

The within-field spatial and temporal distribution of the grain aphid (*Sitobion avenae*) in winter wheat

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ABSTRACT

The within-field spatial distribution of the grain aphid (*Sitobion avenae*) was investigated by intensively sampling a field of winter wheat during the spring and summer of 1996 using a 9 x 7 sampling grid comprising 63 locations at 30 m intervals. The data were described using Taylor's power law and by SADIE statistics in order to identify spatial pattern. Analysis demonstrated generally weak spatial association and some edge effects, although there was a significant within-field dependence of yield on aphid population parameters. The implications of these findings in relation to the development of pest management strategies are discussed.

INTRODUCTION

The infestation of cereals by aphids and the subsequent effects on yield, have been studied in detail by many workers (Dixon, 1987). Aphid populations are often assessed by counts which are randomly located within the study area, which allows the description of mean-variance relationships, but investigations which describe and map within-field distributions are limited. Recent advances in statistical methodology utilising Spatial Analysis by Distance Indices (SADIE) allow the description of two-dimensional spatially referenced data sets (Perry *et al.*, 1996), which provides an opportunity for a detailed analysis of within-field aphid distributions. The way in which aphid populations develop within a field and, in particular, the persistence of discrete sub-populations could influence the development of, for example, precision farming approaches to aphid pest control, the optimisation of scouting crops for aphid infestations and the enhancement of biological control strategies. This paper describes a study which investigated the spatial distribution of the grain aphid (*Sitobion avenae*) within a field of winter wheat during the spring and summer of 1996. The effect of aphids on within-field variations in yield, and the effect of N availability on aphid population dynamics are also reported. The findings from this study are discussed in relation to their relevance to the development of pest management strategies.

MATERIALS AND METHODS

A field of winter wheat (250 m by 180 m, near Wimborne, Dorset, UK) was sampled intensively on six occasions during 1996 between 7 June and 12 July. A grid comprising 63 sampling locations in a 9 x 7 rectangular grid at intervals of 30 m was positioned within the crop. At each location, sampling was done to record aphid numbers, yield per ear and grain N. These data are part of a larger study which included sampling at three spatial scales and recording other parameters including natural enemy numbers and weed cover at each spatial location (Holland, Winder and Perry; unpublished).

Aphid numbers and species were recorded at each location by the inspection of five tillers. The five tillers were marked with black tape and each week counts were done on these tillers on six occasions. Once the crop had reached maturity, yield was measured at each sampling location by harvesting a 0.1m² area of the crop. The number of ears within each 0.1m² quadrat was recorded and the sample was then threshed, the grains weighed and moisture content determined. The grain was analysed for % N by standard Kjeldahl extraction as an assay to determine nitrogen availability to ear feeding aphids (S Duffield, pers. comm.).

Using these data, average aphid densities, yield (corrected for moisture content) and % N values were calculated for each of the 63 locations. Regression analysis using SPSS for Windows determined relationships between aphid days (Ruppel, 1983), peak aphid density, yield and % N. The data were represented visually by surface mapping using Surfer for Windows.

RESULTS

All results refer to *S. avenae* which was the only species present within the crop in significant numbers. Initially, whole field populations were 0.18 aphids shoot⁻¹ and they reached a maximum of 3.82 aphids shoot⁻¹, although there were considerable within-field differences in populations (Table 1, Figure 1). The parameters b and $\log_{10}a$ of Taylor's power law were estimated as 1.5 and 0.68 respectively, which are typical values for insect populations and indicate variance heterogeneity (Taylor *et al.*, 1978).

Table 1. SADIE index of aggregation (I_a). Values of I_a exceeding 1 indicate spatial aggregation. Mean aphid density (m , aphids shoot⁻¹), variance (s^2), and minimum and maximum recorded densities (aphids shoot⁻¹) calculated for whole field. Values for each date calculated from 63 counts from 9 x 7 sampling grid.

