Bulletin of Insectology ***58*** *(1): 9-14, 2005*
ISSN 1721-8861

Trap crop: an agroecological approach to the management of *Lygus rugulipennis* on lettuce

Gianumberto ACCINELLI[1], Alberto LANZONI[1], Fabio RAMILLI[1], Davide DRADI[2], Giovanni BURGIO[1]
[1]*Dipartimento di Scienze e Tecnologie Agroambientali - Entomologia, Università di Bologna, Italy*
[2]*CREA, Centrale Sperimentazione e Servizi Agroambientali, Cesena, Italy*

Abstract

Field trials were carried out in Northern Italy in order to develop an agroecological approach to the control of *Lygus rugulipennis* Poppius (Rhynchota Miridae) on lettuce by using trap crops. Two treatments were compared: lettuce with trap crops, consisting of plots adjacent to alfalfa strips and lettuce without trap crops consisting of another four plots surrounded by bare soil. In 2000 alfalfa strips were not treated; on the contrary, in 2001 and 2002 localised chemical treatments were made weekly on the alfalfa strips. In 2002 the ratio between trap crops and lettuce areas was increased from 0.075 to 0.15. In addition, cultivar 'Trocadero', a cultivar less sensitive to *Lygus* damage, was compared to cultivar 'Romana'. The results demonstrated a general efficiency of alfalfa as a trap plant for managing *L. rugulipennis*. The efficiency in preventing damage to lettuce was not sufficient in 2000 without localised chemical applications on alfalfa. The localised treatment of insecticides on alfalfa strips had a significant effect on reducing the extent of damage on lettuce plots adjacent to the trap crops. In 2002 the cultivar 'Trocadero' had a lower damage index than cultivar 'Romana'. Alfalfa as a trap crop could be used for lettuce in periods of the year where the pest is not as abundant as it is in August and September. Managing *Lygus* bugs with trap crops is not advisable when the variety of lettuce is very sensitive to bug damage, thus trap crops can be effective for lettuce cultivar like 'Trocadero' but not for cultivar 'Romana'.

Key words: *Lygus rugulipennis*, trap crops, lettuce, *Medicago sativa*, biological control, sustainable agriculture, European Tarnished Plant Bug.

Introduction

The European Tarnished Plant Bug *Lygus rugulipennis* Poppius (Rhynchota Miridae) is the most common pest within this family in Italy (Accinelli *et al*., 2002). This polyphagous bug is reported to attack more than 400 species of plants and it is an economic pest to several vegetables, such as eggplant, strawberry and lettuce (Vappula, 1962; Varis, 1972; Dragland, 1991; Holopainen and Varis, 1991). Under particular conditions it can also damage peaches (Tavella *et al*., 1996).

In Northern Italy, *L. rugulipennis* is a key pest of lettuce, especially cultivar 'Romana', particularly to the transplants carried out from mid July to September (Accinelli *et al*., 2002). At that time of year, adults may be found among the leaves of the maturing crop and their feeding causes necrotic areas on the leaves producing aesthetic damage to the crop. Because of its high polyphagy, great mobility, high population densities and because of the low damage threshold in this crop, biocontrol is generally difficult. Therefore, the current control of *L. rugulipennis* relies on the application of insecticides, especially pyrethroids (Accinelli *et al*., 2002). The use of these broad spectrum insecticides has a negative impact on the conservation biological control of another economic pest of lettuce: *Liriomyza huidobrensis* (Blanchard) (Diptera Agromyzidae). Indeed, if pyrethroids are not used, the pea leafminers is normally kept under the economic threshold by several wild parasitoid species belonging to Hymenoptera, (Burgio *et al*., 2000; Lanzoni *et al*., 2003). Moreover, in greenhouses, biological control of this pest could be achieved with the seasonal inoculative release of *Diglyphus isaea* (Walker) (Hymenoptera Eulophidae) and *Dacnusa sibirica* Telenga (Hymenoptera Braconidae) (van der Linden, 1993). The release of these parasitoids is not effective if the control of *L. rugulipennis* relies on chemicals.

Biocontrol options for phytophagous Mirids, have been studied especially in the US (Ruberson and Williams, 2000). They involve inundative release of egg parasitoids, inoculative release of nymphal parasitoids, microbial control with the fungal pathogen *Beauveria bassiana* (Balsamo), and trap crops.

