winter cabbage 1955/56
Total number of Myzus persicae per 50 plants

Date	Crop number B20
September 10th	797
October 11th	219
November 14th	666
December 19th	759
January 18th	294
March 6th	0
March 16th	Cleared

mid-May populations increased slowly and on June 21st 1 alate nymph, 4 apterous adults and 3 apterous nymphs made up the total of 8 M. persicae found on 50 plants. It is probable that a few alate adults developed on and migrated from this crop before it was cleared in early July.

On November 3rd, 450 and 400 M. persicae per plant were found on the two other spring cabbage crops near Invergowrie and Inchture, Perthshire, but no aphids were found on these crops when examined on May 15th.

On the two savoy crops examined on September 6th at Invergowrie, Perthshire and near Kirriemuir, Angus,

populations of M. persicae were estimated at 800 and 450 per plant respectively. When these two crops were examined just before clearing on March 29th no aphids were found.

High populations of M. persicae were recorded in September on the broccoli crop (B19) at Mylnefield and the numbers greatly exceeded those at comparable dates for the broccoli crop (B16) grown there in 1954/55. However, populations declined steadily and no aphids were found from mid-April until the crop was cleared in late May. On the other broccoli crop near Invergowrie the population of M. persicae was estimated at 15,000 per 50 plants on September 6th. On March 29th however, no M. persicae was found on this crop.

The crop of January King cabbage (B20) at Mylnefield carried quite high populations of M. persicae until mid-January. From this time populations declined very rapidly and no aphids were found on March 6th. Ten days later the crop was cleared.

Moray Firth Area

In this part of Scotland the rainfall is low, severe winter frosts are few and the climate generally is favourable for market gardening. The industry is a small one but, as in the Lothians, brassica crops are concentrated into a small area; spring-planted crops follow those that grow throughout the winter and a

suitable succession of hosts for M. persicae is thus provided. Table 5 shows that in 1953, 3½ per cent, 2¼ per cent and 1½ per cent of the total Scottish acreage of cabbage, brussels sprouts and cauliflower respectively was grown in Moray.

Ten crops, three each of spring cabbage and broccoli, two of savoys and one each of winter cabbage and kale, were examined in this area on April 26th and 27th, 1956.

On one of the spring cabbage crops at Elgin, two apterous adults and two apterous nymphs of M. persicae were found on a total of 50 plants examined. No aphids were found on the other two crops.

Of the three broccoli crops, two were at Elgin and one at Nairn. On one of the crops at Elgin a total of four apterous adults were found on 50 plants but there was evidence that much larger populations had been destroyed earlier by fungi (Entomophthora spp.) No M. persicae was found on the other two crops.

Both the savoy crops were situated near Elgin; on one, 85 apterous aphids were found on 50 plants but no aphids were found on the other. On the winter cabbage (January King) crop, near Forres, a total of two apterous adults and 16 apterous nymphs of M. persicae were found on 50 plants.

A search was made on 50 plants in a 2 acre crop of kale for seed near Elgin, but despite the apparent

shelter for aphids offered by this tall growing crop no aphids were found. Although no alate M. persicae were found on any crops at the date of examination, it seemed likely that they would develop on the majority of the infested crops which, according to the growers, would not be cleared for at least four weeks.

The foregoing results are summarised in Tables 22, 23 and 24. They show that crops of spring cabbage, broccoli and cabbage for seed are the most likely to provide conditions suitable for the overwintering and spring development of M. persicae. In general these crops persist long enough to allow alatae to develop which subsequently migrate in early summer to spring-planted crops. Both savoys and brussels sprouts were found to carry substantial populations of apterous aphids throughout the winter but the majority of these crops was cleared by mid-April before the alate forms of M. persicae developed. Only if crops persist until approximately mid-May are they likely to be sources of migrant alatae.

It seems clear, therefore, that in the market garden areas of the Lothians and Moray, where a succession of brassica crops is grown throughout the year, M. persicae consistently overwinters as apterous viviparous females. In areas such as Angus and Perthshire where brassica crops are scattered and spring-planted brassicas are not

Table 22

Frequency of overwintering Myzus persicae on brassicas in the Lothians area.

Crop	Winter seasons 1953/54 No.crops examined	1953/54 No.crops on which M persicae o/wintered	1954/55 No.crops examined	1954/55 No.crops on which M persicae o/wintered	1955/56 No.crops examined	1955/56 No.crops on which M persicae o/wintered	Total No.crops examined	Total no.crops on which M persicae o/wintered
Spring cabbage	3	3	4	4	4	2	11	9
Savoys	3	1	2	0	2	0	7	1
Broccoli	1	0	2	2	2	2	5	4
Brussels sp.	1	0	2	0	2	0	5	0
Cabbage for seed	1	1	-	-	1	1	2	2
Totals	9	5	10	6	11	5	30	16

Table 23

Frequency of overwintering Myzus persicae on brassicas in Angus and Perthshire.

Crop	Winter seasons 1954/55 No.crops examined	1954/55 No.crops on which M persicae o/wintered	1955/56 No.crops examined	1955/56 No.crops on which M persicae o/wintered	Total no.crops examined	Total no.crops on which M persicae o/wintered
Turnip and swedes	7	0	-	-	7	0
Spring cabbage	5	0	3	1	8	1
Savoys	3	0	2	0	5	0
Broccoli	2	0	2	0	4	0
Brussels sprouts	3	0	-	-	3	0
Winter cabbage	-	-	1	0	1	0
Totals	20	0	8	1	28	1

Table 24

Frequency of overwintering Myzus persicae on brassicas in the Moray Firth area

Crop	Winter season 1955/56 No. crops examined	No. crops on which M. persicae overwintered
Spring cabbage	3	1
Savoy	2	1
Broccoli	3	1
Winter cabbage	1	1
Kale	1	0
Totals	10	4

always situated near overwintered crops, few M. persicae survive the winter out of doors. From brief observations in north-east Scotland, Shaw (1955b) concluded M. persicae rarely overwintered successfully on brassicas.

a. Causes of decline of aphid populations

In the main brassica growing area, when parasites and predators had ceased to exert a control of aphids, populations increased during the months of October and November when the plants were still actively growing.

This rise was followed by a sharp decline from the end of November to January, February and March, when few aphids were found. On a few crops, particularly of spring cabbage, no aphids were found during these months, but in April, when the reproductive rate was accelerated by higher temperatures aphids were again recorded. It is possible that the sampling methods adopted failed to detect small numbers of aphids. However, because the population of aphids recorded in April consisted entirely of apterous adults and nymphs it is concluded that these developed from aphids that had overwintered on these crops.

On most brassicas the small populations of overwintering M. persicae were confined to three or four basal leaves and only rarely were aphids found on the heart leaves, even when the plants carried high populations in the summer months.

Of the possible causes of decline in aphid populations during the winter months, low temperature seems the most important. In frosty weather the rate of aphid reproduction decreases, aphids may die of exposure and many others may die as a result of the death and abscission of the leaves on which they feed.

To determine the effect of leaf abscission on aphid populations, four leaves were labelled on each of 25 plants of spring cabbage at Mylnefield on October 25th 1955.

The leaves were labelled A, B, C and D in order of age, A being the oldest leaf. At each date of observation both the number of leaves remaining attached and the number of aphids per leaf were recorded. The results are summarised in Table 25. The increase in the mean number of aphids per leaf on leaves labelled B, C and D on November 22nd 1955 was due to nymph deposition. Few nymphs were deposited on the oldest leaves (A) after October 26th. On December 21st aphids were found only on leaves labelled C and D and the mean numbers per leaf were considerably reduced. By January 25th 1956 only seven of the original 100 labelled leaves remained attached to the plants and no aphids were found on them. These results suggest that as leaves mature and die the aphids bred on them do not move to the younger leaves. When abscission occurs the aphids fall with their host leaf and do not return to their host plant probably because they are partially immobilised by low temperatures.

Possibly in the brassica growing areas of the Lothians and Moray, mild winter climates tend to lessen the effects of these factors which cause the death of aphids and leaves of host plants, and therefore allow of a greater proportion of overwintering aphids to survive.

b. The inter-relationship between overwintered and spring-planted brassicas.

Fig. 8 shows the normal succession of brassica

Table 25

Leaf abscission and decline of aphid populations on spring cabbage at Mylnefield, 1955/56

	Serial letter of leaf							
	A		B		C		D	
Date	No. of leaves remaining attached	Mean no. of aphids per leaf	No. of leaves remaining attached	Mean no. of aphids per leaf	No. of leaves remaining attached	Mean no. of aphids per leaf	No. of leaves remaining attached	Mean no. of aphids per leaf
26/10	25	5.24	25	3.56	25	1.80	25	0.88
22/11	11	4.81	21	5.71	25	5.76	25	3.48
21/12	10	0	21	0	25	1.28	25	0.48
22/1	0	0	0	0	1	0	6	0

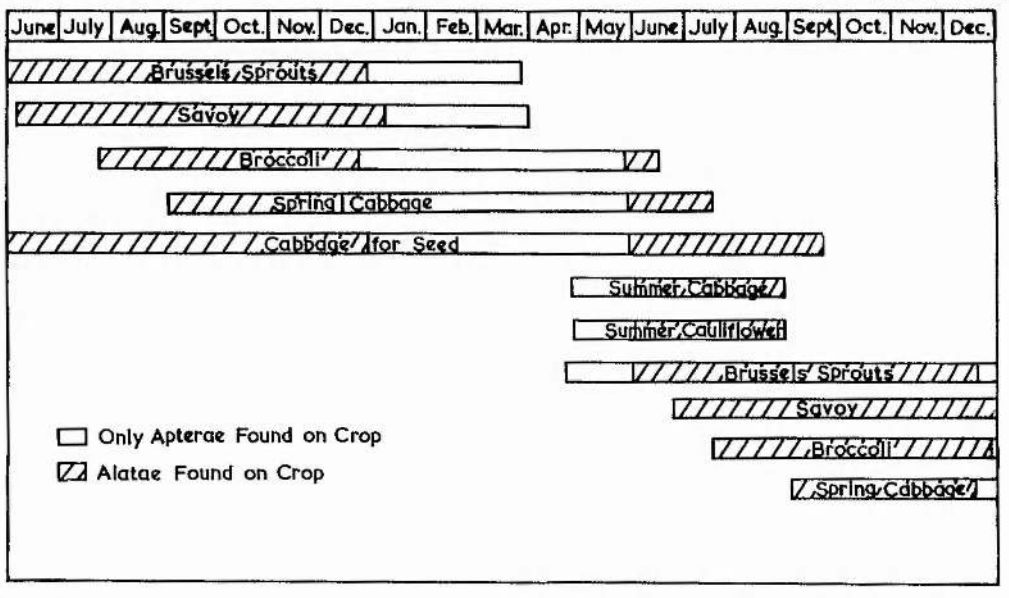


Fig. 8 Succession of field brassica crops in the Lothians area in relation to the occurrence of alate M. persicae

crops in the Lothians area, approximate growing periods and approximate periods during which alate M. persicae were found on these crops. Depending on market demands a small proportion of savoy crops occasionally persists until the end of May and a few spring cabbage crops are sometimes cut as early as December. Although large numbers of apterous aphids develop on savoy and brussels sprout crops during the winter months alatae are seldom produced before these crops are cleared. Only when the clearing of these crops is delayed until the middle of May are they likely to be sources of overwintered aphids. On the other hand, spring cabbage, broccoli and cabbage for seed normally persist long enough to allow of the production of winged aphids capable of migrating to other brassica and potato crops.

Each year summer cabbage, summer cauliflower, Milan turnips, brussels sprouts and potatoes became infested between mid-May and mid-June and savoys, broccoli and spring cabbage became infested as soon as they were planted in the field. Typical figures for the initial infestation by M. persicae are given in Appendix tables 1 and 2 for a summer cabbage crop (B8) at Inveresk in 1955 and for a summer cauliflower crop (B14) at Musselburgh in 1956.

In each of the three summers of 1954, 1955 and 1956 large populations of M. persicae developed on

brassicas in the Lothians; over 1,000 aphids per plant were frequently recorded on savoys, brussels sprouts, summer cabbage and cauliflower and cabbage for seed. Due to an exceptionally warm, dry spring and summer, the highest populations were recorded in 1955. Such large populations of M. persicae are commonly found in the Lothians area and severe damage to crops by aphids in the summers of 1935, 1939 and 1943 is reported by Cameron (1936, 1940, 1944).

