

## **SAMPLING FOR DISTRIBUTION OF THE LETTUCE APHID, *NASONOVIA RIBISNIGRI* (HOMOPTERA:APHIDIDAE), IN FIELDS AND WITHIN HEADS**

J. R. MACKENZIE AND R. S. VERNON  
RESEARCH STATION, AGRICULTURE CANADA  
VANCOUVER, BRITISH COLUMBIA,  
V6T 1X2

### **ABSTRACT**

The lettuce aphid, *Nasonovia ribisnigri* (Mosley), is the most serious pest of crisphead lettuce in the lower Fraser Valley of British Columbia. To develop an efficient monitoring program, several fields of commercially grown head lettuce (cv. Ithaca) were inspected to determine the spatial distribution of the aphids. Infested plants were scattered in the fields but most often were near the margins. Therefore, to monitor for infestations, sampling should be confined to plants around the perimeters of commercial lettuce fields. Distribution within the heads was studied by infesting young plants and inspecting the leaves individually at harvest. Significantly more lettuce aphids were found on the wrapper leaves and just inside the lettuce heads than on the outer or the innermost leaves.

### **INTRODUCTION**

The lettuce aphid, *Nasonovia ribisnigri* (Mosley), is at present the most serious insect pest of field-grown, crisphead lettuce in the lower Fraser Valley of British Columbia. The morphology and local life history of this aphid was described by Forbes and Mackenzie (1982). The aphid, which has not yet been documented as a pest elsewhere in North America, first appeared as a pest on lettuce in British Columbia late in the 1981 growing season, when the crop losses on three farms amounted to \$20,000 (Cdn.). In 1982, all lower Fraser Valley growers were affected, and a \$2,000,000 reduction in marketable heads occurred. Unlike other lettuce-infesting aphids such as the green peach aphid, *Myzus persicae* (Sulzer), and the potato aphid, *Macrosiphum euphorbiae* (Thomas), that prefer the older, outer leaves of head lettuce, *N. ribisnigri* colonizes leaves inside the developing heads. Once inside the heads, the aphids cannot be controlled with available aphicides, and their presence at harvest makes the lettuce unmarketable (Forbes and Mackenzie 1982). Since 1982, the market tolerance for aphids of any species on harvested lettuce heads in the lower Fraser Valley has been set at zero.

To ensure that commercial lettuce remained aphid-free until harvest, a stringent spray routine was undertaken by the affected growers in 1983. The program involved weekly applications of local systemic aphicides, pirimicarb and methamidophos, interrupted by a single pre-heading application of the fully systemic aphicide, demeton. This procedure, although intensive, has successfully prevented further crop losses.

For the spray program, monitoring was needed to give the growers current information on outbreaks and the efficacy of the control measures. With available manpower limited to one person, and a zero market tolerance for lettuce aphids, the monitoring program was designed to locate infested plants quickly and efficiently.

This paper examines the distribution of lettuce aphids in order to identify infested areas within the fields. The distribution of lettuce aphids within the plants was examined to identify their preferred niche. The method of sampling developed optimized efficiency of sampling and precision of results under the given constraints on manpower and the market tolerance for aphids.

### **MATERIALS AND METHODS**

#### **Field Distribution**

Distribution of the aphid in the field was studied by intensively sampling 4 commercial-scale plantings of crisphead lettuce (cv. Ithaca) near Cloverdale, an agricultural region with highly organic soil in the lower Fraser Valley of B.C. Here lettuce is normally planted in raised beds, with four rows of lettuce in each bed. The rows are 35 cm apart, the bed centers 175 cm apart, and the plants within rows thinned to 30 cm spacings. When samples were taken all four

fields were at stages of growth between thinning (about five leaves per plant) and head initiation (about 15 leaves per plant).

Field 1 (31 beds by 120 m long; 0.65 ha) was seeded July 16, 1982 and was not sprayed before being sampled at the nine-leaf stage on 18 August. Every third bed was sampled (i.e. beds 1, 4, 7, .... 31), with one plant being removed from the center of each 20 m interval along each bed. Each plant was selected at random from among the four rows per bed, and destructively examined for aphids. Aphid counts were expressed as the number of living aphids/plant at each sample site.

Fields 2-4 were sampled during an outbreak of lettuce aphids in 1984. In these fields, four adjacent plants, one per row, were examined *in situ* midway along each 10 m of bed. Since Fields 2-4 were sprayed prior to sampling, both living and dead aphids were recorded. Field 2 (21 beds by 220 m long; 0.81 ha) was sampled at the 13 leaf stage on 17 July along five beds. Aphid counts were expressed as the number of living and dead aphids/plant on four plants at each sample site. In Field 3, (28 beds by 210 m long; 1.03 ha), four evenly spaced beds were sampled at the 11 and 13 leaf stage, respectively, on 12 July. In these fields, the number of infested plants of the four examined at each sample site were recorded. A total of 66 plants were examined in Field 1, 460 in Field 2, 384 in Field 3, and 272 in Field 4.

