Insect Distribution in a Spring Pea-Winter Wheat-Spring Barley Crop Rotation System[1]

S. S. Quisenberry,[2] D. J. Schotzko, P. F. Lamb[3] and F. L. Young[4]

Department of Plant, Soil and Entomological Sciences, University of Idaho, Moscow, ID 83843-2339 USA

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Abstract The effects of tillage method (conventional or conservative) and weed management level (recommended or minimum) on insect distribution in a wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), and pea (*Pisum sativum* L.) rotation were studied. Aphids were the major insect species on winter wheat and spring barley, but were not of economic importance. Beneficial species impacted aphid population levels by maintaining their numbers below economic thresholds. Tillage method and weed management level had limited impact on aphid and beneficial insect populations. Pea leaf weevil (*Sitonia lineatus* [L.]) and pea weevil (*Bruchus pisorum* [L.]) populations reached economic injury levels in 1992; two insecticide applications were needed. Pea leaf weevil populations did not reach economic levels in 1993; however, pea weevil populations reached an economic level at flowering stage and an insecticide was applied. Pea leaf weevil populations were higher in conventional tillage plots compared with conservation tillage plots. Early-season insecticide applications suppressed beneficial insects in the pea plots.

Key Words *Sitobion avenae, Schizaphis graminum, Diuraphis noxia, Rhopalosiphum padi, Metopolophium dirhodum, Sitonia lineatus, Bruchus pisorum,* crop rotation, beneficial insects, tillage systems

Conservation tillage is recognized as a means to reduce soil compaction, erosion, and evaporative water loss, all of which increase crop vigor and yields (Engle and McCellan 1984, Sprague and Triplett 1986). The effects of tillage, and to a lesser extent weed management, on the development of pest populations have been investigated for soil- and foliage-dwelling insects (All and Muscik 1978, Stinner and House 1990, Borden 1991). Two major components in cropping systems with different tillage practices can affect insect population development. Increased soil moisture associated with conservation tillage is expected to facilitate plant growth rates and plant vitality while increased surface residue may affect insect populations by limiting insect movement, and altering reproduction and feeding habits.

Aphids (e.g., English grain aphid, *Sitobion avenae* [F.]; Russian wheat aphid, *Diuraphis noxia* [Kurdjumov]; bird cherry-oat aphid, *Rhopalosiphum padi* [L.]; rose grass aphid, *Metopolphium dirhodum* [Walker]); and greenbug, *Shizaphis graminum* [Rodani] are the primary pests of winter and spring cereals (Elberson and Johnson

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[2]College of Agriculture, PO Box 172860, Montana State University, Bozeman, MT 59717-2860.

[3]Southern Agricultural Research Center, Montana State University, 748 Railroad HWY, Huntley, MT 58037-9020.

[4]USDA-ARS, Nonirrigated Agriculture Weed Science Research Unit, Pullman, WA 99164-6421.

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1995), while pea leaf weevil, *Sitonia lineatus* (L.), and pea weevil, *Bruchus pisorum* (L.), are major pests of pea, *Pisum sativum* L., (Schotzko and O'Keeffe 1988, O'Keeffe et al. 1992, Williams et al. 1995) in the Pacific Northwest region. Borden (1991) studied soil- and foliage-dwelling arthropods in small grain (e.g., wheat and barley) and legume (e.g., pea) crops grown under conservation or conventional tillage with varying weed management levels. However, seasonal distribution of key pests in this crop rotation system was not determined. The objective of this research was to determine the effects of tillage method and weed management level on seasonal distribution of selected pests in a wheat (*Triticum aestivum* L.), barley (*Hordeum vulgare* L.), and pea rotation.

Materials and Methods

The experiment was designed as a randomized complete block in a split-plot arrangement with four replications. Each replication contained 12 main plots, which were a combination of two 3-yr crop systems and two tillage systems. Subplots were weed management levels. Insect populations were sampled weekly during the 1992 (April through July) and 1993 (May through August) growing seasons. There were three sampling methods used to determine insect densities. Each method was selected based on sampling effectiveness within a crop, and the insect diversity present. Aphids and associated beneficial insects and pea weevil adult were sampled with sweep nets (Schotzko and O'Keeffe 1989). Five, 180 degree two-sweep samples were taken per sampling date. Pea leaf weevil populations were estimated with 0.3 linear m of row absolute sample per plot (L. E. O'Keeffe, pers. comm.). Samples were dry-sieved in the field to separate plant and insect material from the soil. The field-sieved sample was placed in a paper bag and transported back to the laboratory. Samples were held at 5°C for 2 to 5 until they could be floated to separate insects and plant material from the remaining soil. Pea leaf weevil-damaged pea plants were recorded because this injury is very distinctive from other insect feeding damage (Fisher and O'Keeffe 1979). Pea weevil egg samples consisted of 10 randomly selected pods per plot with the eggs per pod recorded.