On crops infested between mid-May and mid-June alate nymphs were recorded from the beginning of July onwards, and from mid-July until mid-August very large numbers of migrating alatae developed. In 1956, two suction traps were operated, one at Inveresk, Midlothian from May 8th - October 5th and the other at Mylnefield, Perthshire from May 24th - October 13th. Fig. 9 shows the number of alate M. persicae caught per 24 hours in each of the traps. At Inveresk, the small numbers of aphids caught during the latter part of May and June probably developed on overwintered crops whilst the large number caught from mid-July to the end of August were probably migrants from populations that developed on spring planted crops. From mid-August a combination of parasites, predators, fungi (Entomophthora spp.) and clearing of a proportion of host plants decreased the number of flying aphids, but a few capable of migration

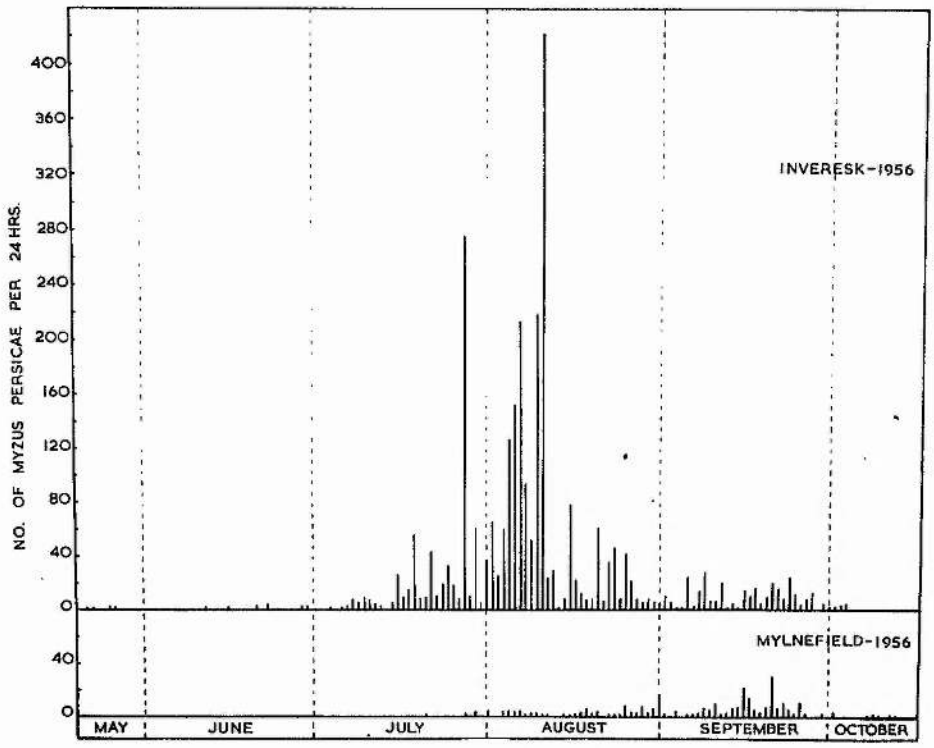


Fig. 9 Daily catches of M. persicae in suction traps at Inveresk and Mylnefield, 1956

were found on savoys, broccoli and brussels sprouts until the end of November or beginning of December. For example on a spring cabbage crop (B10) planted adjacent to an infested brussels sprout crop (Fig. 10) at Inveresk, 64 and 8 alatae per 50 plants were recorded on October 28th and December 2nd, 1955 respectively. As no alate nymphs were found on the spring cabbageit seemed likely that the alatae were immigrants, probably from the brussels sprout crop.

By comparison, at Mylnefield M. persicae was first trapped in mid-July but numbers remained low until September when they increased slightly coincident with the migration of alate aphids from neighbouring potato crops. It seems clear, therefore, that the contribution of migrant alatae from the few and scattered brassica crops in this area must be very small and scarcely influence the time and degree of infestation of the potato crops.

2 OVERWINTERING OF MACROSPHUM EUPHORBIAE (THOMAS)

In spring 1954, 1955 and 1956 viviparous females were taken on strawberries and lettuce outdoors and on Cineraria, Solanum capsicastrum, Hydrangea, Lilium and lettuce under glass. It is not certain whether the aphids found on strawberries overwintered as viviparous females or as eggs but by the end of May large populations were found in several plantations in Angus, particularly

Fig. 10 Spring cabbage planted adjacent to brussels sprouts infested by M. persicae.

Inveresk, autumn 1955.

in 1954. Thomas and Jacob (1943) found M. euphorbiae overwintering as eggs on strawberries in north Wales. This aphid was not found on brassicas although Doncaster and Gregory (1948) recorded that it was not uncommon to find it in small numbers among the colonies of Myzus persicae on brassicas during the winter.

It is probable that in eastern Scotland M. euphorbiae most commonly overwinters under glass.

3 OVERWINTERING OF AULACORTHUM SOLANI (KLTB.)

Although this aphid was not recorded as overwintering outdoors it was commonly found in glasshouses throughout 1954, 1955 and 1956 on a wide range of hosts including Calceolaria, Cineraria, Chrysanthemum, Fuchsia, Geranium, Lilium, Salvia and lettuce. It was also found frequently on lettuce in heated frames. In many glasshouses, alatae were found by the end of April each year.

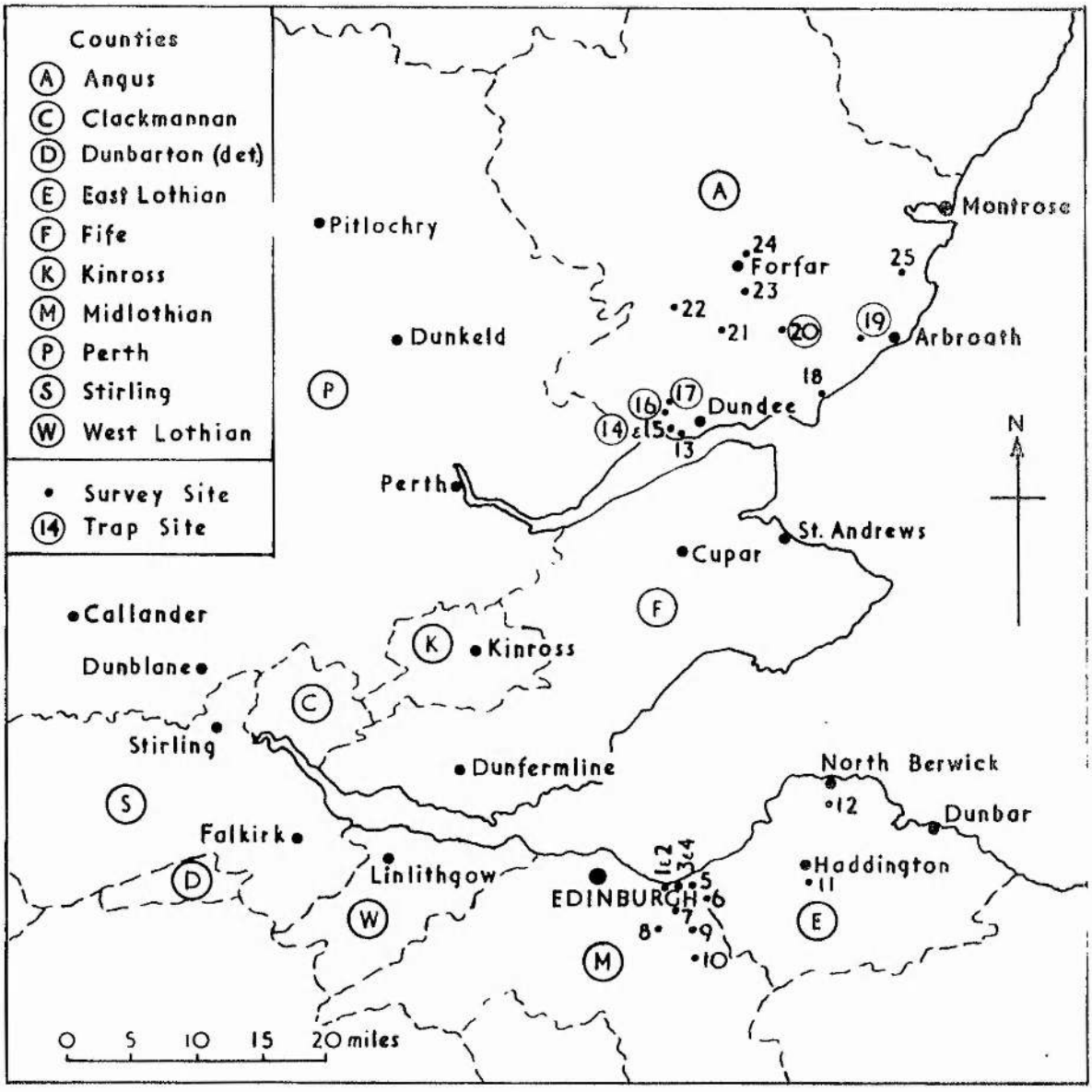
These brief observations indicate that in eastern Scotland A. solani overwinters mainly on protected crops.

IV INFESTATION OF THE POTATO CROP BY APHIDS

Distribution of potato crops surveyed.

Although a major proportion of the Scottish acreage of seed potatoes, 67 per cent in 1956, is grown in eastern Scotland not all districts are equally suitable for the production of high grade stock. For example, Cockerham (1939) showed that a larger proportion of crops in the counties of West Lothian, Midlothian, East Lothian, Fife and Moray was rated "No Grade" because of higher leaf roll infection than elsewhere in eastern Scotland. Furthermore, the few figures available relating to the epidemic spread of leaf roll in the 1945/46 season indicate that spread was worst in the counties of Midlothian, Eastlothian Berwick, Fife and Angus.

In 1954 observations were begun on selected crops in Angus and in the counties of Mid and East Lothian (Fig. 11) in order to compare the time of arrival and subsequent population increase of potato aphids in areas that differed widely in suitability for the production of seed poatoes. By 1955 it was established that brassica crops in the market garden area of the Lothians served as important winter hosts for M. persicae. To see whether there was any correlation between the time of dispersal of aphids from this area and the time of