Biocontrol strategies found by releasing egg and nymphal parasitoids have been used in the U.S for several years even for high cash value crop such as strawberries (Udayagiri *et al*., 2000). The egg parasitoid used in *Lygus* spp. control programs is *Anaphes iole* Girault (Hymenoptera Mimaridae) (Jones and Jackson, 1990; Norton *et al*., 1992; Norton and Welter, 1996; Udayagiri and Welter, 2000). Nymphal parasitoids have been released in the U.S. against several native phytophagous Mirids. In particular the European *Peristenus digoneutis* Loan (Hymenoptera Braconidae) has been introduced into the United States for neo-classical biological control program (Day, 1996; 1999; Day *et al*. 1998) but the success of these importations has been rather limited (Coulson, 1987; Jackson *et al*., 1995).

Microbial control agents for plant bugs (*B. bassiana*) have been tested and have not yielded effective results in the open field (Snodgrass and Elzen, 1994; Kovach, 1996; Steinkraus and Tugwell, 1997; Noma and Strickler, 1999).

Trap cropping is an agroecological approach for the management of many pests, including phytophagous Mirids. The principle of this strategy is based on the fact that even though polyphagous insects have high

polyphagy, they show a distinct preference for certain plant species. To exploit this behavior, a host-preferred plant species is planted adjacent to the target crop, to keep pests out. To be effective, the trap crop, has to be more attractive to the pest than the target crop. This is achieved by the use of a more preferred plant and, ideally, when this is at the most attractive stage for the pest. The success of trap crops could be improved through various manipulations, including the use of sex or aggregation pheromones or insecticides. Where insecticides are used, the pests are attracted to a small area (trap crop) where their management is easier (Hokkanen, 1991). In this way the area chemically treated is notably reduced. Moreover, the insecticide is not sprayed on the main crop, resulting in a lower level of environmental impact.

Instead of insecticides, vacuum machines are also utilized in order to reduce the bug population density in trap crop (Accinelli *et al*., 2004). For *Lygus* bugs, trap cropping was tested in cotton (Stride, 1969; Sevacherian and Stern, 1974) and strawberries (Easterbrook and Tooley, 1999). The efficiency of this strategy reported for cotton was extremely high, but for strawberries the technique was unable to provide large reductions in numbers of *L. rugulipennis*.

The aim of this research is to develop an agroecological approach to the control of *L. rugulipennis* on lettuce by using trap crops, thus avoiding the use of broad spectrum insecticides on large areas, to improve the efficacy of conservation biological control on lettuce.

Materials and methods

The trials were carried out in the eastern Po Valley (Northern Italy) on the experimental farm Martorano 5 (Cesena) for three years between 2000 and 2002.

Field experiment-2000

Eight plots of lettuce cultivar 'Romana', were established. Two treatments were compared: 1) lettuce with trap crops, consisting of four plots adjacent to three alfalfa [*Medicago sativa* (L.)] strips and 2) lettuce without trap crops consisting of another four plots surrounded by bare soil. Lettuce of both treatments was transplanted on August 1st with 0.37 x 0.29 m spacing between plants. The area of each plot was 15 x 8 m. Each strip of alfalfa was 1.5 x 16 m, two of them were sowed laterally to the lettuce plots and the last one was central. The distance between the trap crop treatment and the control was 20 m. A weed control of the soil surrounding the plots was done in order to prevent the onset of weeds. Alfalfa was chosen because of its high attractiveness to *L. rugulipennis* (Holopainen and Varis, 1991; Rämert *et al*., 2001) and its practical management. Both alfalfa strips and lettuce were properly irrigated. The study was conducted from August to September.

The population level of phytophagous mirids was sampled weekly by using an inverted ECHO power blower PB 21 0E vacuum machine. The nozzle (40 cm diameter) was directed on the canopy of both lettuce plots and alfalfa strips for a time of 20 sec. To determine the effectiveness of alfalfa as a trap crop, visual samples of lettuce were taken weekly. In the 3rd row (1 m from the strip) and in the 16th (6 m from the strip), 30 leaves from each row (2 per plant) were examined to evaluate the damage dynamics. At the economic harvest (28 August), 20 heads of lettuce were collected from each plot and inspected in the laboratory. Each leaf was examined and classified into 4 damage levels depending on the severity of damage: 1 = no damage, 2 = small necrotic spots on the mid rib, 3 = from 2 to 3 cm length of necrotic tissue on the mid rib, 4 = more than 3 cm length of necrotic tissue on the mid rib. A damage index proposed by Burgio *et al*. (1993) was calculated by the following equation:

$$DI = \Sigma (n * ds) / N \quad (1)$$

where DI = damage index, n = number of leaves for each damage group, ds = damage score and N = total number of leaves.