Plots were located on a 32-ha site approximately 4.8 km northwest of Pullman, WA. Crops were grown in a 3-yr rotation of winter wheat-spring barley-spring pea in conventional and conservation tillage systems with varying weed management levels. Conventional tillage plots were moldboard-plowed cutting a 15.2 to 20.3 cm furrow slice; whereas, conservation tillage plots were chiseled with 7.6 cm wide twisted teeth set at 20.5 cm intervals at a depth of 19.1 cm. Weed levels were managed by application of herbicides at recommended (1×) and minimum (0.5×) levels (Young et al. 1994). Wheat, barley and pea were grown according to standard agronomic practices (Boerboom et al. 1993, Young et al. 1994). Asana XL® (Du Pont, Wilmington, DE) insecticide (0.06 kg AI per ha) was applied to peas to control pea leaf weevil in 1992 and pea weevil in 1993.

Data were subjected to SAS PROC Univar, PROC GLM, and PROC CORR (SAS Institute 1985). Means were separated using Ryan's Q test (SAS Institute 1985, Day and Quinn 1989).

Results and Discussion

Wheat. Insect populations in winter wheat were low throughout most of the growing season until the beginning of crop senescence in early June 1992 and 1993 (Fig.

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1). Aphids were the major insect species observed in wheat during both growing seasons (Fig. 1A, 1B). English grain aphid, greenbug, and rose grass aphid were most abundant in 1992 (Fig. 1A); whereas, the English grain aphid was the most abundant species from 5 June through 13 July 1993 (Fig. 1B). The Russian wheat and bird cherry-oat aphid populations were the least abundant aphid species both years. Beneficial parasitic wasp and predator populations increased as aphid populations increased (Fig. 1C, 1D). Nabids and lady beetles were the most abundant predators in 1992 (Fig. 1C); whereas, in 1993, parasitoids and lady beetles were the most abundant beneficials (Fig. 1D). These beneficial populations probably helped to maintain or even suppress aphid populations below economic thresholds of in 1992 and 1993.

Tillage methods had limited impact on aphid and beneficial populations in wheat. However, on 18 June 1992, tillage method significantly influenced bird cherry-oat aphid (conventional = 5.69, conservation = 2.23, P = 0.03), rose grass aphid (conventional = 3.604, conservation = 1.625, P = 0.03), and total beneficials (conventional = 3.19, conservation = 2.35, P = 0.05). Tillage method was significant for nabids on 24 June 1993 (conventional = 4.31, conservation = 3.33, P = 0.0001) and total number of beneficials on 8 July (conventional = 1.604, conservation = 0.604, P = 0.04). On 13 July 1993, tillage method significantly affected total aphids (conventional = 6.25, conservation = 10.25, P = 0.002) and total beneficials (conventional = 1.85, conservation = 3.02, P = 0.003).

Weed management levels in wheat did not affect total aphid or beneficial popu-

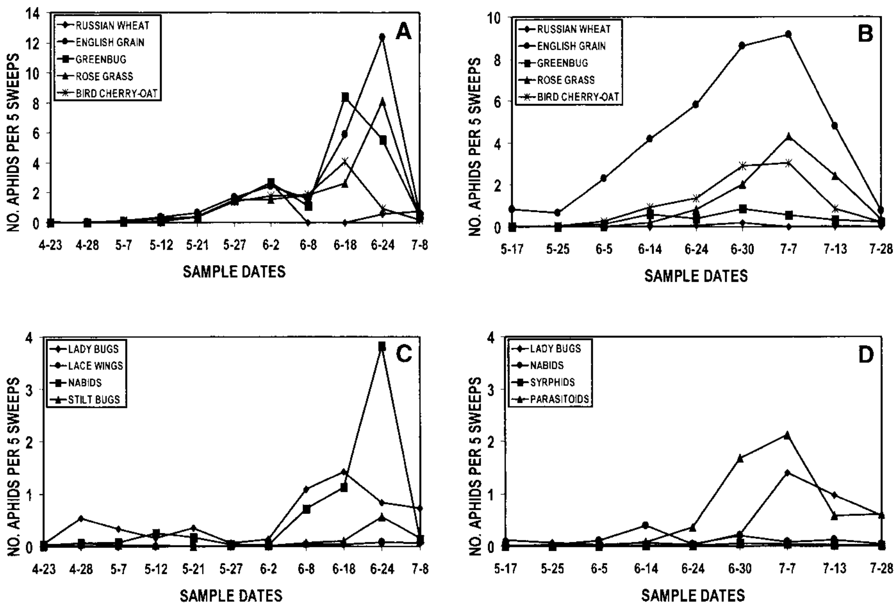

Fig. 1. Insects associated with winter wheat. Seasonal distribution of aphid species, (A) 1992 and (B) 1993. Seasonal distribution of predators and parasitoids, (C) 1992 and (D) 1993.