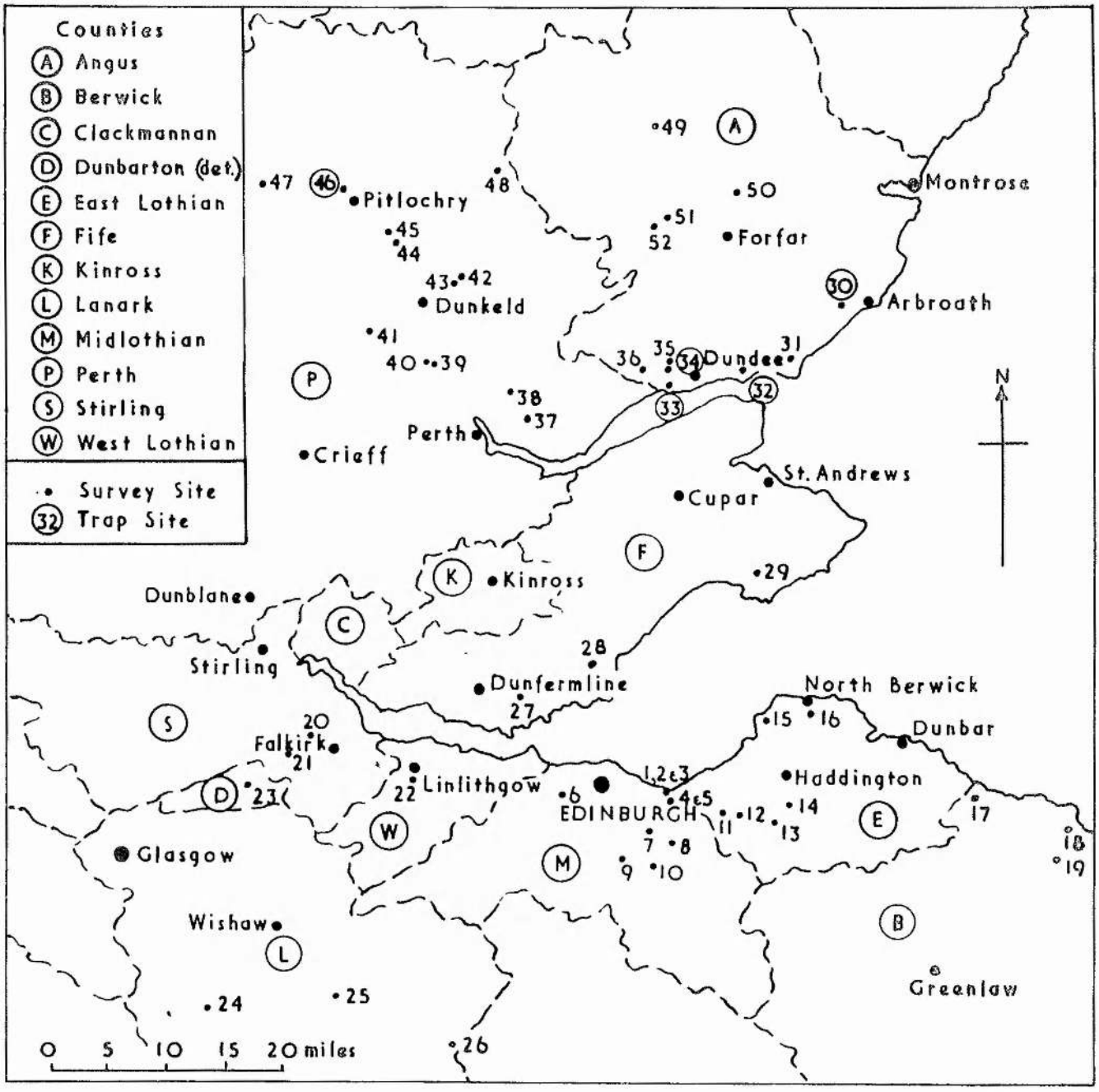


1954

Fig. 11 Map showing situation of survey and trap sites 1954

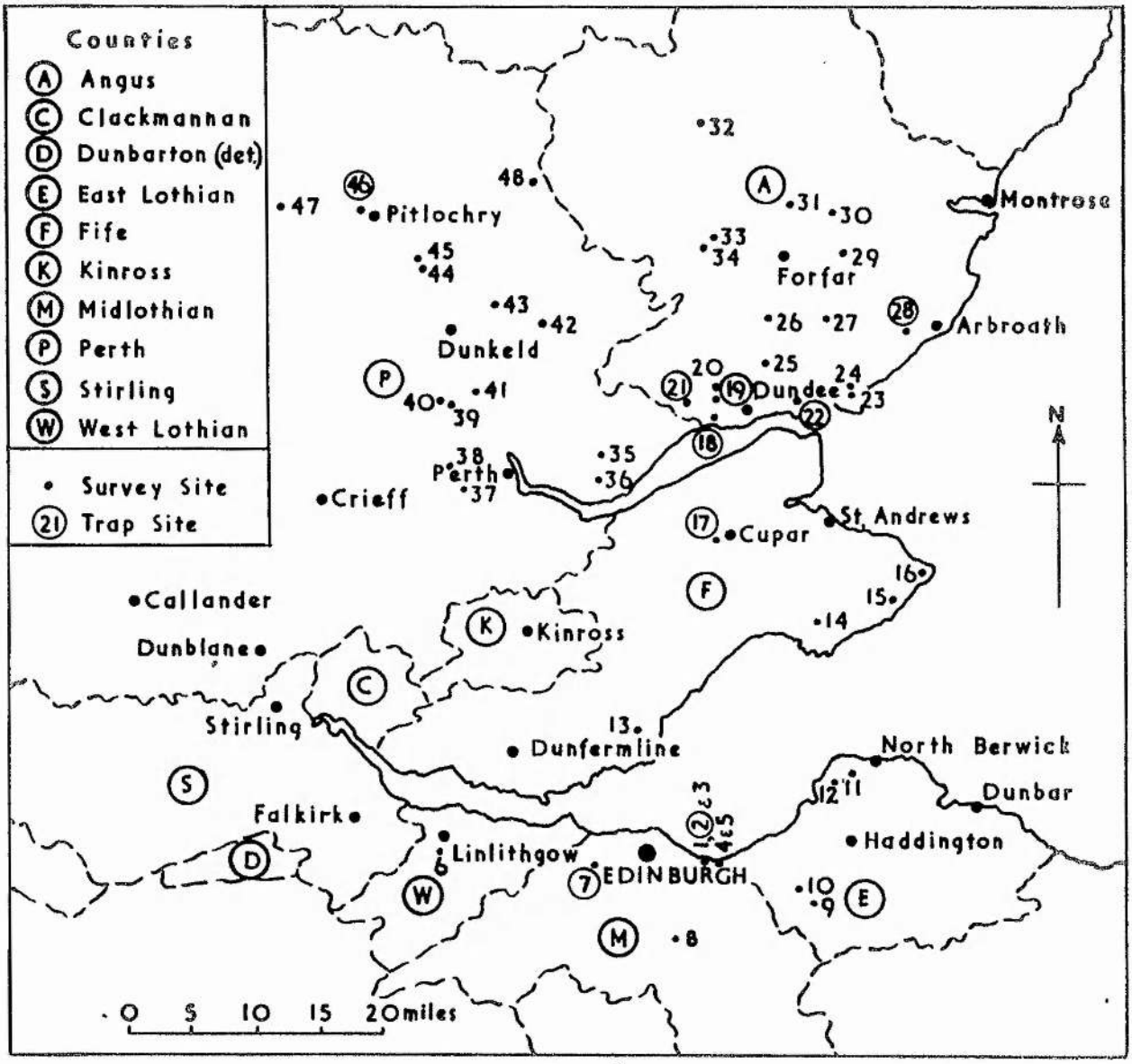
arrival of aphids on potatoes, observations were made on a larger number of crops than in 1954. These were distributed more evenly round the market garden area (Fig. 12), but the majority were in the counties of Mid and East Lothian, Fife Angus and Perth. For convenience both Angus and Perth were arbitrarily divided into north and south areas by a line drawn from a point three miles north of Dunkeld, in the west, to Arbroath, in the east. In 1956 (Fig. 13)it was necessary to curtail the number of crops observed south of the Forth but otherwise the distribution of crops was similar to that of 1955. In mid-August, 1956, a brief visit was made to Moray where a few potato crops were examined in and near the market garden area. The aphids considered were Myzus persicae, Macrosiphum euphorbiae and Aulacorthum solani. Most attention was given to Myzus persicae because it is the principal vector of potato leaf roll Y viruses.

The numbers of adults and nymphs of alatae and apterae of each species per 100 leaves were recorded at most sites. From these figures the numbers of Myzus persicae per plant were calculated and the results are given in the appendix tables. In each of the three years 1954-56 fields were visited at intervals of 1 - 3 weeks, except in the area south of the Forth where some fields were visited at 3 - 4 weekly intervals and others only once. Crops situated near the Perthshire Angus



1955

Fig. 12 Map showing situation of survey and trap sites 1955



1956

Fig. 13 Map showing situation of survey and trap sites 1956

boundary will be considered with the Angus sites.

1 INFESTATION BY MACROSIPHUM EUPHORBIAE (THOMAS) AND AULACORTHUM SOLANI (KLTB)

The locality and reference number of the sites visited are given in Table 26 and Figs. 11, 12 and 13 for 1954, 1955 and 1956 respectively.

Table 27 gives figures condensed from the appendix tables and shows that M. euphorbiae was distributed generally throughout the area of eastern Scotland under investigation; only few crops remained free from infestation. The highest populations were recorded onptato crops in the market garden areas of the Lothians and Moray and in South Angus. In each of the years 1954, 1955 and 1956 the highest populations in south Angus were recorded near Dundee where glasshouses are numerous and strawberries are a common field crop; both provide shelter for M. euphorbiae during the winter. In 1955 and 1956 the highest populations were recorded at Inveresk, Midlothian. In this area overwintering sites are provided by lettuce both in glasshouses and outdoors. In 1956 a high population was recorded on a potato crop adjacent to glasshouses in a market garden at Elgin, Moray.

. The time of initial infestation varied little between years and between areas except at Inveresk where aphids were regularly found about 3 weeks earlier than

Table 26

Reference numbers of sites at which Macrosiphum euphorbiae and Aulacorthum solani were recorded

Area	1954		1955		1956	
	Total no. of sites	Site numbers	Total no. of sites	Site numbers	Total no. of sites	Site numbers
Midlothian			6	1 - 5, 7	5	1,2,4,5,7
Fife			3	27 - 29	5	13 - 17
Angus (south)	9	13 - 21	7	30 - 36	11	18 - 28
Angus (north)	4	22 - 25	4	49 - 52	6	29 - 34
Perth (south)			5	37 - 41	7	35 - 41
Perth (north)			7	42 - 48	7	42 - 48
Moray					7	

Table 27

Macrosiphum euphorbiae

Distribution, time of infestation and maximum population per 100 leaves

Year	Area	No. crops examined	No. crops infested	Date of first record	Max. pop. per 100 leaves	Site of max. pop.	Date max. pop. recorded
1954	Angus (south)	9	9	8/7	247	14	2/8
	Angus (north)	4	4	15/7	22	24	2/9
	Total	13	13				
1955	Midlothian	6	6	16/6	604	5	9/7
	Fife	3	3	14/7	142	28	4/8
	Angus (south)	7	6	5/7	381	32	8/8
	Angus (north)	4	4	22/7	68	51	31/8
	Perth (south)	5	5	28/7	20	38	31/8
	Perth (north)	7	7	30/7	28	42	31/8
	Total	32	31				
1956	Midlothian	5	5	4/7	500	5	2/8
	Fife	5	5	25/7	27	16	8/8
	Angus (south)	11	7	4/8	246	19	17/9
	Angus (north)	6	5	23/7	17	29	10/9
	Perth (south)	7	5	20/7	71	38	8/9
	Perth (north)	7	6	14/8	39	47	4/10
	Moray	7	6		515		15/8

in the other areas.

Table 28 shows that Aulacorthum solani also was distributed generally throughout eastern Scotland. In 1955 however only two out of seven crops examined in Perth (North) became infested. The highest populations were recorded in 1955 and 1956 at Musselburgh and Inveresk, Midlothian on crops near frames and glasshouses where this aphid overwintered. At these sites the initial infestation was recorded about 4 weeks earlier than at the sites in the other areas.

2 INFESTATION BY MYZUS PERSICAE (SULZER)

The localities and reference numbers of the sites visited in 1954, 1955 and 1956 are given in Table 29 and Figs. 11, 12 and 13 respectively. Sites 5, 6 and 12 (1954), 6 and 8 - 26 (1955) and 6 and 9 - 12 (1956) were visited only once and will not be considered in the tables and figures which follow. The Midlothian crops observed were all in or near the main brassica growing areas of Musselburgh and Inveresk.

The principal aphid counts at each of the sites for the three years of the investigation are shown in Figs. 14, 15 and 16. The mean counts per trap are for periods of 3 or 4 days and the leaf-count figures are expressed as numbers of aphids per plant.

The main results to be considered below are summarised in Table 30 which shows that M. persicae was

Table 28

Aulacorthum solani

Distribution, time of infestation and maximum population per 100 leaves

Year	Area	No.crops examined	No.crops infested	Date of first record	Max. pop. per 100 leaves	Site of max. pop.	Date max.pop. recorded
1954	Angus (south)	9	9	14/7	50	21	10/9
	Angus (north)	4	4	25/7	68	23	24/8
	Total	13	13				
1955	Midlothian	6	6	16/6	400	4	5/8
	Fife	3	3	14/7	5	29	14/7
	Angus (south)	7	6	5/7	49	36	18/8
	Angus (north)	4	4	22/7	12	51	12/8
	Perth (south)	5	5	25/7	3	41	25/7
	Perth (north)	7	2	30/7	4	43	12/8
	Total	32	26				
1956	Midlothian	5	5	11/6	400	5	2/8
	Fife	5	5	25/7	104	14	12/9
	Angus (south)	11	7	20/7	69	20	17/9
	Angus (north)	6	5	10/8	71	29	10/9
	Perth (south)	7	6	20/7	25	35	27/9
	Perth (north)	7	4	20/7	24	46	9/9
	Moray	7	6		49		16/8
	Total	48	39				

Table 29

Reference numbers of sites at which Myzus persicae was recorded

Area	1954		1955		1956	
	Total no. of sites	Site numbers	Total no. of sites	Site numbers	Total no. of sites	Site numbers
Midlothian	8	1 - 4, 7 - 10	10	1 - 10	7	1 - 5, 7, 8
East Lothian	4	5, 6, 11,12	6	11 - 16	4	9 - 12
West Lothian	-	-	1	22	1	6
Berwick	-	-	3	17 - 19	-	-
Stirling	-	-	2	20, 21	-	-
Dumbarton	-	-	1	23	-	-
Lanark	-	-	3	24 -26	-	-
Fife	-	-	3	27 - 29	5	13 - 17
Angus (south)	9	13 - 21	7	30 - 36	11	18 - 28
Angus (north)	4	22 - 25	4	49 - 52	6	29 - 32
Perth (south)	-	-	5	37 - 41	7	35 - 41
Perth (north)	-	-	7	42 - 48	7	42 - 48
Moray	-	-	-	-	7	-
Total	25		52		55	

Fig. 14

Trap and leaf counts of M. persicae

1954

1954

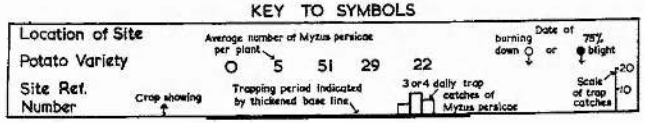
MIDLOTHIAN

MAY	JUNE	JULY	AUGUST	SEPTEMBER
Inveresk Redskin 1	2	400	500	
Inveresk Redskin 2	0	60	400	
Musselburgh Epicure 3	90	1500 ♀		
Musselburgh Epicure 4	12	300 ♀		
Wallyford nr Musselburgh King Edward 7		0	200 ♀	
Dalkeith King Edward 8		0	19	●
Dalkeith King Edward 9		0	14	●
Pathhead Kerr's Pink 10		0	6	●

EASTLOTHIAN

Haddington Arran Banner 11		0	0	

KEY TO SYMBOLS



1954

ANGUS (SOUTH)

MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Benvie nr. Dundee Home Guard 13		1 9	5 31♀		
Invergowrie Majestic 14		4 19	8 11 3 7 7 ●		
Invergowrie Home Guard 15		0	13 8 2 ●		
Birkhill nr. Dundee Majestic 16		0 0	1 18 46 23 ●		
Dronley nr. Invergowrie Majestic 17		0 0	9 9 9 14 ●		
Muirdrum Up-to-Date 18		0 0	4 17♀		
Arbroath Redskin 19		0 0	2 14 24 66 44 ●		
Inverarity Up-to-Date 20		0 0	0 0♀		
Inverarity Majestic 21		0 0	1 7 23 40●		

ANGUS (NORTH)

MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Glamis Up-to-Date 22		1	2 15 86♀		
Lour nr. Forfar Up-to-Date 23		0	1 0 0 ♀		
Forfar Up-to-Date 24			4 0 6 ♀		
Inverkeilor Epicure 25		2	4♀		

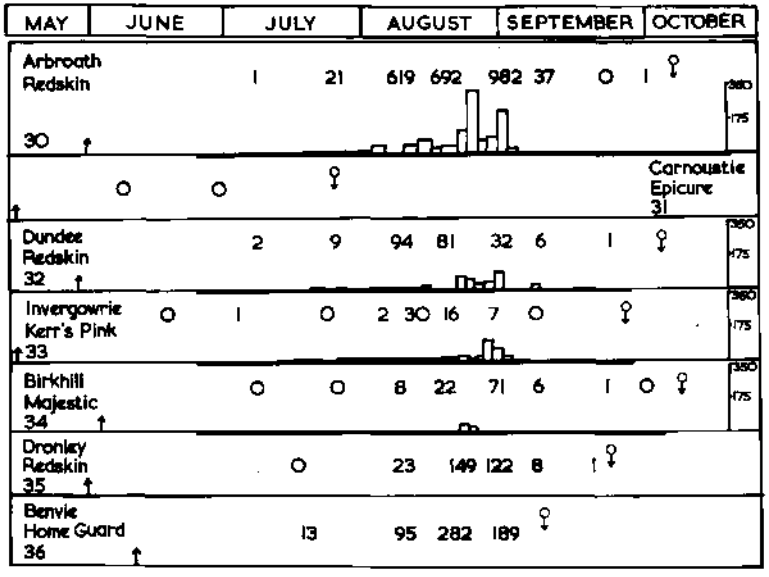
Fig. 15

Trap and leaf counts of M. persicae

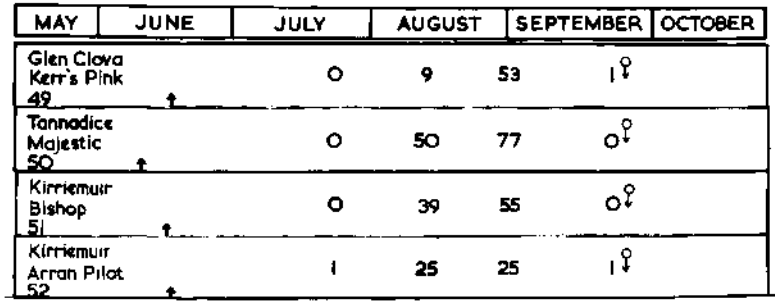
1955

1955

ANGUS (SOUTH)