	I_a	m	s^2	min	max
7 June	1.00	0.18	0.31	0	4.0
14 June	1.04	0.22	0.22	0	3.0
21 June	1.14	0.58	0.53	0	2.4
28 June	1.31	1.76	11.5	0	20.4
5 July	0.89	1.08	4.1	0	10.4
12 July	1.00	3.82	22.4	0	23.4

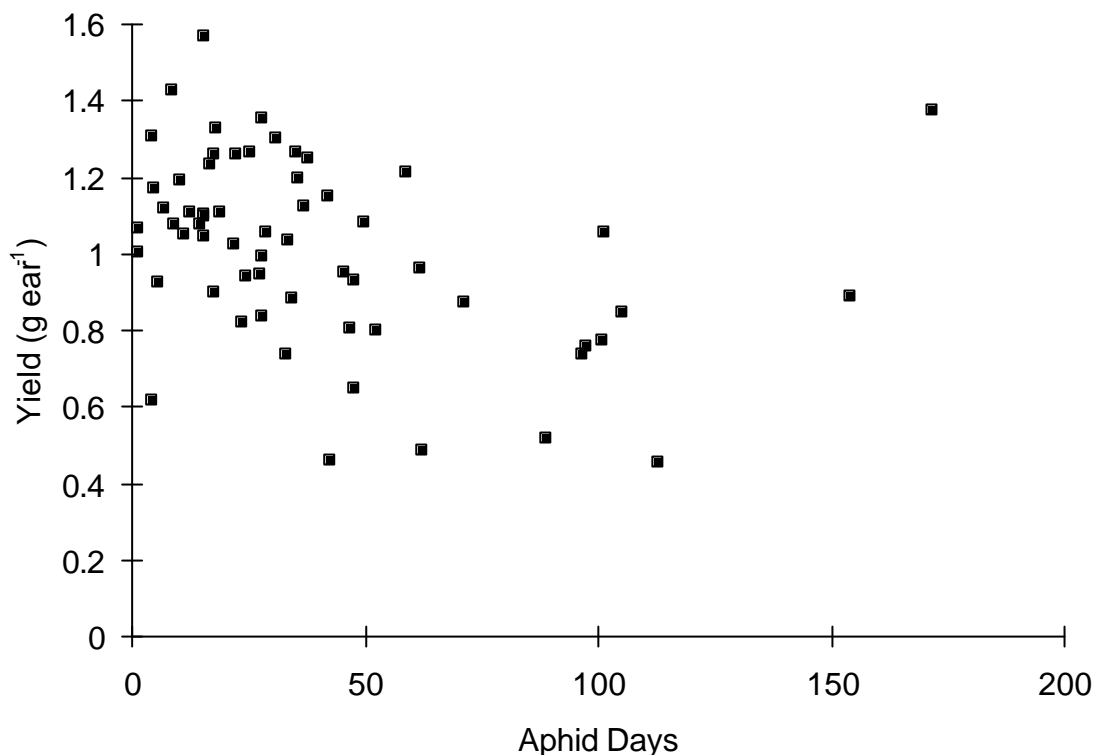


Figure 2. Within-field regression relationship between aphid days (A) calculated using the method of Ruppel (1983) and yield (Y , g ear^{-1}). The regression relationship describing these data is $Y = 1.31 - 0.2\log_{10}A$, $r = 0.34$, $P < 0.01$.

DISCUSSION

This study demonstrated sufficient variability of within-field aphid populations to result in yield reduction. However, characterisation of the within-field distribution was difficult because there was little consistency in spatial pattern between weeks. Aggregation was largely ephemeral, probably due to the high aphid mobility. Sunderland *et al.*, (1986) have shown that up to 90 % of the aphid population shoot¹ fall to the ground each day, although their subsequent dispersal is poorly understood. There was evidence of higher densities towards the edge of the area sampled, extending from 30 m to 60 m into the field; the effect was most evident when aphid data were measured in units of aphid days, due to its integrating effect. Edge effects have been attributed to the influence of windbreaks on the distribution of aphids (Lewis, 1967) or the shelter given to aphids once they have entered the crop (Taylor, 1962). They may be characteristic of a specific field, given its topography, although long-term studies would be needed to confirm this. Additionally, knowledge of the consistency and magnitude of edge effects could improve the precision of pest incidence counts used in decision making during integrated crop management and lead to the selective spraying of 'at risk' areas. Nitrogen has been shown to increase the development of cereal aphid populations in the laboratory (Dixon, 1987) although in this study and in others (Zhou & Carter, 1991) no consistent effect has been demonstrated for *S. avenae* in the field. This indicates that other factors have a much stronger influence on grain aphid population dynamics.