For Fields 1-4, the spatial distribution data were summed by columns (beds) and rows (intervals from which samples were taken along the bed), analyzed by ANOVA and compared by Duncan's multiple range test (Duncan, 1955) when appropriate. Fields 1-4 are equated with Figures 1-4.

Chi-square (Maxwell 1961) was used ( $P = 0.05$ ) to determine differences between sites near the margins of Fields 1-4 (outer sites) and those located near the centres of the fields (inner sites). In Field 1, for example, the outer sites were those in the two outermost beds and the samples taken close to the ends of non-peripheral beds. Inner sites were all those remaining. In all four fields, data were subjected to log transformation before analysis.

In 1982, 26 commercial plantings were monitored for lettuce aphids. The plantings were about 200 m long and ranged from 13-20 beds in width. Within each planting, the two outermost beds and a bed mid-way between the other two were sampled. Within 50 m intervals along each sampled bed, a plant was arbitrarily chosen and destructively examined. The data from all the plantings were compiled and expressed as the mean number of infested plants/50 m interval/outside or inside sites.

### Distribution Within Plants

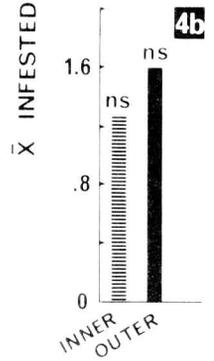
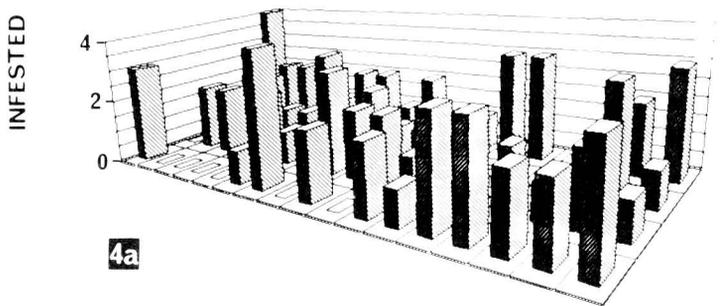
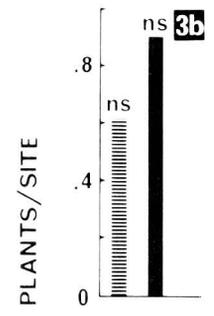
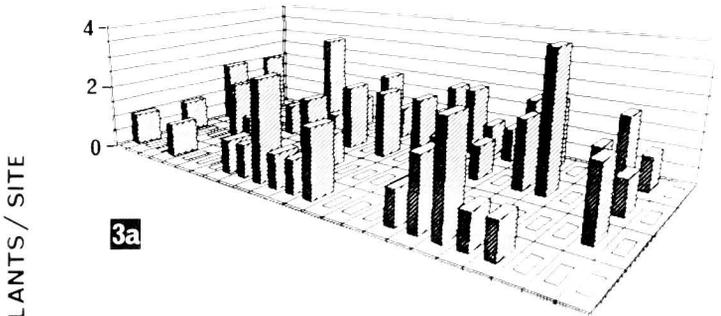
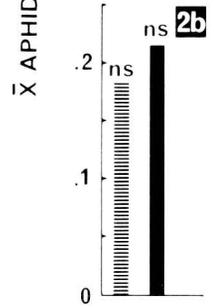
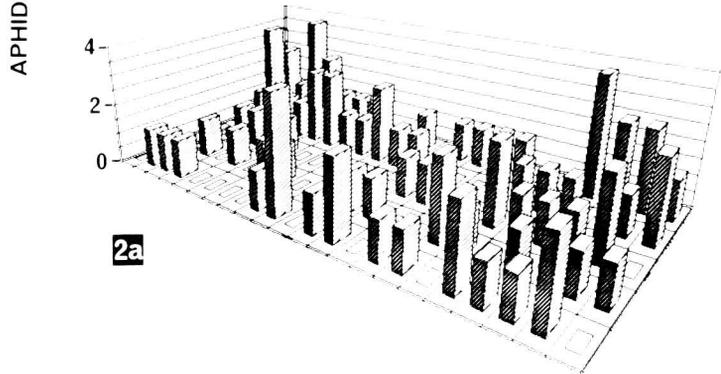
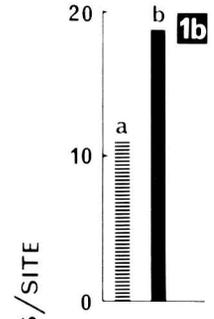
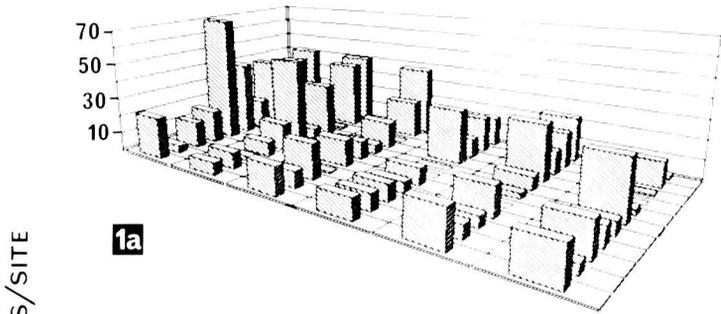
Crisphead lettuce, (*cv.* Ithaca), was seeded on 22 June, 1984 at Abbotsford, B.C. in a 0.12 ha field. The field was divided into four blocks, and within each block 26 plants were selected at random and marked; on 5, 9, 13, and 16 July five lettuce aphids were released on each of the marked plants to simulate an interval of recurring aphid migration and to ensure plants were colonized. Releases were made before the plants had produced five secondary leaves, well before the heading stage. At harvest (29 August), 6-7 plants from each block were examined by sequentially numbering and inspecting each plant leaf for lettuce aphids. The outermost leaf was leaf number 1, and the average number of leaves/plant was 32 (range 27-33). The cumulative number of aphids found alive on each leaf of the plants examined was averaged and expressed as the mean number of aphids/leaf number  $x$ , where  $x$  ranged from 1 to 33.