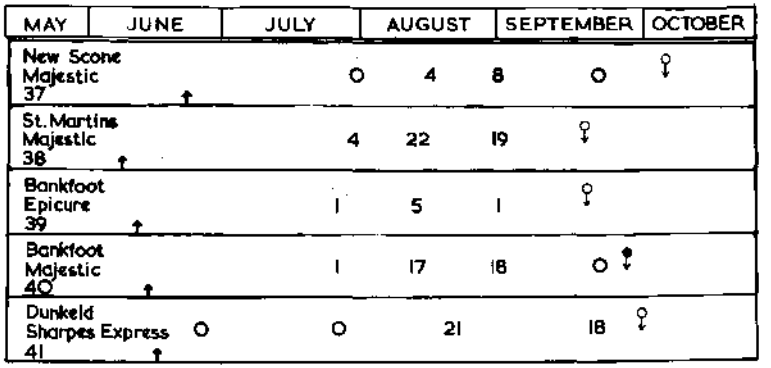


ANGUS (NORTH)



1955

PERTH (SOUTH)



PERTH (NORTH)

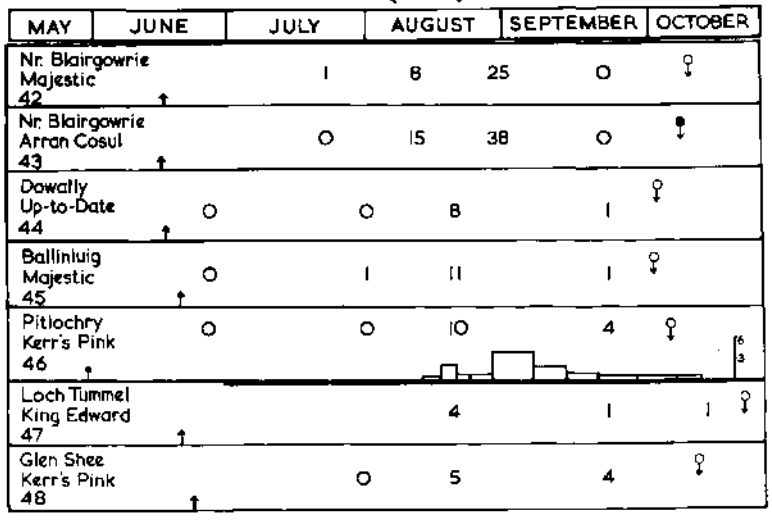


Fig. 16

Trap and leaf counts of M. persicae

1956

PERTH (SOUTH)

MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Rait Kerr's Pink 35		0	5	12	51	19
Glendoick Kerr's Pink 36		2	29	99	43	♂
Tibbermore Majestic 37		0	7	18	46	♂
Methven King Edward 38		0	1	10	65	♂
Bankfoot Epicure 39		0	0	1	0	
Bankfoot Majestic 40		0	2	7	69	♂
Bankfoot Arran Pilot 41		1	7	♀		

PERTH (NORTH)

MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
Nr. Blairgowrie Arran Consul 42		2	12	6	♀	
Nr. Blairgowrie Majestic 43		0	0	10	20	♀
Dowally Kerr's Pink 44		0	1	1	0	0 ♀
Ballinluig Majestic 45		0	1	5	25	♀
Pitlochry Majestic 46		0	0	2	25	♂
Loch Tummel King Edward 47		0	0	0	2	2 ♀
Glen Shee Kerr's Pink 48		0	0	0	1	2 ♂

ANGUS (NORTH)

JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER
dney	0	1	2	28	♂
k	0	20	103	141	♀
e	1	19	24	21	♂
va nk	0	1	0	6	5 ♂
ir	2	7	12	17	♂
lat	0	7	1	♀	

rie nk	16	79	252	44	30 ♂	
	0	0	0	23	141	307 ♂
nk	0	0	1	6	21	81 ♂
ard	0	0	0	5 ♀		
	5	5	90	150	309	23 ♀
	1	♀				Carnoustie Epicure 23
nk	0	5	51	29	22 ♂	
nk	0	0	1	6	11	7 ♂
y	0	0	0	6	27	24 ♂
y ate		0	2	21 ♀		
nk	1	1	17	77	173	25 ♂

Table 30

Distribution and population figures for Myzus persicae

Year	Area	No.crops examined	No.crops infested	First record	Mean max. pop.	Max. pop. per plant	Site of max.pop	Date max. recorded
1954	Midlothian	8	8	16/6	508	1500	3	11/7
	Angus (south)	9	8	15/7	28	67	19	4/9
	Angus (north)	4	4	15/7	25	87	22	24/8
	Total	21	20					
1955	Midlothian	6	6	18/6	1610	8000	4	5/8
	Fife	3	3	14/7	16	21	28,29	4/8
	Angus (south)	7	6	5/7	226	982	30	29/8
	Angus (north)	4	4	22/7	52	77	50	31/8
	Perth (south)	5	5	25/7	15	22	38	12/8
	Perth (north)	7	7	25/7	15	38	43	31/8
	Total	32	31					
1956	Midlothian	7	7	18/5	8401	50000	3	3/8
	Fife	5	5	4/7	235	294	13	8/8
	Angus (south)	11	11	20/6	113	310	22	29/8
	Angus (north)	6	6	23/7	38	141	30	10/9
	Perth (south)	7	7	20/7	48	99	36	21/8
	Perth (north)	7	7	20/7	13	25	45,46	9/9
	Moray	7	7			540		15/8
	Total	50	50					

generally distributed throughout eastern Scotland. Only two of the observed potato crops remained uninfested; one (site 20) in 1954 and the other (site 31) in 1955, both in Angus (South).

i Midlothian

In 1954 and 1955 M. persicae was first found in mid-June although the figures suggest that several crops were probably infested earlier. In 1956 crops were infested earlier and alatae were first recorded on potatoes on May 18th. In each year maximum populations on early crops were recorded just before lifting in mid-July and in early July large numbers of alatae left the crops as shown by the trap catches at site 2 in 1956 (Fig. 16).

On main crops, maximum populations were recorded in early August. At this time each year, parasites, predators and fungi (Entomophthora sp.) became abundant, aphid populations declined drastically and few aphids were found on potatoes in the market garden areas after the end of August.

Fig. 17 A and G shows that the curves for the mean number of aphids per plant and mean percentage of plants infested follow each other closely and that they were similar in 1955 and 1956. Although the hot, dry summer of 1955 favoured aphid multiplication and movement. parasites and predators were numerous in July and mean

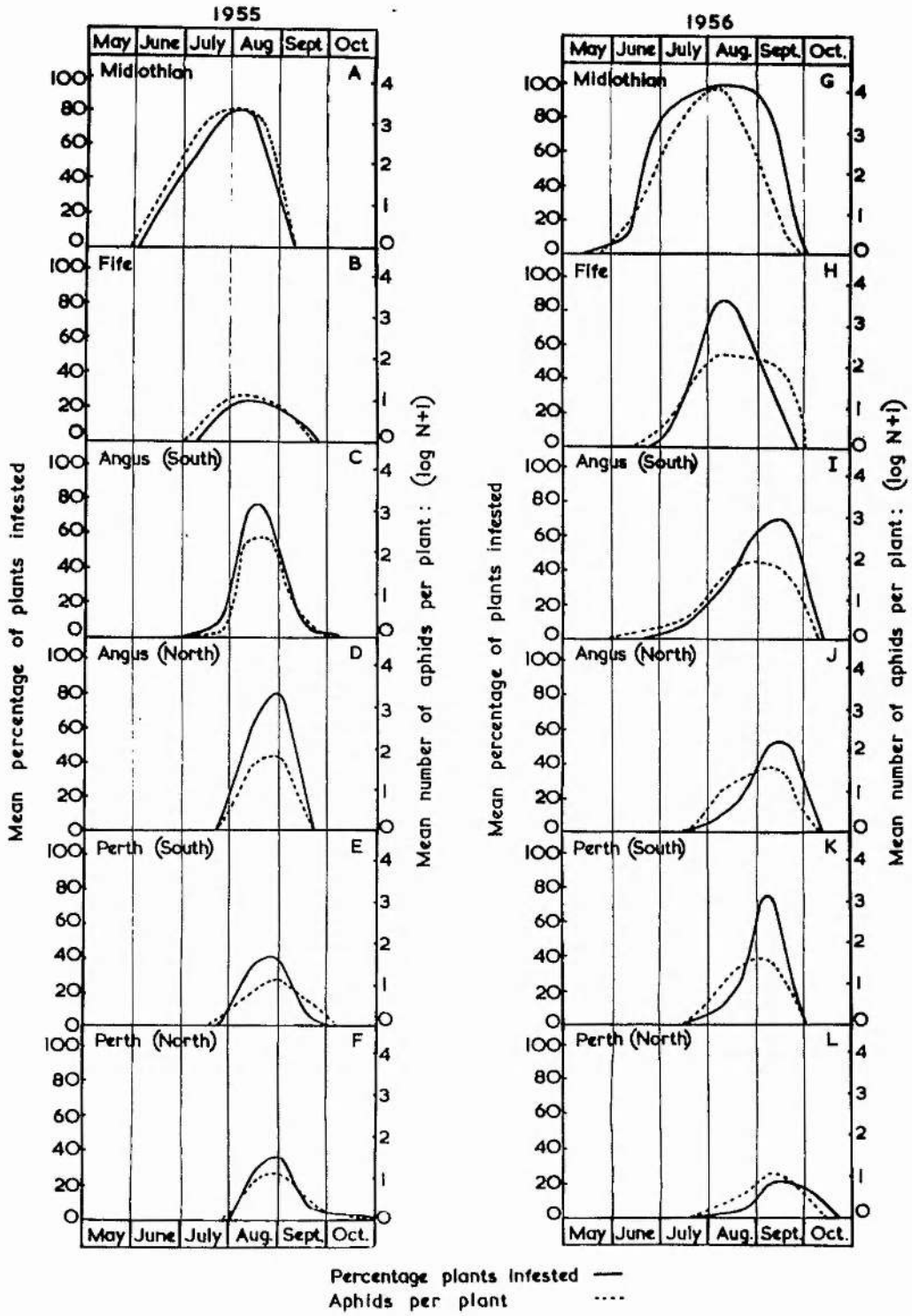


Fig. 17 Mean number of M. persicae per plant and mean percentage of plants infested

maximum infestation was only 87% on August 5th whereas in 1956 with less favourable climatic conditions, 87% of the plants were infested in early July and 98.5% on 2nd August.

The degree of infestation of potato crops by M. persicae was correlated with proximity to infested crops. For example, on June 18th 1955, 25 alatae per 100 leaves were found on a crop of Redskin potatoes (Site 4) planted adjacent to spring cabbage (B1) (Fig. 18) on which M. persicae had successfully over-wintered. On the same date only 2 alatae per 100 leaves were recorded on a similar crop of potatoes (site 5) 400 yards distant. On 5th August, maximum populations of 8,000 and 1,500 aphids per plant were recorded at sites 4 and 5 respectively, and at site 4 the aphids almost completely destroyed the haulms. (Fig. 19)

The highest population, estimated at 50,000 aphids per plant, was found on a Dunbar Standard crop (site 3) in 1956, and it is clear that large numbers of alatae from an adjacent Epicure crop (site 2) infested the Dunbar Standard in early July. As at site 4 (1955) the haulms of this crop were completely destroyed by the aphids in early August.

ii Other sites south of the Forth

Single observations at sites 6 and 8 - 26 (1955) and 6, 9 and 10 (1956) suggested that at these sites

Fig. 18 Redskin potatoes (site 4) planted adjacent to spring cabbage (B1) infested by M. persicae.

Inveresk

June 17th 1955

Fig. 19 Aphid damage to haulms
of Redskin potatoes (site4)
Inveresk
August 6th 1955

maximum populations did not exceed 60 aphids per plant. Sites 11 and 12 (1956) were situated near a large market garden at Dirleton and in early August populations of 550 and 474 aphids per plant respectively were found.

iii Fife

In both 1955 and 1956 aphids were first found in early July and maximum populations in mid-August. Few alatae developed on the three crops observed in 1955 but in 1956 the summer dispersal of alatae started in early August and continued until the crops were destroyed by blight or burning down in mid-September. In 1955 the mean maximum population was only 16 aphids per plant with 22% of the plants infested (Fig. 17 B) compared with a mean maximum population of 235 per plant with 80% of the plants infested in 1956 (Fig. 17 H). Undoubtedly parasites and predators controlled developing aphid populations more efficiently in 1955, but it is also probable that the three crops observed were not entirely representative of the area. In 1956, maximum populations of 249, 292 and 148 aphids per plant were recorded at sites 14, 15 and 16 respectively in south eastern Fife. Intensive searches failed to reveal any source of over-wintered aphids in the vicinity of these crops.

iv Angus (South)

The time of initial infestation of potato crops in this area varied considerably between seasons and

between crops in any one season. Aphids were recorded on a few crops in late June 1956, but the majority of crops did not become infested until mid-July of each year and a few crops remained uninfested until early August. In 1955, an unusually warm and dry season which favoured aphid multiplication, the mean maximum population of 226 aphids per plant was higher and about three weeks earlier than in 1954 and 1956. A mean maximum of 77% of the plants was infested on August 17th 1955 (Fig. 17 C). In 1956, at the same date only 38% of the plants were infested and the mean maximum of 71% was not recorded until September 17th (Fig. 17 I).

The highest population for this area, 982 aphids per plant, was recorded on a Redskin crop at Arbirlot, Arbroath (site 30) on August 29th 1955, and far exceeded the second highest population of 310 per plant recorded at site 22 near Dundee on August 29th 1956. Detailed figures in Appendix Table 6 show that the infestation at Arbirlot began in early July and progressed slowly until the end of July. A large number of alatae were trapped between 1st and 3rd August (Fig. 15) and leaf counts showed that the population had increased to 619 aphids per plant by August 8th when 97% of the plants were infested. From this time onwards migrating alatae developed on the crop and most aphids were trapped between August 20th and 22nd. The maximum population

(982 aphids per plant) was recorded on August 29th and by September 6th, following attacks by parasites, predators and dispersal of aphids from the crop, there were only 37 aphids per plant. The unusually high maximum population seemed associated with the large immigration of alatae in early August, recorded at this site only, but no source of alatae was found in the neighbourhood of this crop.

v Angus (North)

Although a few crops in this area became infested in the third or fourth week of July each year, the majority remained free from aphids until the first or second week of August. Due to the lateness of initial infestation by relatively few alatae, populations seldom rose above 40 aphids per plant and maximum populations were not found before late August or early September. By the third week of September of both 1954 and 1956 most crops not burned down were destroyed by blight and in 1955 parasites and predators had almost completely eliminated aphids by the second week of September. Fig. 17 D shows that the percentage of plants infested increased quickly to a mean maximum of 78% on August 31st 1955. At the same date in 1956 only 30% of the plants were infested and the mean maximum infestation of 52% was recorded on 10th September (Fig. 17 J).