Field experiment-2001

The field trial was replicated under the same experimental conditions. Lettuce was transplanted on July 17th and the experiment was concluded in September. The types of samplings were also the same. In this case however, localised chemical treatments were made weekly on the alfalfa strips, with the pyrethroid Karate (λ-cyhalothrin 2.5%) at a concentration of 1%. The treatment was made in order to increase the effectiveness of the trap crops.

Field experiment-2002

In this year the experimental design was partially changed. The area of each plot of lettuce was reduced to 7 x 8 m (about half of the other years), while the alfalfa strips remained the same width. In this way the ratio between trap crops and lettuce areas increased from 0.075 to 0.15, in order to verify the effect of the methodology in a smaller area. To evaluate the relative efficacy of the ratio increase the following formula was used:

$$E (\%) = (a - b) / a * 100 \quad (2)$$

where E = relative efficacy; $a = DI$ of lettuce without alfalfa; $b = DI$ of lettuce with alfalfa.

In addition, cultivar 'Trocadero', a cultivar less sensitive to *Lygus* damage (G. Accinelli, unpublished data), was compared to cultivar 'Romana'. Each plot was divided in two sub-plots composed of both cultivars. The two cultivars were planted in alternating plants. The sampling design was kept unchanged with respect to the previous years. Lettuce was transplanted on 2nd July and the experiment finished on August 20th.

Statistical analysis

The comparison between percent data was carried out by χ^2 test in 2x2 contingency tables.

Results

Field experiment-2000

The mean number of *L. rugulipennis* collected by the vacuum sampling was considerably higher in the alfalfa

Table 1. Mean number of *Lygus rugulipennis* collected with vacuum sampling (2000).

Weeks following transplanting	1	2	3	4	5	6	7
Lettuce with alfalfa	1±2.00	0.75±0.5	0.5±0.58	1.25±0.96	0	0	0.25±0.50
Lettuce without alfalfa	0.25±0.50	0	0.5±0.58	1.5±1.29	0.25±0.50	0	0
Strip of alfalfa	7±5.57	9.33±6.66	6.33±4.04	8±1	2±1	0.33±0.58	1.66±2.08

Table 2. Mean number of *Lygus rugulipennis* collected with vacuum sampling (2001).

Weeks following transplanting	1	2	3	4	5	6	7
Lettuce with alfalfa	0	0	0	0	4±2.83	0.75±0.96	1.75±0.96
Lettuce without alfalfa	0	0	0	0	3±1.15	0.75±0.96	1.5±1
Strip of alfalfa	0	0.33±0.58	0	0	6±3.61	0.5±0.71	0.33±0.58

strips than in the lettuce plots in the first 5 samplings (table 1). However, no differences were found in the mean number of *L. rugulipennis* on lettuce between the two treatments, during the entire sampling period. The damage, calculated weekly by visual sampling, is shown in figure 1. There was a significant difference between the two strategies only on the 2nd ($\chi^2 = 5.36$; $P = 0.02$) and on the 3rd week after transplant ($\chi^2 = 5.64$; $P = 0.018$) with a lower damage in the trap crop strategy. The damage index, calculated at the economic harvest, showed a slight difference between the two treatments. In particular the index was lower in the trap crop strategy (figure 2).

Field experiment-2001

The population level of *L. rugulipennis* was lower in comparison with the previous year in the whole experiment field. The mean number of Mirids was similar between the alfalfa and lettuce plots of the two strategies (table 2). Only on the 5th week following transplanting did the density of *L. rugulipennis* increase, probably because of the lack of efficiency of the sprays. The reason could be due to the persistent rain in this week, which could have washed away the insecticide. However on this date *L. rugulipennis* populations were more abundant on alfalfa. The weekly sampling of the leaves shows that there was a significant difference in the damage between the two strategies at the 5th ($\chi^2 = 20.2$; $P = 0.001$) and 7th ($\chi^2 = 9.5$; $P = 0.002$) week from the transplantation with a less extensive damage to the lettuce with alfalfa (figure 3).