The aphid numbers within the plants were stratified according to the main leaf types comprising a lettuce plant at harvest: the loose outer leaves (1 to 12); the wrapper leaves (13 to 17); and the head leaves (18 to 33). Aphid counts were compiled by leaf type, analyzed by ANOVA, and compared by Duncan's multiple range test (Duncan 1955).

## RESULTS AND DISCUSSION

### Distribution Within Fields

In Fields 1-4, (Figs. 1a-4a, respectively), an analysis of variance between rows and columns was conducted and differences compared by Duncan's multiple range test. Either no significant differences were apparent (Field 4), or significantly ( $P < 0.05$ ) greater numbers of aphids or infested plants were found in one or more outer rows or columns (Fields 1, 2 and 3).



INNER OUTER

Figs. 1-4. Infestation of fields of crisphead lettuce by *N. ribisnigri* in the lower Fraser Valley of British Columbia.

Fig. 1a) Counts of living aphids on four plants/sample site, using 66 plants in all from Field 1, at the 9-leaf stage, 18 Aug., 1982; 1b) Chi-square comparison of mean numbers of aphids/inner vs outer field sites; 2a) Counts of living and dead aphids on four plants/sample site, using 460 plants in all from Field 2, at the 13-leaf stage, 17 July, 1984; 2b) As for Fig. 1b; 3a) Counts of infested plants out of four/sample site using 384 plants in all from Field 3, at the 11-leaf stage, 12 July, 1984; 3b) Chi-square comparison of mean numbers of infested plants/inner vs outer field sites; 4a) Counts of infested plants out of four/sample site using 272 plants in all from Field 4, at the 13-leaf stage, 12 July, 1984; 4b) As for Fig. 3b.

Overall, the number of instances in which an outer row or column had significantly more aphids or infested plants than an inner row or column was 14 in contrast to only 3 for the opposite case. When the data were examined on the average numbers of aphids or infested plants found near the outer as compared to the inner sites, more infested plants were found at the margins of all fields (Figs. 1b-4b). Only in Field 1, however, were there significantly more aphids at peripheral sites ( $\chi^2 = 3.841$ ;  $df = 1$ ,  $P < 0.05$ ).

Records from 26 monitored commercial plantings in 1982 (unpublished data) confirmed that outer sites of plantings tended to be more heavily infested than inner sites. Overall, the average number of infested plants found at outer sites (0.35) was 25% greater than the number of infested plants found well inside the fields (0.26).

**Distribution Within Plants**

A total of 3,592 lettuce aphids were counted in the 26 infested plants examined at harvest. Of this total, 430 (12%) were found on the outer leaves, 2,111 (59%) on the wrapper leaves, and 1,051 (29%) were found within the heads (Fig. 5). Significantly more aphids were found on the five wrapper leaves and first five head leaves than on the outer leaves or innermost head leaves. Where the occasional plant was infested with both lettuce and green peach aphids, we observed a well defined transition from the latter on the outer leaves, to the former on the wrapper leaves, at about leaf 13. The preferred habitats of these 2 species in lettuce appear to be quite distinct. On lettuce inspected before the heading stage in several commercial