The highest population of 141 aphids per plant

was recorded on September 10th 1956 on a Kerr's Pink crop (site 30) situated on a south facing slope at an elevation of almost 700 feet.

vi Perth (South)

In 1955 most crops were infested by the fourth week of July. Maximum populations not exceeding 22 aphids per plant, with 38% of the plants infested (Fig. 17 E), were found at the end of August, when parasites and predators became abundant and controlled aphids on most crops.

Although in 1956 the initial infestation was delayed until the first or second week of August, a higher mean maximum population was recorded and 76% of the plants were infested on September 8th (Fig. 17 K). After the second week of September few parasitised aphids were found and blight was the main cause of reduction of aphid populations.

vii Perth (North)

Although most of the crops selected in this area were situated on high ground remote from sources of overwintered M. persicae, aphids were found on a few crops in the last week of July 1955 and 1956. The majority however remained free from aphids until the second or third week of August. In 1955 the mean maximum population of 15 aphids per plant with 37% plants infested was recorded on August 31st. (Fig. 17 F). The corresponding figures for 1956, 13 aphids per plant with

20% plants infested were recorded on September 9th (Fig. 17 L).

viii Moray

Seven potato crops in this area were examined on August 15th and 16th 1956, and the mean population of 158 M. persicae per plant recorded. The highest populations of 540 and 207 aphids per plant were found on two crops in a market garden at Elgin, and the smallest population of 15 aphids per plant was found on a crop at Orton, 10 miles south of the main market garden area. Populations ranged from 53 to 145 aphids per plant on the remaining crops situated between Elgin and Forres.

From these brief observations it seemed that the situation in this area resembled that of the similar but more extensive market garden area of the Lothians, and fewer aphids were found on potatoes as the distance of the crops from brassicas increased.

These results show clearly that between areas in eastern Scotland there were differences in the time and degree of infestation of potato crops by M. persicae, and that these differences were consistent in the contrasting seasons of 1955 and 1956.

However, for each areathe pattern of infestation was similar. Except in the market garden area of the Lothians, few immigrant alatae were found either on the potato crops or in the traps, and on a few crops, the

first evidence of infestation was provided by the small groups of nymphs found, usually on the middle or lower leaves, distributed through the crop. Only on potato crops adjacent to a source of alate aphids was there any evidence that the first plants to become colonised were those along one or more edges of the field. (cf. Doncaster and Gregory 1948). At all other sites, plants colonised seemed evenly distributed through the crops (cf. Profft 1939). On most crops examined these initial colonies averaged three nymphs each, and it seems likely that at least a proportion of immigrant alatae are capable of depositing nymphs on several plants. It has been shown that climatic conditions, particularly temperature, affect the movement of alatae. High summer temperatures encourage movement and it is likely that more plants become infested by a given number of alatae per unit crop area when temperatures are high than when they are low.

From these nymphs successive apterous generations develop but these seem to play only a small part in spreading the infestation throughout the crop, probably because aphids move mostly from leaf to leaf on the same plant rather than from plant to plant. In an experiment at Mylnefield (site 18) in 1956, nine leaf roll infected plants were artificially colonised on July 2nd by caging one alate aphid on each of three leaves

of each plant. When colonies of nymphs were established, the cages were removed and the alatae destroyed. On August 16th the artificially colonised plants had populations ranging from 700 - 1,200 aphids per plant, whilst adjacent plants carried populations similar to the field average of 250 aphids per plant.

Most M. persicae were found on the lower and middle leaves and seldom more than four per cent of the total population per plant was found on the upper leaves. On only one occasion, on a Kerr's Pink crop at Glen Clova (site 49, 1955) were M. persicae found in numbers on the upper part of the plants when the foliage was still fresh and green; on this crop two or three alatae were found on 50 per cent of the flower heads when examined on August 31st. When the lower and middle leaves of the crops were destroyed by blight, however, aphids moved to the upper green leaves. This was particularly noticeable on a Majestic crop (site 37) on September 8th 1956 when an average of only 16 leaves per plant remained and the aphid population averaged 46 per plant.

The alatae which developed on crops within three to five weeks of initial infestation appeared to be more important than apterae in increasing the proportion of plants infested, particularly where only a few plants were infested initially.

Although the behaviour of M. persicae on individual crops varied little from the described pattern, there were considerable variations in the time and degree of infestation of crops in different areas. With the exception of the Fife area these variations were reasonably consistent between the two seasons 1955 and 1956. The mean percentages of plants infested in all crops in each area on the different sampling occasions (Fig. 17) show that in the poor seed growing area of Midlothian the plants were colonised in late May or early June and 80-98 per cent were infested by the end of July. As the distance from Midlothian increased, there was a tendency for crops to become infested both later and to a lesser degree. In the better seed growing area of Perth (North) plants were first colonised in late July or early August and only 37 and 20 per cent of the plants were infested in late August 1955 and early September, 1956 respectively.

Although weather conditions in 1955 and 1956 differed greatly there was little difference between years in the time of initial colonisation and the maximum percentage of plants infested in crops in different areas. But in the hot dry summer of 1955, crops became infested more rapidly and the maximum infestation was reached earlier than in the cool wet season of 1956.

The differences between areas and seasons in the time of movement of alatae are emphasised by the

figures for mean percentage of alate M. persicae trapped per month in different areas in 1955 (Table 31) and 1956 (Table 32).

In the better seed districts where crops were colonised late in the season, the destruction of the haulms by burning down or blight undoubtedly curtailed the numbers of autumn migrants leaving many crops, but alatae or alate nymphs were found on all but two (sites 20 and 23) three (sites 31, 37 and 44) and two (sites 23 and 44) crops in 1954, 1955 and 1956 respectively.

It seems likely that climatic conditions which promote aphid activity early in the season in seed-growing districts are important in determining the rate of virus spread.

Table 31

Percentage of M. persicae trapped per month

1955

	Angus (south)	Perth (north)
	Water traps	Water traps
	Mean of sites 30,32,33 and 34	Site 46
July	0.59	0
August	87.00	57.44
September	12.02	36.18
October	0.39	6.38
Total	100.00	100.00

Table 32

Percentage of M. persicae trapped per month

1956

	Midlothian		Fife	Angus (south)		Perth (north)
	Water traps	Suction trap	Water traps	Water traps	Suction trap	Water traps
	site 7	Near site 5	site 17	Mean, sites 18,19 21,22 28	Near site 18	site 46
May	0	0.14	-	-	0	-
June	0.95	0.42	0	0	0.38	0
July	25.12	22.57	32.5	3.43	1.89	0
August	70.62	66.32	67.5	43.87	28.03	16.60
September	2.36	10.13	0	51.93	66.29	83.40
October	0.95	0.42	-	0.77	3.41	0
Total	100	100	100	100	100	100

V DISCUSSION

The results of this work show that all three species of potato aphid - Myzus persicae, Macrosiphum euphorbiae and Aulacorthum solani - overwinter successfully in eastern Scotland and that they do so primarily as apterae living on perennial, glasshouse, frame and brassica crops. Although M. persicae, the most important aphid concerned with the spread of viruses in potatoes, was found overwintering also as eggs laid on peach, peaches seem unimportant hosts in this part of the country.

Brassica crops were by far the commonest hosts of overwintering M. persicae and the fact that most of these, together with a large acreage of frame crops, are concentrated in the Edinburgh area seems important. In mid-May in each of the years 1954, 1955 and 1956 alatae developed from the overwintered colonies of M. persicae on spring cabbage, broccoli, seed cabbage and crops in heated frames. Often higher populations of aphids were found on brussels sprouts and savoys throughout the winter but the majority of these crops were cleared in March before alatae developed. Alatae from the overwintered crops quickly colonised the relatively larger acreage of spring planted brassica and potato crops. By July, large populations, frequently exceeding 1,000 aphids per plant were found on crops in this area and from the first or second week of July

until mid-August very large numbers of migrant alatae developed on them. The quantitative differences between spring and summer migrations can be gauged from the analyses (Table 32) of the catches recorded in the suction trap at Inveresk between May 8th and October 6th 1956. These show that only 0.57 per cent of the total number of aphids were trapped in May and June compared with 88.89 per cent in July and August.

In Angus and Perthshire, spring cabbage, broccoli and savoys seem of limited importance as overwintering hosts for M. persicae. Compared with the Lothians only a small and scattered acreage is grown and if aphids did survive the winter outdoors, a suitable succession of brassicas was rarely available for colonisation. No aphids were found overwintering on turnips and swedes of which a large acreage is grown for stock feed. In these areas M. persicae consistently overwintered in the egg stage on peach and viviparously on plants in glasshouses. However the influence of such sites seemed localised and certainly no alatae from peach were found either in the traps or colonising field potato crops. General observations indicated that the situation in Fife was similar.

Potato crops in the market garden area of the Lothians became infested between mid-May and mid-June and maximum populations, recorded in early August, were

considerably higher than in the other areas investigated. In Fife and Angus (South) the majority of crops became infested in late June and early July; in Angus (North) and Perth (South) initial infestation occurred from mid-July to early August whereas in Perth (North) most crops remained free from aphids until the end of July or mid-August.

Clearly the early infestation of potatoes in Midlothian was associated with the large numbers of alatae produced on overwintered crops. In other districts, late infestation seemed due to the paucity of overwintering sites for M. persicae. Both Davies (1939) and Shaw (1955a) found that M. persicae was most numerous on potato crops near urban areas, and in general the results of this investigation confirm this observation. However infestation was earlier and larger populations developed on many crops near which no local overwintering sites were found e.g. at Arbroath (site 30) in 1955, and in 1956 near Forfar (site 30) and crops in south-east Fife. A large proportion of the vast numbers of alatae that developed on crops in the Lothians presumably migrated to other areas in July and August and it seems significant that the time of colonisation of potatoes in Fife, Angus and Perthshire was coincident with this dispersal. Johnson (1954) showed that the aerial population of alate aphids was proportional to the numbers of such

aphids that developed on plants; weather conditions affected the numbers flying more by influencing their activity. On their first migratory flight the majority of aphids fly vertically upwards and are soon carried into windy regions. As aphids cannot make headway against winds of over 2 m.p.h. they are carried passively in the direction of the wind, sometimes for distances of at least 150 miles (Hardy and Milne, 1937). A proportion of alatae also make short non-migratory flights from plant to plant. The proportion of local to departure flights is not known although considered small by Johnson(1954). Meteorological records from Leuchars in Fife (Climate and Weather of the British Isles Vol. VI No. 2) show that an average of about 37 per cent of the winds (surface to 3,000 feet) in summer come from a southerly direction. A considerable proportion of the alatae that develop on crops in the Edinburgh area may therefore be blown northwards to the seed areas of Fife, Angus and Perthshire.

The graphs of mean percentage of plants infested in crops in each area 1955 and 1956 (Fig. 17) show that in general, besides being later, the maximum percentage infestation became smaller as the distance from the Edinburgh area increased. The reasons for this are probably twofold:

1) as the distance from the source of alatae

increases, the concentration of aphids in the aerial population and therefore the number of potential colonisers decreases;

2) The further alatae have travelled, the less active they will be in the crop and therefore the slower will be the rate of colonisation.

Broadbent (1949) suggested that alatae move less frequently as they get older and after prolonged exercise. Later Bruce Johnson (1953) found that alatae were capable of actively flying for only a few days before flight is prevented by wing-muscle autolysis.

Investigations in England have shown that in the ware growing areas of the south and east, immigration starts during May; populations are maximal in July when alatae disperse from the crops. In poor seed areas crops become colonised in June but the better seed areas in the north and west of the country remain free from aphids until mid-July. Hollings (1955) showed that in the poor seed areas the summer dispersal migrants were often numerous and were usually associated with extensive spread of virus; but in the better seed areas this dispersal did not take place until mid-August or later when the movement of alatae was largely ineffective in spreading virus. It is interesting to compare Hollings' data with those obtained in Scotland. Even in the seed districts of Fife and Angus (South) the number of

aphids per plant was sometimes greater than in the ware districts of England. However, although there were seasonal differences, infestation was usually earlier and maximum populations were reached sooner in England than in eastern Scotland. As in the better seed areas of England dispersal of alatae which developed on crops in Fife, Angus and Perthshire did not take place until the middle of August or later.

Of the many factors which influence the rate of spread of virus diseases in the potato crop, the numbers, activity and time of movement of the vectors are probably the most important. In the market garden area of the Lothians, early colonisation of a large percentage of plants is associated with rapid spread of virus diseases. For example, less than one per cent leaf roll was found in the Redskin crop at Inveresk (site 4) in July 1955 which was granted an "A" certificate. In 1956 the crop at site 5, Inveresk was grown from this "A" seed and contained 53.4 per cent leaf roll. The results (J. Chambers, private communication) of work on virus spread in experimental and field crops complementary to the present investigation, have shown that most spread of virus occurred early in the season when few aphids were found on the crops and it seems likely that the alatae which originally colonised the crops were responsible.

Furthermore there appeared to be no close correlation between the rate of virus spread and the maximum population of aphids per plant (cf. Gregory, 1943; Broadbent and Gregory, 1948; Hollings, 1955).

In studies on virus spread on seed potato areas in England and Wales, Hollings (1955) found a close correlation between the spread of leaf roll and virus Y and activity of M. persicae within the crop. He used leaf count data to obtain the percentage of plants infested at each count. Plotted against time these showed the date and rapidity of infestation build up; the greater the aphid activity the quicker the colonisation. He then measured the angle of slope of such graphs of infestation from an arbitrary zero point, taken as June 1st, on the time scale to maximum infestation which gave an index termed the "Angle of Colonisation". He found that there was a good positive correlation between spread of both leaf roll and virus Y with the angle of colonisation.