The damage index, calculated at the economic harvest, indicated a marked difference between the two treatments: in the lettuce with trap crops the index was lower than the control (figure 2).

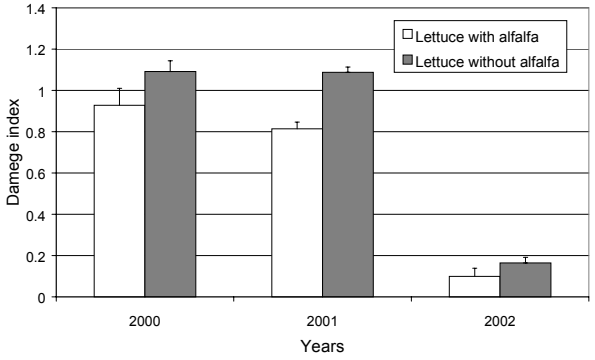

Figure 2. Damage index (DI) of *Lygus rugulipennis* on lettuce in the three years of experiment (DI; mean +SD).

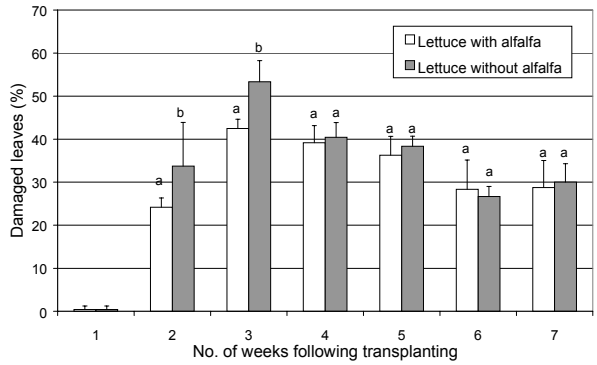

Figure 1. Weekly trend of damage of *Lygus rugulipennis* on lettuce in 2000 (% of damage leaves; mean +SD). Different letters indicate statistical differences for $P < 0.05$.

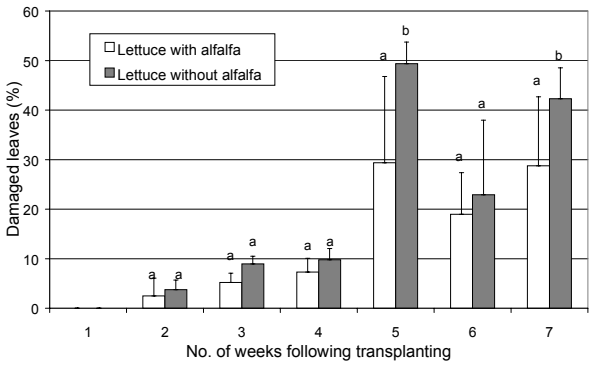

Figure 3. Weekly trend of damage of *Lygus rugulipennis* on lettuce in 2001 (% of damage leaves; mean +SD). Different letters indicate statistical differences for $P < 0.05$.

Table 3. Mean number of *Lygus rugulipennis* collected with vacuum sampling (2002).

Weeks following transplanting	1	2	3	4	5	6	7
Lettuce with alfalfa	0	0	0	0	0	0.25±0.5	1±0.81
Lettuce without alfalfa	0	0	0	0	0.5±1	0.25±0.5	0.5±0.58
Strip of alfalfa	0.33 ± 0.58	0	0	0	1±1	0.33±0.58	1.33±0.58

Field experiment-2002

The density of *L. rugulipennis* was low, in both treatments and alfalfa strips (table 3).

The damage on cultivar 'Romana', calculated from the weekly visual sampling, was always lower in the lettuce with alfalfa with significant differences in the 4th (χ^2 = 14.78; df = 1; P = 0.0001), 5th (χ^2 = 11.75; df = 1; P = 0.0006), and 7th (χ^2 = 36.30; df = 1; P < 0.00001) weeks following transplanting (figure 4A). Also on cultivar 'Trocadero' the damage was lower in the lettuce adjacent the trap crop with significant differences in the 5th (χ^2 = 26.25; df = 1; P < 0.00001), 6th (χ^2 = 17.31; df = 1; P < 0.00001), and 7th (χ^2 = 26.03; df = 1; P < 0.00001) weeks following transplanting (figure 4B). Moreover a significant difference in the weekly damage was detected between cultivar 'Romana' and cultivar 'Trocadero' on the 4th (χ^2 = 4.97; df = 1; P = 0.0258); 7th week from transplantation (χ^2 = 23.55; df = 1; P < 0.00001) (figure 5).

