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Agriculture, Ecosystems and Environment 105 (2005) 17–21

Agriculture Ecosystems & Environment

www.elsevier.com/locate/agee

Mass releases of *Aphidius rhopalosiphi* (Hymenoptera: Aphidiinae), and strip management to control of wheat aphids

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Received 13 February 2003; received in revised form 8 June 2004; accepted 28 June 2004

Abstract

Biological control of cereal aphids was attempted during two years, using two approaches: (1) mass-release of *Aphidius rhopalosiphi* (21,000 individuals/ha) in May and (2) use of a clover-ryegrass strip as a parasitoid reservoir. Two aphid species (*Metopolophium festucae* and *Acyrtosiphon pisum*) considered as alternative hosts for cereal aphid parasitoids occurred in the grassy strips. Three fields for each of the mass release or strip management were compared in 2000 with two control fields where no aphid control was done. Aphid population growth was significantly reduced under both mass release and management compared to controls. There was no significant difference between the two treatments. Yet, the parasitism rates were significantly higher under mass release and strip management than in the controls. In 2001, three fields per treatment were compared with three controls. Aphid numbers were very low in all fields, strip management being the only treatment to slow down aphid population growth.

Keywords: Biological control; Field experiment; Mass release; Strip management; Parasitoid; *Aphidius rhopalosiphi*; Aphid

1. Introduction

Mass releases of control agents are currently used against aphids in greenhouses (Hagvar and Hofsvang, 1991; van Lenteren et al., 1997). In field situations, natural populations of parasitoids can be increased by alternative hosts (Langer and Hance, 2004). According to Starý (1970), *Cytisus scoparius* (L.) (broom) helped the parasitoid *Aphidius ervi* Haliday in regulating the aphid *Acyrthosiphon pisum* Harris on alfalfa.

The objective of the present study was to test and compare the impact of parasitoid mass-releases and

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doi:10.1016/j.agee.2004.06.004

strip management on the aphid population growth under field conditions. *Aphidius rhopalosiphi* De Stefani-Peres was selected for mass release on the basis of laboratory testing. This species has a type III functional response and its numerical response maximizes the exploitation of dense patches (Stilmant, 1996). High fecundity is the most important factor, one female parasitizing on average 160 aphids during the first five days of its adult life (Stilmant, 1994). Preliminary experiments have shown that mass-releases of *A. rhopalosiphi* were likely to reduce wheat aphid populations (Levie et al., 2000). Langer et al. (1997) and Langer and Hance (2004) showed that strips of alfalfa, meadow fescue, ryegrass and red clover, containing alternative hosts of *A. rhopalosiphi*, *A. ervi*, *Praon volucre* (Haliday) and *A. picipes* (Nees) enhanced parasitism in the wheat field during the whole season.

2. Materials and methods

Parasitoids collected in 1999–2000 in Belgium in three different locations to maximize genetic diversity were mass-produced in cages containing wheat pots infested with *Sitobion avenae* in an insectary at $20 \pm 1.5\,^{\circ}C$, 60% relative humidity and a 16:8 h L:D regime.

Eight and nine winter wheat (cv. Ritmo) plots, 50 m × 100 m long included in several ha fields were used in 2000 and 2001, respectively, all located at four farms around Louvain-la-Neuve (Belgium). All were on similar soils, in the same intensive agricultural landscape and no insecticide was sprayed during the whole season. Fields were on roadside and boundaries between fields and the road were narrow (<1 m wide). Two plots were used as controls (three in 2001), three for mass release of *A. rhopalosiphi* and another three had a grassy strip along their border. Strips 3 m × 100 m were established in August 1999 and 2000 along one side of three fields, 1 km apart. Half the strip (50 m) was planted to red clover cv. Merviaut, host plant of *A. pisum*, the other half to ryegrass cv. Wigor, host plant of *Metopolophium festucae* (Theobald). In mass release plots, in 2000, 10,000 mummies per plots were released on 31 May and 11,000 mummies one week later on one side of the plots in both cases. In 2001, 5000 mummies were released on 31 May and 10,000 one week later under the same condition. In both years, controls showed that 97–100% mummies emerged within three days of release, 55% of the adults being females.