The angles of colonisation calculated from the data presented here suggest that the Lothians area would be quite unfit for seed production but that Perth (North) would be highly satisfactory. This conclusion does not conflict with the imformation at present avail able on virus spread. However preliminary results show that leaf roll and Y viruses may spread at greatly different rates in crops that have similar angles of colonisation.

Although much work remains to be done on this aspect of the subject, it is probable that virus diseases spread more rapidly even in the best seed areas in seasons such as 1955, when weather conditions favour multiplication and increase the activity of aphids.

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APPENDIX TABLE 1. Counts of Myzus persicae on brassica crops in Midlothian, 1954-55.

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site No.	Date of Planting	Crop	Date of Count	Myzus persicae No. per 50 plants					Number per plant
				W	w	A	a	Total	
B1	18 Sept	Spring cabbage	1954						
			6/11	0	1	45	48	94	1.9
			13/12	0	0	6	1	7	0.1
			1955						
			1/2	0	0	1	0	1	-
			11/3	0	0	1	2	3	-
			15/4	0	0	0	0	0	-
			20/5	0	0	4	0	4	0.1
			18/6	14	102	164	1022	1302	26
			9/7	-	-	-	-	-	*340
			5/8	-	-	-	-	-	*200
B2	24 Aug	Spring cabbage	1954						
			4/11	2	0	1	1	4	0.1
			13/12	1	0	0	0	1	-
			1955						
			1/2	0	0	0	0	0	0
			11/3	0	0	0	1	1	-
			15/4	0	0	1	0	1	-
			20/5	0	0	4	0	4	0.1
			19/6	27	191	131	825	1174	23.5
B3	End of August	Spring cabbage	1954						
			4/11	3	3	25	60	111	2.2
			14/12	0	0	8	5	13	0.2
			1955						
			31/1	0	0	0	0	0	0
			10/3	0	0	0	0	0	0
			14/4	0	0	1	6	7	0.1
			20/5	0	1	2	23	26	0.5
			17/6	3	24	113	557	697	14
			8/7	-	-	-	-	-	*180
B4	Mid-Sept	Spring cabbage	1954						
			5/11	0	0	5	16	21	0.4
			14/12	0	0	2	0	2	0.1
			1955						
			31/1	0	0	1	1	2	0.1
			10/3	0	0	0	0	0	0
			14/4	0	0	0	0	0	0

APPENDIX TABLE 1. continued.

Site No.	Date of Planting	Crop	Date of Count	Myzus persicae No. per 50 plants					Number per plant
				W	w	A	a	Total	
			20/5	0	0	1	14	15	0.3
			17/6	8	12	22	159	201	4
			8/7	-	-	-	-	-	*64
B5	20 June	Savoy	1954						
			29/9	-	-	-	-	*4000	*80
			13/12	0	28	155	161	344	6.9
			1955						
			1/2	0	1	60	158	219	4.2
			10/3	0	0	1	1	2	0.1
B6	End of June	Savoy	1954						
			29/9	-	-	-	-	*2000	*400
			14/12	-	-	-	-	*2500	*50
			1955						
			31/1	3	8	66	209	286	5.7
			10/3	0	0	2	2	4	0.1
B7	July	Broccoli	1954						
			6/11	3	33	42	147	225	4.5
			13/12	6	8	28	19	61	1
			1955						
			1/2	1	0	6	5	12	0.2
			11/3	0	0	0	0	0	0
			15/4	0	0	0	0	0	0
			20/5	1	0	0	0	1	0
			18/6	56	84	140	1120	1400	28
B8	First week, May	Summer cabbage	1955						
			15/4	0	0	0	0	0	0
			18/6	4	0	2	56	62	1.2
			9/7	3	25	33	285	346	6.9

APPENDIX TABLE 2. Counts of Myzus persicae on brassica crops in Midlothian, 1955-56

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site No.	Date of Planting	Crop	Date of Count	Myzus persicae No. per 50 plants					Number per plant
				W	w	A	a	Total	
B9	5 Sept	Spring cabbage	1955						
			28/10	41	2	420	487	950	19
			2/12	2	9	108	183	302	6
			1956						
			11/1	0	0	7	0	7	0.1
			2/3	0	0	0	0	0	0
			11/4	0	0	0	0	0	0
			18/5	0	16	7	25	48	1
B10	7 Oct	Spring cabbage	1955						
			28/10	64	0	8	295	367	7.4
			2/12	8	0	203	348	559	11
			1956						
			11/1	0	0	14	6	20	0.4
			2/3	0	0	0	0	0	0
			11/4	0	0	0	0	0	0
			18/5	0	0	0	1	1	0.1
			12/6	2	0	1	5	8	0.2
			7/7	-	-	-	-	-	*50
B11	First week, Sept	Spring cabbage	1955						
			27/10	9	0	147	153	309	6.2
			1/12	1	1	182	267	451	9
			1956						
			11/1	1	0	22	8	31	0.6
			2/3	0	0	1	4	5	0.1
			11/4	Cleared					
B12	Fourth week, Aug	Spring cabbage	1955						
			27/10	7	0	181	404	592	11.8
			1/12	Cleared					
B13	Autumn 1954	Cabbage (Seed)	1955						
			28/10	-	-	-	-	*8750	*175
			2/12	-	-	-	-	*3500	*70
			1956						
			12/1	-	-	-	-	*600	*12
			2/3	0	0	2	0	2	0.1
			11/4	0	0	1	2	3	0.1
			18/5	0	0	21	9	30	0.6
			13/6	-	-	-	-	*320	6.4

APPENDIX TABLE 2. continued.

Site No.	Date of Planting	Crop	Date of Count	Myzus persicae No. per 50 plants					Number per plant
				W	w	A	a	Total	
			6/7	-	-	-	-	*10000	*200
			3/8	-	-	-	-	*3500	*70
B14	First week, April	Summer caulifl.	1956						
			11/4	0	0	0	0	0	0
			18/5	0	0	0	0	0	0
			11/6	11	0	14	92	117	2.4

APPENDIX TABLE 3. Counts of Myzus persicae on brassica crops at Mylnefield, near Dundee, 1954-55.

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site No.	Date of Planting	Crop	Date of Count	Myzus persicae No. per 50 plants					Number per plant
				W	w	A	a	Total	
B15	June	Savoy	1954						
			14/10	0	0	132	120	252	5
			10/11	4	51	70	80	205	4
			3/12	1	3	85	21	110	2.2
			30/12	0	4	4	8	16	0.3
			1955						
			26/1	0	0	0	0	0	0
			4/3	0	0	0	0	0	0
			18/3	0	0	0	0	0	0
B16	July	Broccoli	1954						
			19/10	14	570	680	878	2142	42.8
			9/11	9	385	222	364	980	19.6
			6/12	4	21	62	77	164	3.3
			29/12	0	0	41	36	77	1.5
			1955						
			25/1	0	2	0	3	5	0.1
			2/3	0	0	1	0	1	0.02
			18/3	0	0	0	0	0	0
			1/4	0	0	0	0	0	0
			15/4	0	0	0	0	0	0
B17	May	Brussels Sprouts	1954						
			12/10	7	0	138	97	242	4.8
			10/11	6	255	154	270	685	13.7
			10/12	1	6	20	11	38	0.8
			1955						
			6/1	0	0	0	0	0	0
			31/1	0	0	0	0	0	0
			4/3	0	0	0	0	0	0
			18/3	0	0	0	0	0	0

APPENDIX TABLE 4. Counts of *Myzus persicae* on brassica crops at Mylnefield, near Dundee, 1955-56.

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site No.	Date of Planting	Crop	Date of Count	Myzus persicae No. per 50 plants					Number per plant
				W	w	A	a	Total	
B18	6 Sept.	Spring Cabbage	1955						
			27/9	12	0	47	176	235	4.7
			18/10	15	0	75	517	607	12.1
			23/11	10	13	221	585	829	16.6
			29/12	0	6	20	16	42	0.8
			1956						
			30/1	0	0	0	0	0	0
			28/2	0	0	1	3	4	0.1
			26/3	0	0	0	0	0	0
			22/5	0	0	1	4	5	0.1
			21/6	0	1	4	3	8	0.2
B19	July	Broccoli	1955						
			6/9	143	2083	4306	10261	16793	335.8
			30/9	133	3713	4271	11206	19323	386.5
			10/11	154	2627	1774	4880	9435	188.7
			15/12	44	524	370	721	1659	33.1
			1956						
			12/1	10	150	66	173	399	8
			23/2	0	0	1	2	3	0.1
			23/3	0	0	1	1	2	0.1
			19/4	0	0	0	0	0	0
			25/5	0	0	0	0	0	0
B20	June	Cabbage	1955						
			10/9	31	64	196	506	797	15.9
			11/10	4	40	87	88	219	4.4
			14/11	52	108	193	313	666	13.3
			19/12	63	132	178	386	759	15.2
			1956						
			18/1	2	39	83	170	294	5.8
			6/3	0	0	0	0	0	0

APPENDIX TABLE 5. Counts of potato aphids, 1954.

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
1	Redskin	16/6	4	0	0	0	4	2	-	-	-	-	-	-	-	-	-	-
		12/7	-	-	-	-	-	*400	-	-	-	-	-	-	-	-	-	-
		8/8	-	-	-	-	-	*500	-	-	-	-	-	-	-	-	-	-
2	Redskin	16/6	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
		12/7	-	-	-	-	-	* 60	-	-	-	-	-	-	-	-	-	-
		8/8	-	-	-	-	-	*400	-	-	-	-	-	-	-	-	-	-
3	Epicure	16/6	-	-	-	-	-	* 90	-	-	-	-	-	-	-	-	-	-
		11/7	-	-	-	-	-	*1500	-	-	-	-	-	-	-	-	-	-
4	Epicure	16/6	5	0	0	20	25	12	-	-	-	-	-	-	-	-	-	-
		11/7	-	-	-	-	-	*300	-	-	-	-	-	-	-	-	-	-
5	Epicure	11/7	-	-	-	-	-	*150	-	-	-	-	-	-	-	-	-	-
6	Majestic	6/8	3	0	18	0	21	11	-	-	-	-	-	-	-	-	-	-
7	King Edward	13/7	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
		6/8	-	-	-	-	-	*200	-	-	-	-	-	-	-	-	-	-
8	King Edward	13/7	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
		6/8	0	5	5	24	34	19	-	-	-	-	-	-	-	-	-	-

APPENDIX TABLE 5. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
9	King Edward	13/7	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
		6/8	0	0	10	17	27	14	-	-	-	-	-	-	-	-	-	-
10	Kerr's Pink	13/7	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
		6/8	0	0	5	5	10	6	-	-	-	-	-	-	-	-	-	-
11	Arran Banner	13/7	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
		5/8	0	0	2	1	3	0	-	-	-	-	-	-	-	-	-	-
12	Home Guard	5/8	1	0	4	0	5	2.5	-	-	-	-	-	-	-	-	-	-
13	Home Guard	8/7	0	0	0	2	2	1	0	0	0	3	3	0	0	0	0	0
		23/7	0	0	3	13	16	9	1	0	0	6	7	0	0	0	1	1
		1/8	2	3	1	2	8	5	0	0	0	10	10	0	1	2	6	9
		12/8	0	5	15	28	48	31	0	0	0	2	2	0	0	0	0	0
14	Majestic	15/7	0	0	2	6	8	4	0	0	4	0	4	0	0	0	0	0
		27/7	1	1	3	27	32	19	11	49	7	63	130	0	0	1	1	2
		2/8	1	2	4	5	12	8	28	76	33	110	247	0	0	8	26	34
		15/8	0	2	4	9	15	11	3	13	5	18	39	0	0	0	12	12
		24/8	0	0	2	2	4	3	0	1	1	2	4	0	0	0	0	0
		30/8	3	4	3	2	12	7	0	3	2	16	21	0	0	1	1	2
		7/9	0	2	7	7	16	7	0	2	1	1	4	0	0	0	0	0

APPENDIX TABLE 5. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
15	Home Guard	14/7	0	0	0	0	0	0	0	0	0	1	1	0	0	0	2	2
		4/8	2	4	7	9	22	13	0	0	0	0	0	0	0	0	0	0
		15/8	2	1	3	7	13	8	2	0	3	13	18	0	0	0	0	0
		24/8	0	0	0	3	3	2	0	3	0	2	5	0	0	0	0	0
16	Majestic	25/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1/8	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
		12/8	0	0	1	0	1	1	1	2	0	20	23	0	0	0	0	0
		23/8	0	1	10	19	30	18	0	1	2	13	16	0	0	2	1	3
		2/9	1	18	28	64	111	46	1	5	6	35	47	0	0	5	16	21
		8/9	1	39	27	12	79	23	3	8	11	25	47	1	0	4	16	21
17	Majestic	25/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	0	3	10	13	9	0	0	1	0	1	0	0	1	6	7
		23/8	1	2	4	11	18	9	0	0	0	1	1	0	2	2	5	9
		2/9	1	4	7	15	27	9	0	1	2	16	19	0	7	1	9	17
		10/9	1	23	18	20	62	14	0	2	8	37	47	0	8	6	23	37
18	Up-to-Date	28/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		12/8	1	0	1	4	6	4	0	0	0	0	0	0	1	0	0	1
		24/8	0	3	4	22	29	17	0	0	0	2	2	0	1	2	11	14

APPENDIX TABLE 5. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
19	Redskin	19/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		24/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		1/8	0	0	1	3	4	2	0	0	0	0	0	0	0	2	11	13
		12/8	2	1	10	9	22	14	0	0	0	0	0	0	0	2	7	9
		24/8	1	2	12	22	37	25	0	0	1	8	9	0	0	3	23	26
		4/9	0	36	11	75	122	66	0	0	0	4	4	2	0	4	11	17
		11/9	1	37	22	47	107	44	0	0	2	1	3	0	1	6	7	14
20	Up-to-Date	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		1/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		22/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	3
21	Majestic	27/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		3/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16/8	0	0	0	1	1	1	0	0	0	0	0	0	0	0	8	8
		25/8	1	0	5	4	10	7	2	0	0	3	5	0	0	2	10	12
		2/9	0	2	10	25	37	23	1	2	6	22	31	0	0	2	13	15
		10/9	0	18	18	33	69	40	0	1	7	36	44	0	0	13	37	50
22	Up-to-Date	18/7	0	0	2	0	2	1	0	0	0	0	0	0	0	0	0	0
		1/8	0	0	0	3	3	2	0	0	0	0	0	0	0	2	24	26
		15/8	2	0	4	15	21	15	0	0	0	0	0	0	0	3	16	19
		24/8	1	14	23	74	112	86	0	3	0	2	5	0	0	8	20	28

APPENDIX TABLE 5. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
23	Up-to-Date	20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		29/7	1	0	0	0	1	1	0	0	0	0	0	0	0	5	4	9
		9/8	0	0	0	0	0	0	0	0	0	7	7	0	0	0	0	0
		24/8	0	0	0	0	0	0	1	7	0	6	14	0	0	14	54	68
24	Up-to-Date	11/8	0	2	1	4	7	4	0	0	0	5	5	0	0	0	0	0
		21/8	0	0	0	0	0	0	1	0	0	0	0	0	0	2	3	5
		2/9	0	0	0	11	11	6	2	1	0	19	22	0	0	6	5	11
25	Epicure	15/7	0	0	1	2	3	2	0	0	0	1	1	0	0	0	0	0
		25/7	0	1	3	3	7	4	0	0	0	0	0	0	0	1	0	1

APPENDIX TABLE 6. Counts of potato aphids, 1955.