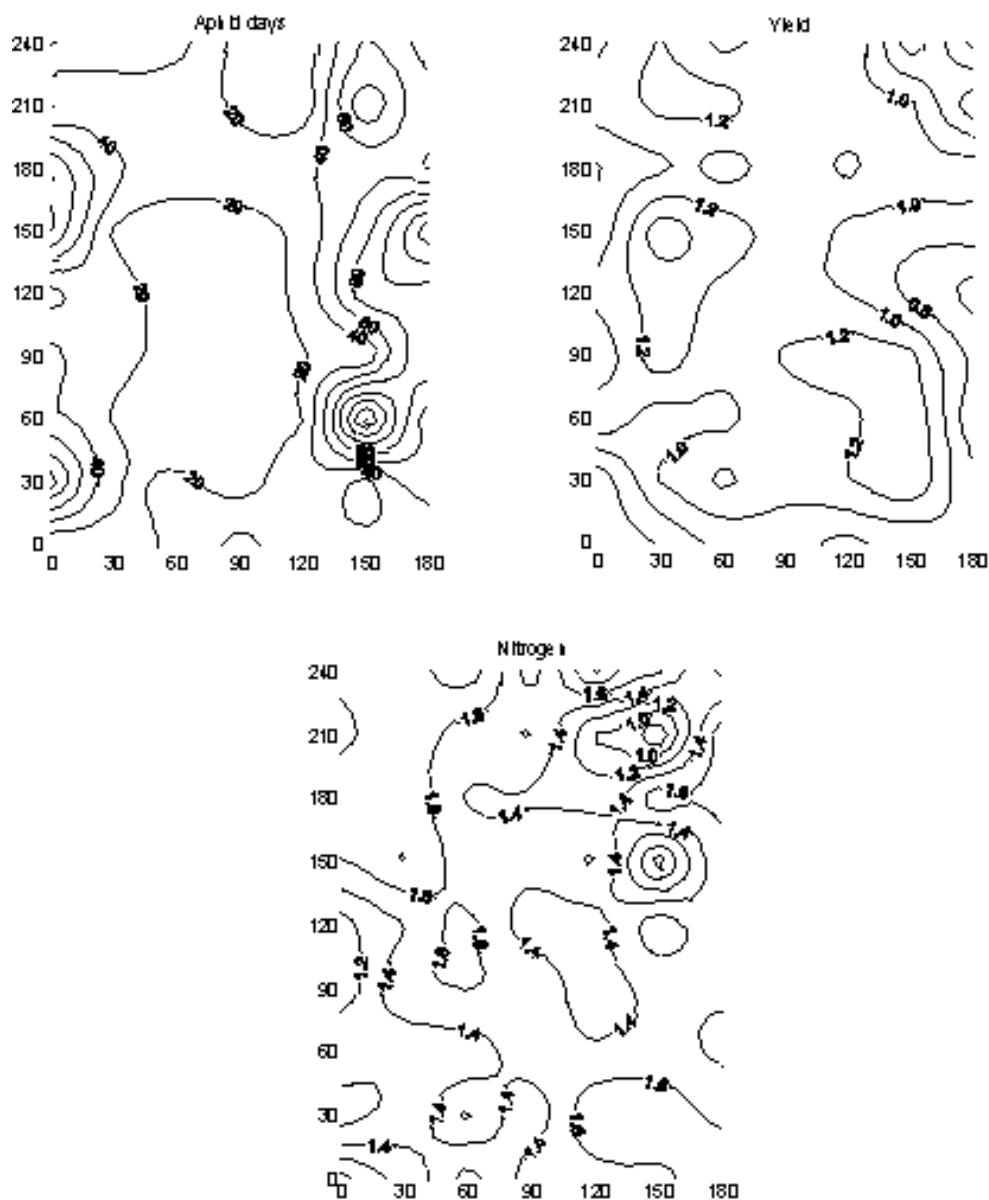


Figure 3. Maps representing within-field distributions of aphid days (Ruppel, 1983), yield (g ear^{-1}) and % N in grain. The x and y axes on each map are in metres.

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