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lations in 1992. Weed management level significantly affected total aphids on 7 July 1993 (0.5x = 14.81, 1.0x = 19.46, $P = 0.01$), but did not affect total beneficials on any date.

Barley. Aphids were the major insect species associated with barley throughout both growing seasons (Figs. 2A, 2B). As on wheat, the beneficial populations on barley were higher than aphid populations at the beginning of the season in 1992 (Fig. 2C). Parasitic wasp populations began to increase 1 w after aphid populations increased and declined as aphid populations declined in 1993 (Fig. 2D). Insecticide treatment for aphid management was not needed on spring barley in 1992 or 1993.

On 25 June 1992, both tillage method and weed management level affected densities of greenbugs in barley (tillage method: conventional = 1.00, conservation = 0.38, $P = 0.15$; weed management level: 0.5x = 0.83, 1.0x = 0.54, P 0.04). Tillage method influenced rose grass aphid (conventional = 0.27, conservation = 0.4, $P = 0.02$) and total aphids (conventional = 1.46, conservation = 0.67, $P = 0.03$) on 9 July. On 2 August 1993, tillage method significantly affected total aphids (conventional = 20.28, conservation = 30.80, $P = 0.0002$) and total beneficials on 9 August (conventional = 3.60, conservation = 6.46, $P = 0.01$).

Weed management level in barley had no effect on total aphid or beneficial populations in 1992. Weed management level significantly affected total aphids on 2 August 1993 (0.5x = 21.69, 1.0x = 29.33, $P = 0.01$), but did not affect total beneficials on any data.

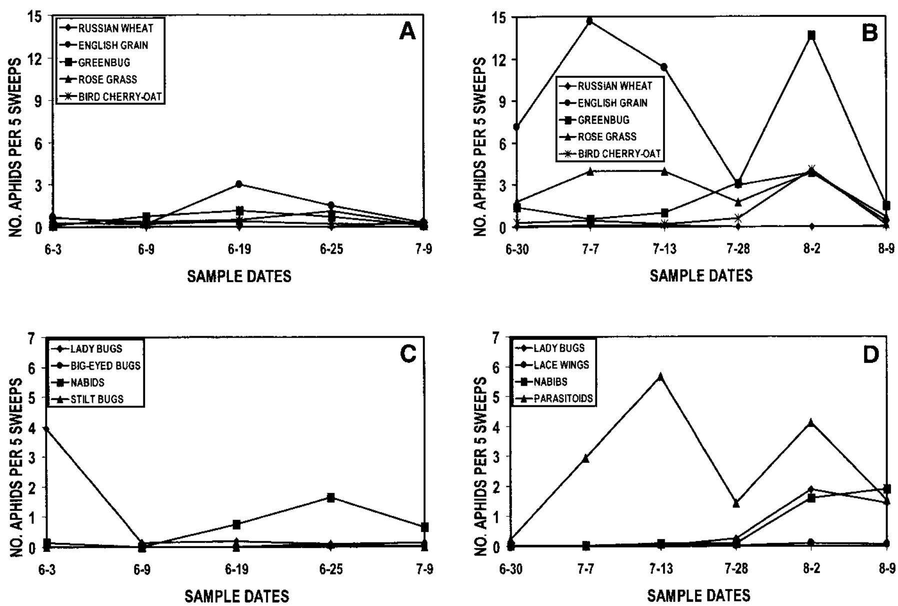

Fig. 2. Insects associated with barley. Seasonal distribution of aphid species, (A) 1992 and (B) 1993. Seasonal distribution of predators and parasitoids, (C) 1992 and (D) 1993.

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Peas. Pea leaf weevil populations reached the economic injury level (i.e., three or more adult pea leaf weevil adults per sweep) in 1992, and plots were treated with insecticide. Thus, there were no significant differences in number of weevils or damaged plants influenced by tillage method because pea leaf populations were eliminated with the insecticide application (Fig. 3A). Weevil numbers were affected by tillage method in 1993 (Fig. 3B; conventional = 3.13, conservation = 2.53, $P = 0.02$). Schotzko and Quisenberry (1999) reported that smoother soil surfaces and reduced plant residues in conventional tillage plots facilitated population aggregation development by allowing increased weevil movement. Weevil damage levels were not affected by tillage method. Pea leaf weevils were not affected by weed management level either year (Figs. 3C, 3D).