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
1	Epicure	20/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16/6	2	0	0	4	6	2	0	0	0	0	0	2	1	7	12	22
		7/7	3	1	6	60	70	49	5	4	2	25	36	0	2	3	13	18
2	Kerr's Pink	7/7	8	0	9	72	89	88	2	0	3	34	39	2	0	7	9	18
		5/8	2	0	5	84	91	61	4	4	13	101	122	0	0	0	0	0
		8/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	Epicure	20/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16/6	0	0	0	0	0	0	0	0	8	4	12	0	0	1	1	2
		7/7	1	4	4	17	26	16	4	11	19	186	220	0	2	5	47	54
4	Redskin	18/6	25	0	2	167	194	92	0	0	0	7	7	0	0	0	1	1
		9/7	58	71	257	3814	4200	2799	4	4	21	163	192	0	2	5	27	34
		5/8	-	-	-	-	*8900	*8000	-	-	-	-	-	-	-	-	-	*400
		9/9	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
5	Redskin	18/6	2	0	4	28	34	17	0	0	2	6	8	0	0	0	0	0
		9/7	9	0	2	151	162	110	13	7	56	529	604	0	0	0	4	4
		5/8	-	-	-	-	*1650	*1500	-	-	-	-	-	-	-	-	-	*300
		9/9	0	0	0	0	0	0	-	-	-	-	-	-	-	-	-	-
6	Kerr's Pink	14/9	3	0	15	63	81	39	0	0	7	25	32	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
7	Kerr's Pink	9/7	0	0	0	6	6	2	1	0	2	10	13	0	0	0	1	1
		6/8	4	0	5	48	57	33	5	6	10	80	101	0	0	0	0	0
		10/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Majestic	26/8	1	0	7	31	39	26	0	1	9	1	11	0	0	1	2	3
9	Majestic	8/9	1	0	0	3	4	2	0	1	0	0	1	0	0	0	0	0
10	Dr. McIntosh	8/9	1	0	1	11	13	9	0	0	0	3	3	0	0	0	0	0
11	Majestic	26/8	6	0	3	37	46	30	0	0	0	1	1	0	0	1	3	4
12	Majestic	26/8	2	0	5	63	70	46	2	1	6	13	22	0	0	0	0	0
13	Majestic	3/9	3	0	7	67	77	51	1	0	0	1	2	0	0	1	1	2
14	Majestic	3/9	0	0	1	45	46	26	0	0	0	2	2	0	0	0	0	0
15	Majestic	6/9	0	0	0	4	4	3	0	0	0	0	0	0	0	0	0	0
16	Majestic	7/9	0	0	1	7	8	5	0	0	1	1	2	0	0	0	0	0
17	Majestic	6/9	4	0	4	23	31	20	0	0	3	7	10	0	0	0	0	0
18	Majestic	6/9	2	0	1	13	16	10	0	1	7	3	11	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
19	Majestic	6/9	3	0	0	6	9	5	0	0	1	5	6	0	0	0	0	0
20	Redskin	29/8	1	1	9	73	84	46	0	0	3	1	4	0	0	0	0	0
21	Kerr's Pink	29/8	2	1	5	75	83	55	0	0	1	0	1	0	0	0	0	0
22	Kerr's Pink	29/8	2	0	8	78	88	57	0	0	1	3	4	0	0	0	0	0
23	Kerr's Pink	31/8	1	0	1	15	17	11	0	0	0	1	1	0	0	0	0	0
24	Kerr's Pink	2/9	0	0	1	0	1	1	0	0	0	0	0	0	0	1	0	1
25	Kerr's Pink	31/8	0	0	1	7	8	5	0	0	0	2	2	0	0	0	0	0
26	Golden Wonder	8/10	1	0	0	7	8	4	0	0	1	0	1	0	0	0	0	0
27	Golden Wonder	14/7	0	0	0	0	0	0	0	0	0	4	4	0	0	0	1	1
		4/8	0	0	0	0	0	0	0	0	1	4	5	0	0	0	0	0
		7/9	1	0	2	7	10	5	0	0	0	0	0	0	0	0	0	0
28	Kerr's Pink	14/7	0	0	1	6	7	2	0	0	1	8	9	0	0	0	0	0
		4/8	0	1	2	23	26	21	2	3	18	119	142	0	0	1	0	1
		7/9	1	0	1	3	5	3	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 6. continued

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
29	Arran Consul	14/7	0	0	0	0	0	0	0	0	1	0	1	0	0	0	5	5
		4/8	0	0	4	26	30	21	0	0	2	18	20	1	0	0	0	1
		7/9	4	0	0	0	4	3	0	0	0	0	0	0	0	0	0	0
30	Redskin	9/7	0	0	0	4	4	1	1	0	1	10	12	0	0	0	1	1
		26/7	1	0	1	42	44	21	0	0	0	8	8	0	0	2	26	28
		8/8	7	43	104	936	1090	619	0	1	0	23	24	1	0	2	22	25
		17/8	12	132	77	795	1016	692	2	14	5	43	64	0	0	0	0	0
		29/8	3	73	240	1227	1543	982	1	5	0	15	21	0	0	8	31	39
		6/9	4	2	17	40	63	37	0	0	0	2	2	0	0	0	0	0
		21/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		28/9	1	0	2	2	5	1	0	0	0	0	0	0	0	0	0	0
31	Epicure	6/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32	Redskin	9/7	0	0	0	6	6	2	0	0	1	4	5	0	0	1	3	4
		26/7	0	0	2	22	24	9	1	0	6	46	53	1	0	0	2	3
		8/8	4	7	21	128	160	94	11	54	32	284	381	0	1	5	9	15
		21/8	1	3	19	103	126	81	3	43	22	182	250	0	1	2	8	11
		29/8	1	0	8	44	53	32	1	6	13	72	92	0	0	0	8	8
		5/9	4	1	1	7	13	16	0	0	1	0	1	0	0	0	0	0
		19/9	1	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
33	Kerr's Pink	20/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		5/7	1	0	0	1	2	1	0	0	1	0	1	0	0	1	6	7
		22/7	0	0	0	0	0	0	1	3	11	17	32	1	0	2	7	10
		5/8	0	0	3	0	3	2	8	82	88	194	372	0	2	13	25	40
		10/8	0	2	11	25	38	30	14	0	0	0	14	0	0	0	0	0
		18/8	2	0	6	11	19	16	11	24	15	68	118	0	0	3	3	6
		28/8	2	0	1	7	10	7	2	1	0	6	9	0	0	1	1	2
		6/9	0	0	0	0	0	0	0	0	1	0	1	0	0	0	0	0
34	Majestic	9/7	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
		26/7	0	0	0?	0	0	0	0	0	2	12	14	0	0	0	3	3
		8/8	1	0	2	8	11	8	5	3	7	140	155	0	0	4	18	22
		17/8	4	0	3	21	28	22	2	7	11	185	205	0	0	0	4	4
		27/8	1	0	27	61	89	71	4	27	16	164	211	0	0	0	3	3
		4/9	0	0	4	8	12	6	2	0	2	5	9	0	0	0	0	0
		19/9	1	0	1	0	2	1	0	0	0	0	0	0	0	0	0	0
		28/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
35	Redskin	17/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		8/8	1	2	8	21	32	23	1	3	1	34	39	0	0	1	10	11
		21/8	6	8	42	141	197	149	7	16	14	154	181	0	0	5	2	7
		27/8	2	1	35	114	152	122	1	24	23	242	290	0	0	7	18	25
		5/9	0	1	3	11	15	8	0	1	3	10	14	0	0	0	5	5
		19/9	0	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
36	Home Guard	20/7	0	7	10	11	28	13	0	0	0	1	1	0	0	0	0	0
		8/8	5	7	41	113	166	95	4	14	22	118	158	0	0	3	11	14
		18/8	8	90	81	259	438	282	1	17	30	222	320	0	0	8	41	49
		28/8	3	25	85	211	324	189	3	15	59	270	347	0	0	3	12	15
37	Majestic	29/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		16/8	1	0	2	7	10	4	0	1	2	8	11	0	0	0	1	1
		31/8	0	0	1	10	17	8	0	0	0	2	2	0	0	0	0	0
		22/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	Majestic	28/7	0	0	1	6	7	4	0	0	0	11	11	0	0	1	0	1
		12/8	3	0	11	23	37	22	0	0	3	8	11	0	0	0	0	0
		31/8	1	1	2	28	32	19	0	0	4	16	20	0	0	0	2	2
39	Epicure	25/7	0	0	0	3	3	1	0	0	0	0	0	0	0	0	0	0
		12/8	1	0	1	7	9	5	0	0	0	0	0	0	0	1	0	1
		31/8	0	0	1	1	2	1	0	0	0	2	2	0	0	0	0	0
40	Majestic	25/7	0	0	1	3	4	1	0	0	0	0	0	0	0	0	1	1
		12/8	1	4	7	28	34	17	0	0	0	3	3	0	0	0	1	1
		31/8	2	0	5	21	28	18	0	0	0	1	1	0	0	0	0	0
		22/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	Sharpe's Express	25/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		25/7	1	0	0	2	3	0	0	0	0	0	0	0	0	1	2	3
		19/8	0	2	15	31	48	21	1	2	6	5	14	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
42	Majestic	25/7	1	0	0	1	2	1	0	0	0	0	0	0	0	0	0	0
		12/8	1	1	2	14	18	8	0	0	0	4	4	0	0	0	0	0
		31/8	3	0	12	26	41	25	2	0	1	25	28	0	0	0	0	0
		22/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
43	Arran Consul	25/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		12/8	1	0	7	26	34	15	0	0	1	0	1	0	0	0	4	4
		31/8	3	2	26	48	79	38	1	0	1	6	8	0	0	0	0	0
		22/9	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
44	Up-to-Date	25/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		30/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		19/8	0	0	2	14	16	8	0	0	1	4	5	0	0	0	0	0
		20/9	0	0	1	0	1	1	0	0	1	2	3	0	0	0	0	0
45	Majestic	25/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		30/7	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0
		19/8	1	0	6	18	25	11	0	2	0	0	2	0	0	0	0	0
		20/9	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0
46	Redskin	25/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		30/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		19/8	0	0	0	18	18	10	0	0	0	2	2	0	0	0	0	0
		20/9	0	1	3	3	7	4	0	0	0	1	1	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
47	King Edward	19/8	0	0	4	5	9	4	0	0	2	6	8	0	0	0	0	0
		20/9	0	0	1	2	3	1	0	0	1	2	3	0	0	0	0	0
		12/10	0	3	1	0	4	1	0	0	0	0	0	0	0	0	0	0
48	Kerr's Pink	30/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		19/8	1	0	1	8	10	5	3	0	2	9	14	0	0	0	0	0
		20/9	0	1	4	1	6	4	0	0	0	0	0	0	0	0	0	0
49	Kerr's Pink	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		12/8	3	1	0	12	16	9	0	0	2	18	20	0	0	1	4	5
		31/8	4	1	16	59	80	53	1	0	2	6	9	0	0	0	0	0
		22/9	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0
50	Majestic	22/7	0	0	0	0	0	0	0	0	1	2	3	0	0	0	0	0
		12/8	1	2	19	61	83	50	1	3	5	40	49	0	1	3	3	7
		31/8	1	2	63	101	167	77	1	3	8	43	55	0	0	1	2	3
		22/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	Bishop	22/7	0	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0
		12/8	3	1	0	12	16	9	0	0	2	18	20	0	0	1	4	5
		31/8	4	1	16	59	80	53	1	0	2	6	9	0	0	0	0	0
		22/9	0	0	0	2	2	0	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 6. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
52	Arran Pilot	22/7	0	0	0	1	1	1	1	0	0	0	0	0	0	4	1	5
		12/8	1	3	13	33	50	25	2	0	5	18	25	0	0	3	0	3
		31/8	1	3	40	39	83	25	0	0	7	18	25	0	0	0	0	0
		22/9	0	0	1	1	2	1	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 7. Counts of potato aphids, 1956

W = alate adult A = apterous adult * = estimate
w = alate nymph a = apterous nymph