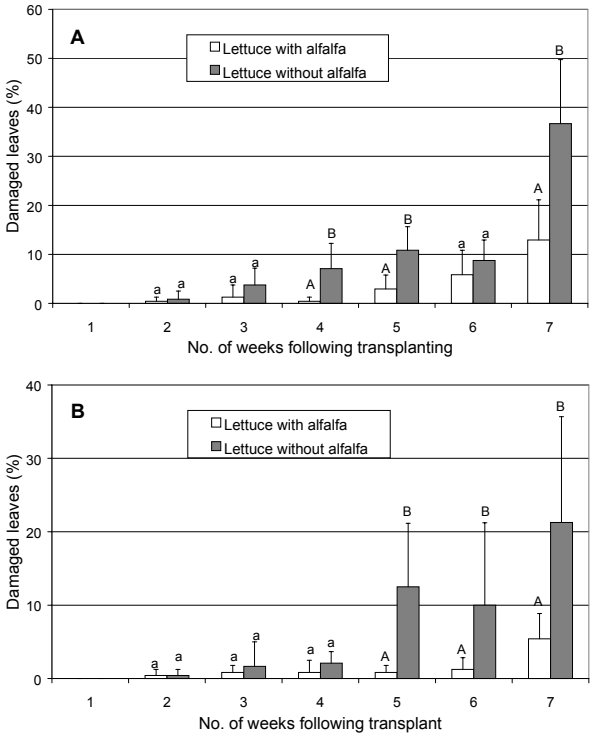

Figure 4. Weekly trend of damage of *Lygus rugulipennis* on lettuce cultivar 'Romana' (A) and cultivar 'Trocadero' (B) in 2002 (% of damage leaves; mean +SD). Different letters indicate statistical differences for P < 0.05 (tiny letters) or P < 0.01 (capital letters).

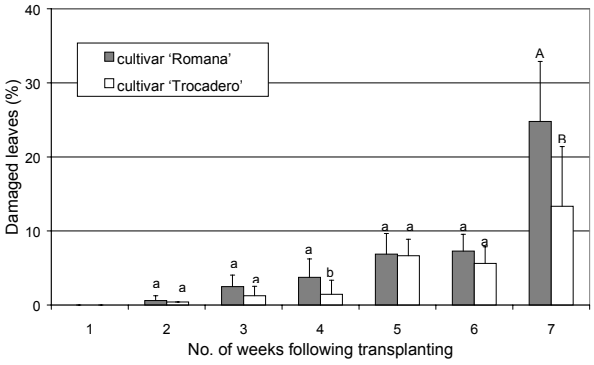

Figure 5. Weekly trend of damage of *Lygus rugulipennis* on the two cultivar of lettuce in 2002 (% of damage leaves; mean +SD). Different letters indicate statistical differences for P < 0.05 (tiny letters) or P < 0.01 (capital letters).

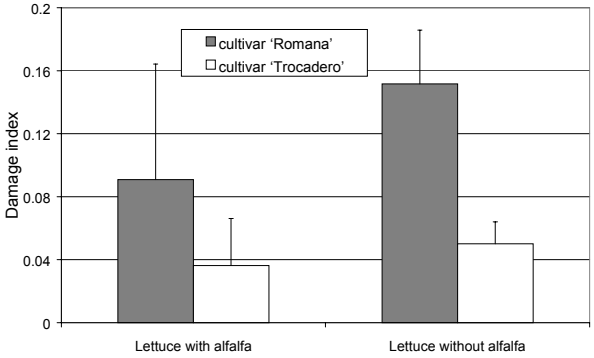

Figure 6. Damage index (DI) of *Lygus rugulipennis* on lettuce in the two cultivars of lettuce in 2002.

The damage index calculated at the economic harvest showed a lower value on the lettuce with alfalfa strip (figure 2). In this year the extent of the damage was notably lower than the other years, probably because of the persistent rain during the experiment and the advance of the transplant. These may have affected the population level of *L. rugulipennis*. Furthermore the cultivar 'Trocadero' had a lower damage index than cultivar 'Romana' in both strategies (figure 6).