Three samples of 15 tillers were collected on three transects, 10 m apart, 90° to the length of each plot. Three sampling occurred, i.e. within the first 15, 15–30 and 30–45 m once a week from 15 May to 4 July 2000, from 14 May to 9 July 2001. Samples were left to dry for one night at room temperature and treated with dimethylether vapor. Aphids were counted, placed on winter wheat in the laboratory, and checked for mummies each day. The total number of aphids and mummies was recorded.

The growth phase of the aphid population was fitted by a linear regression and a slope heterogeneity test performed on the number of aphids per sample. A three-way ANCOVA with two fixed factors (treatment and time as continuous variable) and one random factor (field) was performed. Field effect being non-significant, ANOVA (one fixed factor: treatment) was performed on the maximum aphid numbers. The influence of distance from the field edge on aphid population growth was tested using a two-way ANOVA with two fixed factors (distance and time).

The regression coefficient (r^2) of the number of mummies to number of aphids was used as an estimate of the parasitism rate. A slope heterogeneity test was performed on the number of parasitized aphids, a three-way ANCOVA with two fixed factors (treatment and total number of aphids as continuous variable) and one random factor (field, hierarchical to the treatment). A one-way ANOVA with one fixed factor (treatment) was performed on the slope coefficients weighted by the number of data divided by the sum of the square errors. The influence of distance was tested for each treatment by a two-way ANOVA with two fixed factors; distance and time as continuous variables. All statistical analyses were done with SAS (SAS Institute, 1989).

3. Results

In 2000, aphid populations went through a stationary phase up to early June (mean of 0.62 aphids per tiller) to sharply increase at the end of June and decreased when wheat matured. The plot effect

Table 1
Maximum aphid numbers per wheat tiller in 2000 (26th June) and parasitism rates in Belgium, levels of significance (*F*, *P*) and correlation coefficients (r^2)

Plot	Aphid no. per tiller	Parasitism (%)	*F*	*P*	r^2
Control 1	6.1 ± 3.9	6.1	38.39	0.0001	0.744
Control 2	6.2 ± 3.1	4.6	17.53	0.0001	0.223
Release 1	1.8 ± 1.3	15.5	48.51	0.0001	0.443
Release 2	4.6 ± 1.8	23.5	69.38	0.0001	0.532
Release 3	1.9 ± 1.2	21.8	48.21	0.0001	0.441
Strip 1	2.5 ± 1.7	14.1	73.02	0.0001	0.371
Strip 2	3.2 ± 1.2	17.4	90.60	0.0001	0.422
Strip 3	2.7 ± 0.9	11.1	63.59	0.0001	0.339

was not significant ($F = 1.25$, $P = 0.2828$), whereas treatment, time and their interaction were significant ($F = 5.35$, $P = 0.0051$; $F = 191.34$, $P = 0.0001$; $F = 14.08$, $P = 0.0001$, respectively). Aphid number per sample (Table 1) was significantly lower for release than for control plots ($F = 19.97$, $P = 0.0001$) and for strip than for control plots ($F = 19.95$, $P = 0.0001$), strip and release plots being not different ($F = 0.38$, $P = 0.5417$).

The regression coefficient (r^2) of the number of parasitized aphids on the total number of aphids was used to estimate parasitism rates (Table 2). The plot effect was not significant ($F = 0.27$, $P = 0.9313$). As a consequence, the reduced model with only treatments and total number of aphids was used. Both factors and the interaction were significant ($F = 4.33$, $P = 0.0135$; $F = 440.25$, $P = 0.0001$; $F = 55.53$, $P = 0.0001$, respectively). The larger the total aphid population, the larger the difference between treatments. The parasitism rates were higher in the strip-managed fields than in the control fields ($F = 6.75$, $P = 0.0483$) and higher in the mass release fields than in the control fields ($F = 18.55$, $P = 0.0077$). No significant difference was found between the parasitism rates of release fields and strip-managed fields ($F = 3.88$, $P = 0.1058$).

The aphid populations did not differ with distance in strip ($F = 0.03$, $P = 0.8712$), mass release ($F = 0.01$, $P = 0.9407$) and in control plots ($F = 0.47$, $P = 0.4938$). In the same way, the parasitism rate do not showed significant relation with distance in strip ($F = 0.69$, $P = 0.4073$), release ($F = 0.01$ $P = 0.9247$) and control plots ($F = 0.59$ $P = 0.4430$).