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
1	Epicure	18/5	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		11/6	3	0	7	27	37	10	0	0	0	0	0	1	0	5	10	16
		5/7	-	-	-	-	-	*400	-	-	-	-	*150	-	-	-	-	*100
2	Epicure	18/5	2	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0
		11/6	1	0	0	0	1	0	0	0	0	0	0	0	0	0	2	2
		4/7	11	19	124	933	1087	313	1	0	0	2	3	7	90	24	166	287
3	Dunbar Standard	11/6	-	-	-	-	-	*1	-	-	-	-	-	-	-	-	-	-
		4/7	-	-	-	-	-	*3000	-	-	-	-	-	-	-	-	-	-
		3/8	-	-	-	-	-	*50000	-	-	-	-	-	-	-	-	-	-
		30/8	-	-	-	-	-	*1000	-	-	-	-	-	-	-	-	-	-
4	Redskin	13/6	3	0	0	0	3	1	0	0	0	0	0	0	0	0	0	0
		6/7	2	0	67	290	359	185	0	0	1	7	8	0	0	1	7	8
		2/8	97	1172	281	1862	3412	2817	-	-	-	-	*200	-	-	-	-	*150
		30/8	1	8	7	24	40	25	0	0	0	0	0	0	0	0	0	0
5	Redskin	12/6	1	0	0	6	7	25	0	0	0	0	0	0	0	0	0	0
		6/7	0	0	37	325	362	175	0	0	1	5	6	0	0	0	2	2
		2/8	-	-	-	-	-	*5000	-	-	-	-	*600	-	-	-	-	*400
		31/8	4	81	44	133	262	165	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
6	Kerr's Pink	21/7	1	0	20	14	35	24	0	0	1	6	7	0	0	7	7	14
7	Kerr's Pink	29/6	0	0	10	30	40	15	0	0	0	0	0	0	0	0	0	0
		27/7	4	6	102	288	400	278	0	5	18	26	49	0	0	12	9	21
		31/8	4	4	27	66	101	85	0	1	0	8	9	0	0	0	0	0
		19/9	0	0	4	26	30	14	0	0	0	1	1	0	0	0	1	1
8	Majestic	3/7	0	0	1	4	5	2	0	0	0	0	0	0	0	0	0	0
		2/8	-	-	-	-	-	*25	-	-	-	-	-	-	-	-	-	-
		15/9	0	2	0	6	8	4	0	0	0	0	0	0	0	0	2	2
9	Majestic	3/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	Majestic	2/8	3	0	26	89	118	83	1	10	14	37	62	3	1	1	74	79
11	Golden Wonder	4/8	-	-	-	-	-	*550	-	-	-	-	-	-	-	-	-	-
12	Majestic	31/7	5	0	138	495	638	474	2	0	19	49	65	1	0	6	36	43
13	Kerr's Pink	4/7	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		25/7	0	5	20	68	93	63	0	0	0	0	0	0	0	0	0	0
		8/8	5	93	25	211	334	293	0	0	1	1	2	0	0	1	15	16
		22/8	10	106	23	136	275	266	0	0	1	9	10	0	0	0	0	0
		12/9	5	85	16	86	192	93	0	0	1	20	21	0	0	3	15	18

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
14	Redskin	4/7	0	0	1	16	17	6	0	0	0	0	0	0	0	0	0	0
		25/7	0	5	11	33	49	27	0	0	0	0	0	0	0	0	0	0
		8/8	4	39	22	154	219	151	0	0	0	0	0	0	0	0	0	0
		22/8	11	97	47	251	406	249	0	0	0	0	0	0	0	0	0	0
		12/9	13	395	67	714	1189	198	0	0	0	12	12	0	7	19	78	104
15	King Edward	4/7	0	0	0	2	2	1	0	0	0	0	0	0	0	0	0	0
		25/7	3	33	9	65	110	95	0	0	0	0	0	0	0	2	3	5
		8/8	8	142	39	197	386	292	0	0	0	3	3	0	0	0	5	5
		22/8	6	48	2	74	130	40	0	0	1	0	1	0	0	1	3	4
16	Majestic	4/7	0	0	2	3	5	3	0	0	0	0	0	0	0	0	0	0
		25/7	0	3	4	13	20	14	0	0	0	9	9	0	0	0	0	0
		8/8	4	72	34	128	238	148	0	5	0	22	27	0	0	0	0	0
		22/8	5	31	15	55	106	47	0	0	1	0	1	0	0	1	0	1
17	Redskin	4/7	0	0	1	6	7	5	0	0	0	0	0	0	0	0	0	0
		25/7	1	29	21	108	159	91	0	0	1	1	0	0	0	0	0	0
		8/8	4	118	32	154	308	175	0	0	0	8	8	0	0	0	2	2
		22/8	10	79	43	189	321	192	0	0	0	0	0	0	0	0	0	0
18	Kerr's Pink	10/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/7	0	1	3	20	24	16	0	0	0	0	0	0	0	7	0	7

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
		4/8	1	45	14	64	124	79	0	3	3	7	13	0	0	3	2	5
		16/8	1	63	27	212	303	252	0	0	0	0	0	0	0	0	0	0
		27/8	5	20	2	27	54	44	1	0	0	8	9	0	0	0	0	0
		17/9	1	19	9	38	67	30	0	0	0	0	0	0	0	0	0	0
19	Majestic	26/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		17/8	0	0	5	27	32	23	0	0	0	0	0	0	0	0	0	0
		28/8	2	15	35	132	184	141	0	0	5	23	28	0	0	4	31	35
		17/9	11	589	77	246	923	307	1	26	39	180	246	0	0	0	0	0
20	Redskin	26/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2/8	0	0	0	2	2	1	0	0	1	1	2	0	0	0	0	0
		19/8	0	1	1	6	8	6	0	0	0	0	0	0	0	0	0	0
		29/8	1	11	5	10	27	21	0	8	0	2	10	0	0	3	14	17
		17/9	3	60	16	65	144	81	0	0	0	0	0	0	0	12	57	69
21	Home Guard	26/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		4/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		19/8	1	0	2	6	9	5	0	0	0	0	0	0	0	0	0	0
22	Redskin	26/6	0	0	4	13	17	5	0	0	0	0	0	0	0	0	0	0
		20/7	0	0	4	9	13	5	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
		3/8	1	26	18	102	147	90	0	0	0	0	0	0	0	0	0	0
		20/8	3	49	46	174	272	150	1	0	2	16	19	0	0	0	0	0
		29/8	3	100	47	280	430	309	0	2	0	9	11	0	0	0	0	0
		18/9	1	19	5	27	52	23	0	0	0	0	0	0	0	0	12	12
23	Epicure	30/5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/6	0	0	1	0	1	1	0	0	0	0	0	0	0	0	0	0
24	Kerr's Pink	27/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/7	0	1	3	4	8	5	0	0	0	0	0	0	0	0	0	0
		6/8	1	31	5	31	68	51	0	0	1	0	1	0	0	0	0	0
		20/8	1	16	4	24	45	29	0	0	0	0	0	0	0	2	3	5
		29/8	0	9	9	26	44	22	1	1	0	0	2	0	0	2	2	4
25	Kerr's Pink	29/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		19/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2/8	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
		20/8	0	1	2	5	8	6	0	0	0	10	10	0	0	0	0	0
		28/8	0	7	2	5	14	11	0	0	0	0	0	0	0	0	0	0
		17/9	3	30	2	1	36	7	0	0	2	9	11	0	0	0	0	0

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
26	Majestic	30/6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		19/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		2/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		20/8	1	0	2	8	11	6	0	0	0	4	4	0	0	0	0	0
		28/8	0	2	5	35	42	27	0	0	1	10	11	0	2	8	3	13
		10/9	2	21	23	77	123	24	0	1	2	7	10	0	0	3	4	7
27	Up-to-Date	23/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10/8	0	0	0	2	2	2	0	0	0	0	0	0	0	0	0	0
		24/8	1	18	3	9	31	21	0	0	0	0	0	0	0	0	0	0
28	Redskin	27/6	1	0	0	4	5	1	0	0	0	0	0	0	0	0	0	0
		21/7	0	0	1	2	3	1	0	0	0	0	0	0	0	0	0	0
		3/8	0	2	4	25	31	17	0	0	0	0	0	0	0	0	0	0
		20/8	4	15	29	108	156	77	0	0	4	14	18	0	0	0	0	0
		27/8	3	84	31	133	251	173	1	3	1	4	9	0	2	2	24	28
		16/9	1	134	18	53	206	25	0	2	0	10	12	0	0	0	0	0
29	Royal Kidney	23/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10/8	0	0	0	1	1	1	0	0	0	0	0	0	0	0	1	1
		24/8	0	0	1	3	4	2	0	0	0	0	0	0	0	6	13	19
		10/9	1	34	26	84	145	28	0	0	3	14	17	0	0	12	59	71

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
30	Kerr's Pink	23/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10/8	0	7	4	26	37	20	0	0	0	1	1	0	0	1	1	2
		24/8	2	5	16	108	131	103	0	0	0	0	0	0	0	0	0	0
		10/9	3	61	25	120	209	141	0	0	0	0	0	0	0	0	3	3
31	Majestic	23/7	0	0	2	2	4	1	0	0	0	0	0	0	0	0	0	0
		10/8	0	3	16	43	62	19	0	0	0	3	3	0	0	0	3	3
		24/8	3	5	9	36	53	24	0	0	2	3	5	0	0	0	0	0
		10/9	0	16	10	32	58	21	1	3	0	0	4	0	0	0	0	0
32	Kerr's Pink	23/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10/8	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		24/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10/9	1	0	4	4	9	6	0	0	0	0	0	0	0	0	0	0
		28/9	0	14	3	18	35	5	0	0	0	0	0	0	0	0	0	0
33	Bishop	23/7	0	0	0	7	7	2	0	0	0	1	1	0	0	0	0	0
		10/8	0	1	0	13	14	7	0	0	0	0	0	0	0	0	1	1
		24/8	1	3	3	14	21	12	0	0	0	0	0	0	0	0	0	0
		10/9	1	33	15	39	88	17	0	0	2	9	11	0	0	0	14	14
34	Arran Pilot	23/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		10/8	0	2	3	9	14	7	0	0	0	0	0	0	0	0	2	2
		24/8	0	3	1	6	10	1	0	0	2	2	4	0	0	0	0	0

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
35	Kerr's Pink	20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7/8	0	0	1	7	8	5	0	0	0	0	0	0	0	0	0	0
		21/8	0	0	2	14	16	12	0	0	0	0	0	0	0	0	0	0
		8/9	0	0	15	43	67	51	0	0	0	0	0	0	0	0	6	6
		27/9	4	61	15	47	127	19	0	0	11	47	58	0	0	6	19	25
36	Kerr's Pink	20/7	0	0	0	4	4	2	0	0	0	0	0	0	0	1	3	4
		7/8	0	6	11	16	33	29	0	0	5	13	18	0	0	1	0	1
		21/8	2	18	19	82	121	99	1	0	2	6	9	0	0	1	4	5
		8/9	0	60	14	34	108	43	0	3	0	9	12	0	0	3	13	16
		27/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
37	Majestic	20/7	0	0	0	0	0	0	1	0	0	6	7	0	0	0	1	1
		7/8	0	2	3	8	13	7	1	0	0	4	5	0	0	0	0	0
		21/8	0	5	4	19	28	18	0	0	0	0	0	0	0	0	0	0
		8/9	1	135	159	473	768	46	1	0	2	31	34	0	6	0	0	0
		27/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
38	King Edward	20/7	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0
		7/8	0	0	0	2	2	1	0	0	1	6	7	0	0	0	0	0
		21/8	0	2	0	14	16	10	0	0	1	0	1	0	0	0	0	0
		8/9	2	88	36	151	277	65	2	0	10	59	71	0	0	0	12	12
		27/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
39	Epicure	20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		7/8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		21/8	0	1	1	1	3	1	0	0	0	0	0	0	0	0	0	0
		8/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
40	Majestic	20/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
		7/8	0	0	1	3	4	2	0	0	0	0	0	0	0	0	0	0
		21/8	1	0	3	8	12	7	0	0	0	0	0	0	0	0	0	0
		8/9	1	42	26	102	171	69	0	0	0	13	13	0	0	0	0	0
		27/9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
41	Arran Pilot	20/7	0	0	0	3	3	1	0	0	0	0	0	0	0	1	17	18
		7/8	0	1	2	8	11	7	0	0	0	0	0	0	0	0	0	0
42	Arran Consul	20/7	0	1	1	3	5	2	0	0	0	0	0	0	0	0	3	3
		7/8	0	2	5	18	25	12	0	0	0	0	0	0	0	1	0	1
		21/8	0	1	5	9	15	6	0	0	0	0	0	0	0	0	0	0
43	Majestic	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		26/8	0	0	4	13	17	10	0	5	1	0	6	0	0	0	8	8
		9/9	0	10	6	24	40	20	0	1	0	0	1	0	0	1	2	3

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
44	Kerr's Pink	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	1	0	1	1	3	1	0	0	0	1	1	0	0	0	0	0
		26/8	0	0	0	1	1	1	0	0	0	0	0	0	0	1	0	1
		9/9	0	0	1	0	1	0	0	0	0	0	0	0	0	1	0	1
		4/10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
45	Majestic	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	0	1	2	3	1	0	0	0	0	0	0	0	0	0	0
		26/8	0	2	1	8	11	5	0	0	0	0	0	0	0	0	0	0
		9/9	0	8	12	37	57	25	1	0	0	4	5	0	0	0	0	0
46	Majestic	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0
		26/8	0	0	0	3	3	2	1	1	0	0	2	0	0	0	12	12
		9/9	0	10	7	23	40	25	0	7	6	19	32	0	0	5	19	24
47	King Edward	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0
		26/8	0	0	0	0	0	0	0	0	1	0	1	0	0	1	10	11
		9/9	0	1	1	1	3	2	0	0	0	0	0	0	0	0	0	0
		4/10	0	3	2	8	13	2	0	0	7	32	39	0	0	1	5	6

APPENDIX TABLE 7. continued.

Site Number	Variety	Date of Count	M. persicae				Number per 100 leaves	Number per plant	M. euphorbiae				Number per 100 leaves	A. solani				Number per 100 leaves
			W	w	A	a			W	w	A	a		W	w	A	a	
48	Kerr's Pink	22/7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		14/8	0	0	0	0	0	0	0	1	1	1	3	0	0	0	0	0
		26/8	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0
		9/9	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0
		4/10	1	3	3	9	16	2	0	0	1	5	6	0	0	0	0	0