The increase of the ratio between alfalfa and lettuce improved the trap crop efficacy. In fact the percentage of efficacy calculated using formula 2 increased from 25.14 in 2001 to 40.11 in 2002.

Discussion and conclusion

Alfalfa showed a general efficiency as a trap plant for managing *L. rugulipennis*. This was demonstrated by the difference between alfalfa and lettuce plots in the number of *Lygus* collected by vacuum sampling. However the efficiency in preventing damage to lettuce was not sufficient in 2000. Indeed, without localised chemical applications on alfalfa, the damage at the economic harvest showed only slightly difference between the two strategies. Nevertheless the localised treatment of insecticides on alfalfa strips had a notable effect on reducing the extent of damage on lettuce plots adjacent to the trap crops.

Generally, the trap crop strategy is an efficient methodology for managing insect pest but, in these conditions, it can be applied only in certain situations for a crop as sensitive as lettuce. Indeed, lettuce has a very low damage threshold (aesthetic damage), and, in Northern Italy in August and September, the population level of *L. rugulipennis* is very high (Accinelli *et al.* 2002).

Alfalfa as a trap crop could be used for lettuce in periods of the year when the pest is not as abundant as it is in August and September. Trap crops seems to be effective for lettuce cultivar 'Trocadero' but not for lettuce cultivar 'Romana'. Therefore managing *Lygus* bugs with trap crops is not advisable when the variety of lettuce is very sensitive to bug damage.

One limit of this technique consists in the use of chemicals on alfalfa strips. Indeed the strips would otherwise be an optimum habitat for many beneficial insects including predators and parasitoids of Mirids (Accinelli, 2004). In order to avoid the use of insecticides, a localised release of Hymenoptera parasitoids could be performed on the alfalfa strips. There, the beneficial insects can find excellent living conditions both for high density of hosts and abundance of food sources (pollen, nectar, honeydew etc.). In these conditions the released parasitoids could secure a large field colonisation that could make further releases unnecessary. In Italy the most common parasitoids attacking *L. rugulipennis* are *Anaphes fuscipennis* Haliday (Conti *et al.,* 1991; Conti *et al.*, 1994; Accinelli and Burgio, 2002) and *P. digoneutis* (Tavella *et al*., 2002; Accinelli, 2004) which could be released for this purpose.

In conclusion, the trap crops technique could be useful in managing *L. rugulipennis* on lettuce in the early season and for varieties of lettuce not very sensitive to damage. Nevertheless the technique requires additional study to determine the phenological stage when the plant, used as a trap crops, is the most attractive to the pest, the optimal ratio between trap crops and lettuce, and the possibility of release of *L. rugulipennis* parasitoids.

Acknowledgements

We are grateful to Antonio Masetti, Davide Negro and Paula Fernandez for their technical assistance in the course of the experiments. We would like to thank Eugenio Cozzolino and Matteo Antonelli (Martorano 5, Cesena, Italy) for their cooperation and kindness. This research was funded by CRPV (Cesena, Italy) and the Regional Government of Emilia-Romagna, Italy.

References

ACCINELLI G., 2004.- Studio del sistema Piante-Miridi-Parassitoidi: prospettive di lotta biologica. 134p., *PhD thesis* - University of Bologna, Italy.

ACCINELLI G., BURGIO G., 2002.- A faunistic study of egg parasitoids of *Lygus rugulipennis* in the eastern Po Valley (Northern Italy), p. 17. In:, *Egg Parasitoids for biocontrol of insect pests. Proceedings of the 6th International Symposium*, (BIN F., BOIVIN G., WAJNBERG E., Eds) Perugia, Italy, 15-18 September 2002.

ACCINELLI G., FERRARI R., DRADI D., POZZATI M., 2002.- Principali Miridi fitofagi: caratteristiche distintive, danni alle colture e metodologie di lotta.- *Informatore Agrario Verona*, 41: 47-50.

ACCINELLI G., FERRARI R., BURGIO G., 2004.- Lotta a basso impatto ambientale ai miridi fitofagi.- *Informatore Agrario Verona*, 29: 57-60.

BURGIO G., MAINI S., MANFREDINI L., MAINI C., 1993.- Confronto fra lotta microbiologica e chimica contro *Ostrinia nubilalis* (Hb.) su mais dolce.- *Informatore Fitopatologico*, 7-8: 45-48.