Pea weevil also reached economic injury levels and pea plots were treated with a second application of insecticide in 1992. Numbers of pea weevil eggs per pod prior to insecticide treatment were significantly influenced by tillage method (Fig. 4A; conventional = 8.48, conservation = 10.41, $P = 0.03$). Weed management level did not affect the number of pea weevil eggs per pod (Fig. 4B). In 1993, pea weevil reached economic injury levels at the flowering stage and plots again had to be treated with insecticide. Therefore, counts of pea weevil eggs in pods could not be measured because insecticide treatment caused adult mortality before oviposition occurred. Beneficial species were not abundant in spring peas either year.

Borden (1991) reported foliage-dwelling arthropod abundance and community di-

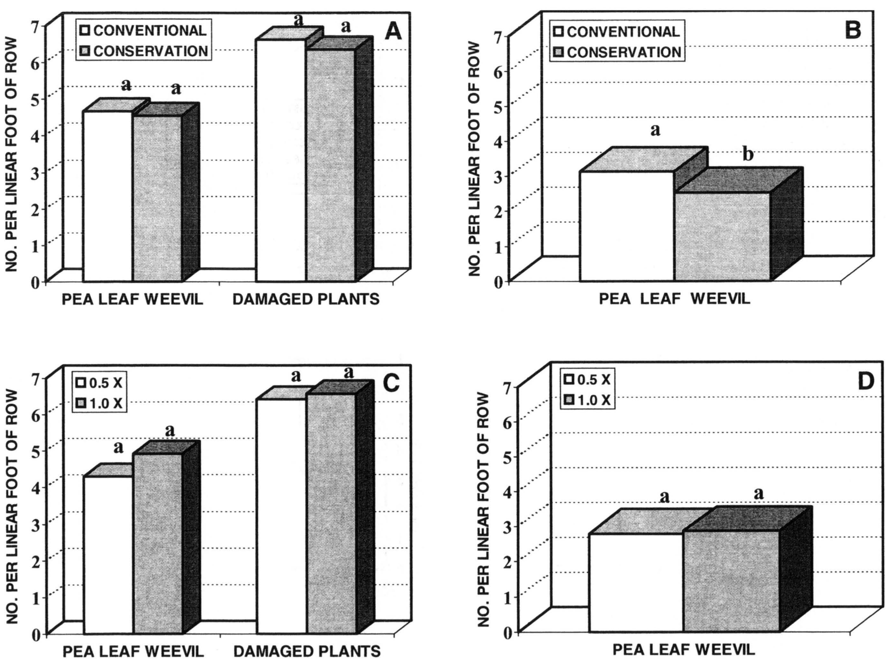

Fig. 3. Number of pea leaf weevil by tillage method, (A) 1992 and (B) 1993, and weed management level, (C) 1992 and (D) 1993.

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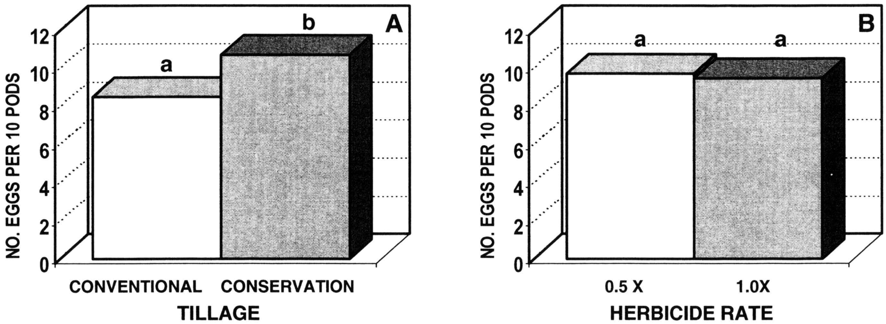

Fig. 4. Number of pea leaf weevil eggs per pod in 1992 by tillage method (A) and weed management level (B).

versity were higher in a wheat conservation tillage system, while the barley and peas supported similar communities in both tillage systems. Even though tillage method and weed management level significantly influenced aphid and beneficial populations on a few sampling dates during our study, overall, their impact on insect populations was limited in wheat and barley. A relationship between weed management and species diversity was only observed in peas. Pea leaf weevil and pea weevil populations reached economic levels in our study, and populations were influenced by tillage system. Our research shows that conservation practices, including reduced tillage and minimal weed management, does not increase insect pest crop damage in winter wheat, barley and pea.

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