In 2001, the plot effect being not significant ($F = 1.51$, $P = 0.1866$) a reduced model was used in which the treatment effect was significant ($F = 9.10$, $P = 0.0003$). The number of aphids per sample was significantly lower for strip than for control plots (9th July, $F = 17.42$, $P = 0.0001$) and for strip than for mass release plots ($F = 8.05$, $P = 0.0058$) but there was no difference between release and control plots ($F = 1.68$, $P = 0.1984$). Although the parasitism rates seem to be higher in the strip-managed fields, no statistical difference was found between controls, release and strip plots ($F = 0.27$, $P = 0.7632$).

Table 2
Maximum aphid numbers per tiller in 2001 (July 9th), parasitism rates in Belgium (2001), level of significance (*F*, *P*) and correlation coefficients (r^2)

Field	Aphid no. per tiller	Parasitism (%)	*F*	*P*	r^2
Control 1	1.5 ± 0.9	8.5	49.94	<0.0001	0.387
Control 2	1.5 ± 0.7	3.0	8.61	0.0044	0.098
Control 3	1.3 ± 0.9	2.9	6.32	0.0140	0.074
Release 1	1.3 ± 0.4	7.4	30.90	<0.0001	0.286
Release 2	0.7 ± 0.5	7.4	13.08	0.0005	0.150
Release 3	1.4 ± 1.0	6.8	19.19	<0.0001	0.195
Strip 1	0.4 ± 0.2	14.6	42.29	<0.0001	0.349
Strip 2	0.7 ± 0.3	6.0	16.15	0.0001	0.170
Strip 3	1.1 ± 0.6	8.0	27.99	<0.0001	0.262

4. Discussion

Latteur and Oger (1991) showed that in 5 out of 11 years recorded in Belgium, there was no need to spray insecticides, because of the role played by Aphidiine parasitoids in particular. Latteur (1985) showed that in 24 out of 40 sites sampled between 1971 and 1982 in Belgium there was no yield difference between insecticide treated and non-treated parts of the sites.

Both mass releases and strip management reduced aphid populations in field conditions to the same extent, i.e. 46 and 45%, respectively of the population observed in the control plots. Parasitism rates were over three times higher in release plots than in control plots and over as twice as high in strip than in control plots. Langer and Hance (2004) have shown that grassy strip may increase aphid parasitism level in adjacent fields. They attributed this observation to apparent competition. When the aphid density was low (year 2001), only strip management significantly decreased aphid populations. Mass released parasitoids probably dispersed outside the target plot when aphid density was low whereas they were attracted and sustained by the alternative hosts in strip plots. Strip plots are likely to also enhance populations of aphid predators.

Field experiments have been performed in England and The Netherlands to determine the effect of aphid infestation on wheat yield. An early infestation followed by a sharp population increase induces yield losses (George, 1975; George and Gair, 1979; Watt and Wratten, 1984; Oakley and Walters, 1994). Yield losses ranged between 11 and 15% (George, 1975; Wratten, 1975; George and Gair, 1979; Watt and Wratten, 1984; Oakley and Walters, 1994). Latteur (1985) showed that one insecticide application represented an equivalent cost to 1.9–3% yield value. In the present study, one aphicide application have been required in 2000 and strip management as mass release maintained aphid level under the economic threshold.

The released parasitoid probably moved far beyond 45 m from the release point as no distance effect was observed in the present experiment. Muratori et al. (2000) showed that after a release of 2400 marked parasitoids, some were already collected after 90 min at a distance of 100 m on yellow sticky traps.

Farmers may receive a financial support for setting up grassy strips in the context of agri–environmental measures aiming at promoting biodiversity and at limiting environmental impact of pesticides and fertilizers. An appropriate management could allow parasitoid reservoirs build up and thereby provide cheap biological control. The costs of parasitoids mass releasing is at present much too high for field use. Some 20.000 *A. ervi* are sold at about €2000 by insect producing companies, a price that should be reduced at least 20 times to be interesting for field application.

Acknowledgments

This study was supported by the ''Service de la Recherche Agronomique, Ministère des Classes Moyennes et de l'Agriculture, Belgium''. The authors are grateful to Vincent Cambier for his constructive advice, to Renate Wesseling for the English review of this paper and to all the persons who have helped out with this time-consuming experiment. Authors thank anonymous reviewers for improving the manuscript. This paper is publication number BRC026 of the Research Center on Biodiversity, UCL.

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