BURGIO G., LANZONI A., ACCINELLI G., MASETTI A., NAVONE P., 2000.- The role of weeds in marginale areas as reservoirs of parasitoids of Agromyzidae, p. 47. In: *Antonie Leeuwenhoek Symposium. Proceedings of the 7th European Workshop on Insect Parasitoids*, (VAN LENTEREN J.C., KOK C.E., Eds) Haarlem, The Netherlands, 1-6 October 2000.

CONTI E., COLAZZA S., BIN F., 1991.- Imenotteri parassitoidi di uova endofitiche di Eterotteri: alcune associazioni nei Miridi e nei Nabidi, pp. 929-931. In: *Atti XVI Congresso nazionale italiano di Entomologia*, Martina Franca (TA), Italy, 23-28 September 1991.

CONTI E., BEYENE A. E., BIN F., 1994.- Distribuzione e parassitizzazione delle uova di *Lygus* spp. sul girasole in Italia centrale (Heteroptera: Miridae; Hymenoptera: Mimaridae), pp. 523-526. In: *Atti XVI Congresso nazionale italiano di Entomologia*, Udine, Italy, 13-18 June 1994.

COULSON J. R., 1987.- Studies on the biological control of plant bugs (Heteroptera: Miridae): an introduction and history. In: *Economic Importance and Biological Control of Lygus and Adelphocoris in North America*, (HEDLUNG R.C., GRAHAM H.M., Eds).- USDA-ARS-64.

DAY W. H., 1996.- Evaluation of biological control of the tarnished plant bug (Hemiptera: Miridae) in alfalfa by the introduced parasite *Peristenus digoneutis (*Hymenoptera: Braconidae).- *Environmental Entomology*, 16: 379-389.

DAY W. H., 1999.- Host preferences of introduced and native parasites (Hymenoptera: Braconidae) of phytophagous plant bugs (Hemiptera: Miridae) in alfalfa-grass fields in the northeastern USA.- *BioControl*, 44: 249-261.

DAY W. H., TROPP J. M., ROMING R. F., VAN DRIESHE R. G., CHIANESE R. J., 1998.- Geographic distributions of *Peristenus conradi* and *P. digoneutis* (Hymenoptera: Braconidae), parasites of the alfalfa plant bug and the tarnished plant bug (Hemiptera: Miridae) in the northeastern United States.- *Journal of the New York Entomological Society*, 106: 69-75.

DRAGLAND S., 1991.- *Lygus rugulipennis* Popp., a harmful insect to many cultivated plants. II. Damage in cabbage fields and control measures.- *Norsk landbruksforsking*, 5: 67-76.

EASTERBROOK M.A., TOOLEY J.A., 1999.- Assessment of trap

plants to regulate numbers of European tarnished plant bug, *Lygus rugulipennis*, on late-season strawberries.- *Entomologia Experimentalis et Applicata*, 92: 119-125.

HOKKANEN H.M.T., 1991.- Trap cropping in pest management.- *Annual Review of Entomology*, 36: 119-138.

HOLOPAINEN J.K., VARIS A.L., 1991.- Host plants of the European tarnished plant bug *Lygus rugulipennis* Poppius (Het., Miridae).- *Journal of Applied Entomology*, 111: 484-498.

JACKSON C.G., DEBOLT J.W., ELLINGTON J.J., 1995.- Lygus bugs, pp. 87-90. In: *Biological Control in the Western United States* (NECHOLS J.R., ANDRES L.A., BEARDSLEY J.W., GOEDEN R.D., JACKSON C.G., Eds). DANR Publ., University of California, Oakland CA.

JONES W.A., JACKSON C.G., 1990.- Mass production of *Anaphes iole* for augmentation against *Lygus hesperus*: effects of food on fecundity and longevity.- *Southwestern Entomology*, 15: 463-467.

LANZONI A., MASETTI A., PLANKENSTEINER D., BURGIO G., 2003.- Role of field margin habitats and annual flowering plant mixture on parasitization of economic Agromyzid pests.- *IOBC/WPRS Bulletin*, 26(4): 95-100

NOMA T., STRICKLER K., 1999.- Factors affecting *Beauveria bassiana* for control of lygus bug (Hemiptera: Miridae) in alfalfa seed field.- *Journal of Agricultural and Urban Entomology*, 16: 215-233.