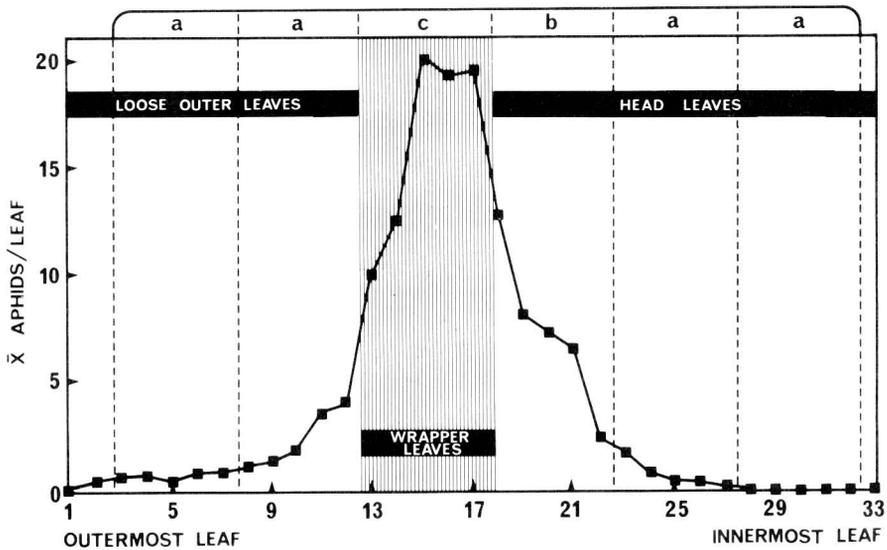


Fig. 5. Mean numbers of *N. ribisnigri* observed on leaves of 26 crisphead lettuce plants (cv. Ithaca) at harvest, 68 days after seeding. Groups of leaves marked with the same letter are not significantly different (Duncan's multiple range test:  $P < 0.05$ ).

plantings, *N. ribisnigri* alates or apterae were most frequently observed on the youngest leaves near the middle of the plants.

### Sampling Program for *N. ribisnigri*

The studies of field distribution reported here indicated that samples taken along the outermost beds on either side of a lettuce planting would be equal to, or better than, samples taken within a planting for detecting plants infested with *N. ribisnigri*. Since the market tolerance for all aphids is zero, and manpower for sampling is often severely limited, restricting monitoring to the perimeters of plantings would be efficient and overestimate the mean population of the entire planting.

The study of aphid distribution in plants showed that lettuce may be infested by *M. persicae* on the outer leaves and *N. ribisnigri* on the middle and inner leaves. Since the zero tolerance applies to all aphid species, lettuce plants must be completely inspected *in situ*, for all species living above-ground. A method of non-destructive sampling is required, since many samples may be taken between thinning and heading in commercial plantings (Dun 1984). This can be accomplished with moderate ease prior to the heading stage by gently prying apart the leaves for inspection. Once the head begins to form, however, plants can only be effectively examined destructively, requiring that sampling intensity be either reduced or stopped to avoid direct crop losses. The usefulness of monitoring after heading is questionable anyway, since *N. ribisnigri* infestations cannot be controlled once heads have formed.

In 1984, an industry-wide pilot monitoring program was implemented in the lower Fraser Valley, with about 127 lettuce plantings (a cumulative total of 560 ha) being examined for aphids over a 4-month period by a single person (Dun 1984). Four lettuce plants were examined *in situ* every 10 m along the outer perimeters of each planting from the thinning to the heading stage. This routine allowed the worker to visit each planting at least once a week, to inspect 100-150 plants/visit. This sample size was adequate, since the objective of monitoring was to ensure that pre-scheduled sprays (British Columbia Ministry of Agriculture and Food 1984) were being applied correctly and at the right time, rather than to determine if sprays were needed. In 1984, the sampling approach was very effective in locating aphids in lettuce in early stages of infestation, and unsatisfactory spray routines were identified and corrected. Since 1984, growers following the advice resulting from this sampling strategy have prevented crop loss attributed to aphids.

If the present level of aphid control on lettuce is maintained, it is likely that the strict intolerance for aphid infested lettuce at harvest will eventually be relaxed. Once this occurs, it will be possible to modify the existing monitoring program to assist growers in withholding insecticide sprays, and reducing the total number of sprays applied to a lettuce crop. A sequential sampling program based on more conservative action thresholds has been proposed by Mackenzie (1986). The proposed program reduces labour in years of high *N. ribisnigri* infestation, and reduces the number of sprays applied in years of low infestation.

### ACKNOWLEDGEMENTS

We thank Cloverdale Produce Farms and the lower Fraser Valley lettuce growers for their cooperation; D. Bartel, J. Brookes, D. Dyck and B. Johnston for help in the field; W. MacDiarmid for figure preparation, and B. Frazer and H.R. MacCarthy for their critical reviews. Financial assistance was provided by the Province of British Columbia, D.A.T.E. (Demonstration of Agricultural Technology and Economics) Project No. 99, 1982.

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