NORTON A. P., WELTER S. C., 1996.- Augmentation of the egg parasitoid *Anaphes iole* (Hymenoptera: Mymaridae) for *Lygus hesperus* (Heteroptera: Miridae) management in strawberries.- *Environmental Entomology*, 25: 1406-1414.

NORTON A. P., WELTER S. C., FLEXNER J. L., JACKSON C. G., DEBOULT J. W. PICKEL C., 1992.- Parasitism of *Lygus hesperus* (Miridae) by *Anaphes iole* (Mymaridae) and *Leiophron uniformis* (Braconidae) in California strawberry.- Biological Control 2:131-137.

KOWACH J., 1996.- Using *Beauveria bassiana* to manage tarnished plant bug in strawberries 1995.- *Strawberries IPM Update, IA State University*, 3(2): 7-8.

RÄMERT B., HELLQVIST S., EKBOM B., BANKS J. E., 2001. Assessment of trap crops for *Lygus* spp. in lettuce.- *International Journal of Pest Management*, 47: 273-276.

RUBERSON J. R., WILLIAMS L. H., 2000.- Biological control of *Lygus* spp.: a component of areawide management.- *Southwestern Entomology*, 23: 96-110.

SEVACHERICAN V., STERN V. M., 1974.- Host Plant Preferences of *Lygus* Bugs in Alfalfa-interplanted Cotton Fields.- *Environmental Entomology*, 3: 761-766.

SNODGRASS G. L., ELZEN G. W., 1994.- Efficacy of Naturalis-L for adults and nymphs of the tarnished plant bug in cotton, pp. 1103-1104. In: *Proceedings of Beltwide Cotton Production Res. Conference*, (HERBER D. J., RICHTER D. A. Eds) San Diego, CA, 5-8 January 1994. National Cotton Council, Memphis, TN.

STEINKRAUS D. C., TUGWELL N. P., 1997.- *Beauveria bassiana* (Deuteromycotina: Moniliales) effects on *Lygus lineolaris* (Hemiptera: Miridae).- *Journal of Entomological Science*, 32: 79-90.

STRIDE G. O., 1969.- Investigation into the use of a trap crop to protect cotton from attack by *Lygus vosseleri* (Heteroptera: Miridae).- *Journal of the Entomological Society of Southern Africa*, 32: 469-477.

TAVELLA L., ARZONE A., ALMA A., GALLIANO A., 1996.- IPM application in peach orchards against *Lygus rugulipennis* Poppius.- *IOBC/WPRS Bulletin*, 19(4): 160-164.

TAVELLA L., GUIDONE L., COLOMBERA S., 2002.- Indagine sui parassitoidi degli stadi giovanili di *Lygus rugulipennis* Poppius (Heteroptera Miridae) in differenti agroecosistemi, pp. 517-521. In: *Atti XIX Congresso Nazionale Italiano di Entomologia*, (BARBAGALLO S., LONGO S., NANNELLI R., RAPISARDA C., RUSSO A., SISCARO G., Eds), June 10-15, 2002, Catania, Italy.

UDAYAGIRI S., WELTER S. C., 2000.- Escape of *Lygus hesperus* (Heteroptera: Miridae) eggs from parasitism by *Anaphes iole* (Hymenoptera: Mymaridae) in strawberries plant structure effects.- *Biological Control*, 17: 234-242.

UDAYAGIRI S. WELTER S. C., NORTON A. P., 2000.- Biological control of *Lygus hesperus* with inundative releases of *Anaphes iole* in a high cash value crop.- *Southwestern Entomology*, 23, 27-38.

VAN DER LINDEN A.,.1993.- Biological control of leafminers in glass house lettuce, pp. 157-162. In: *Conference on leafmining flies in cultivated plants*, Montpellier, France, 24-26 March 1993.

VAPPULA N. A., 1962.- Pest of cultivated plants in Finland.- *Annales Agriculturae Fenniae*, 1: 12-39.

VARIS A., 1972.- The biology of *Lygus rugulipennis* Popp. (Het., Miridae) and the damage caused by this species to sugar beet.- *Annales Agriculturae Fenniae*, 11: 1-56.

Corresponding author: Gianumberto ACCINELLI (e-mail: gaccinelli@entom.agrsci.unibo.it), DiSTA - Entomologia, *Alma Mater Studiorum* Università di Bologna, viale G. Fanin, 42, 40127 Bologna, Italy.

Received September 20, 2004. Accepted January 28, 2005.