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Louis S. Hesler
Northern Grain Insects Research Laboratory

Robert W. Kieckhefer
Northern Grain Insects Research Laboratory

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WHEAT STEM MAGGOT IN SPRING WHEAT-ALFALFA INTERCROPS WITH DIFFERENT CROP MANAGEMENT INTENSITIES

Louis S. Hesler[1] and Robert W. Kieckhefer[1]

ABSTRACT

Larval infestations and adult counts of wheat stem maggot (*Meormyza americana*) were each compared among plots of intercropped spring wheat and alfalfa grown under high, intermediate, or low crop management intensity (CMI). CMI varied primarily in the amounts of nitrogen fertilizer, herbicide, and tillage used. Infestation of wheat plants was measured from 1990 through 1993 as the percentage of white grain heads caused by larval feeding within the stems. Adult counts were made from sweep net samples within plots 3 to 5 times per year from 1991 through 1993. Larval infestation varied among years but not by CMI. The mean percentages of white heads in 1991 (2.0%) was greater than in other years (each ≤ 1.3%). Counts of adult *M. americana* differed among sampling dates within years but not by CMI. The number of adults collected was bimodal, peaking on the first and last sampling dates each year. The interpretation of our results is discussed in the context of cropping systems research.

Wheat stem maggot (*Meromyza americana* Fitch) is an insect pest that occasionally causes economic damage to spring wheat (*Triticum aestivum* L.) in South Dakota (Gilbertson 1925, Kieckhefer and Morrill 1970). Adult *M. americana* first appear in spring wheat fields in South Dakota from late May to early June and deposit eggs on leaves near the stems of wheat plants (Gilbertson 1925, Kieckhefer 1974). Larvae feed and tunnel within the stems, resulting in sterile white heads among infested stems (Morrill 1995). Adults emerge from stems in July, and second and partial third generations follow (Gilbertson 1925).

M. americana is polyphagous, and the larvae may feed on many grassy weed species in addition to small grain plants such as wheat, barley, and rye (Gilbertson 1925, Morrill 1995). Thus, suppression of grassy weeds through tillage and herbicides can aid in management of *M. americana* (Gilbertson 1925, Morrill 1995). Crop rotation also limits damage from *M. americana* in small grain fields (Gilbertson 1925, Morrill 1995).

Spring wheat, an annual row crop, is sometimes intercropped with alfalfa (*Medicago sativa*), a perennial forage crop, in eastern South Dakota and surrounding areas. Wheat produces a harvestable crop within one season. Alfalfa establishes during the first year and is maintained for an additional one to three years. Spring wheat and alfalfa are often part of a larger crop rotation system that includes corn and soybeans in eastern South Dakota.

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[1]Northern Grain Insects Research Laboratory, USDA-ARS, 2923 Medary Ave., Brookings, SD 57006-9410.

Spring wheat-alfalfa intercrops may be produced in cropping systems that vary in the kinds and intensity of crop management practices. Such practices may include nitrogen (N) fertilizer application(s) to increase grain yield of wheat; early season, post-emergent herbicide applications (particularly for broadleaf weeds); and tillage for seedbed preparation and additional weed control. Individual crop management practices can vary in intensity by the amount, frequency, or degree to which they are used within a particular cropping system.

Some crop management practices used for improving fertility or weed control may have inadvertent effects on populations of insect pests such as *M. americana*. For instance, the use of N fertilizer generally increases the growth rate and fecundity of phytophagous insects (van Emden 1966, McNeill and Southwood 1978, Mattson 1980). Weed control may also affect insect population levels by eliminating alternate host plants for larvae and sources of pollen and nectar for adults.

Studies have not been performed in the north central US in regard to the effects of varying crop management intensity on levels of *M. americana* in intercropped spring wheat and alfalfa. Moreover, information about *M. americana* infestations in South Dakota was obtained more than 25 years ago primarily in wheat monocultures (Gilbertson 1925, Kieckhefer and Morrill 1970, Kieckhefer 1974). Our goals were to determine the incidence of *M. americana* in eastern South Dakota among rotated spring wheat-alfalfa plots and to compare the incidence under high, intermediate, and low crop management intensities.

MATERIALS AND METHODS

Research was conducted at the Eastern South Dakota Soil and Water Research Farm (ESDSWRF) near Brookings, South Dakota, from 1990 through 1993. Our research was part of a series of studies at this site designed to measure insect, crop and soil fertility responses to various crop management treatments (Ellsbury et al. 1998, Riedell et al. 1998, Hesler et al. 2000). Our studies were conducted within 30.5 by 30.5-m plots that were part of a four-crop rotation with variable crop management intensities established in 1990. The rotation included annual crops of corn, soybeans, and a spring wheat-alfalfa interplanting, with the alfalfa crop continuing an additional year. Plots were farmed under one of three levels of crop management intensity (i.e., high, intermediate and low CMI). Plots were arranged in a randomized block design, and each crop-CMI level combination was replicated three times per year. Each block represented a replication.

Details about crops and CMI treatments are given in Table 1 and in Hesler et al. (2000). Briefly, high CMI plots received rates of N fertilizer designed to achieve relatively high yield goals (e.g., 3.0 Mg/ha wheat), broadcast applications of herbicides, fall moldboard plowing and spring disking, and spring field cultivation of corn fields. Intermediate CMI plots received one-half the amount of N fertilizer applied to high CMI plots, and labeled rates of herbicides broadcast prophylactically in spring wheat-alfalfa plots and banded along rows of preceding crops of corn and soybean as needed based on weed seed counts in soil cores. Intermediate CMI plots received fall moldboard plowing in years preceding corn and wheat and fall chisel plowing in other years. In the spring, these plots were disked and cultivated. All agrichemicals in high and intermediate CMI wheat-alfalfa plots were applied before 1 June of each year. Low intensity plots received no fertilizer or herbicide.

Table 1. Planting dates, wheat varieties, seeding rates, and fertilizer and herbicide use in intercropped spring wheat-alfalfa plots under high, intermediate and low crop management intensities (CMI), Brookings, SD.

Year	Planting date	Spring wheat variety[1], kg/ha	Fertilizer[2]: kg/ha	Herbicide[3]: liters (AI)/ha
1990	26 April	'Guard,' 104	High: 101 Intermediate: 50 Low: 0	High: 1.2 Intermediate: 0.6 Low: 0
1991	4 April	'Guard,' 104	High: 117 Intermediate: 58 Low: 0	High:1.2 Intermediate: 0.6 Low: 0
1992	7 April	'Guard,' 104	High: 90 Intermediate: 45 Low: 0	High: 1.2 Intermediate: 0.6 Low: 0
1993	20 April	'Butte,' 118	High: 90 Intermediate: 45 Low: 0	High: 1.2 Intermediate: 0.6 Low: 0

[1] Interseeded with 'Coyote 990' alfalfa planted at a rate of 12 kg/ha.
[2] Applied as urea form of nitrogen (46-0-0, N-P-K), kg/ha.
[3] MCPA = 2-methyl-4-chlorophenoxyacetic acid. Applied post-emergent during first year of intercrop plots.

Tillage in these plots consisted of fall chisel plowing and spring disking and field cultivation.

Spring wheat was sampled for adult *M. americana* and symptoms of larval infestation using methods similar to those of Kieckhefer and Morrill (1970). Larval infestation was determined by counting the number of white heads within each of 50 0.09 m^2-quadrats per plot. Mean head density was estimated by counting all grain heads within an additional 10 quadrat samples. The percentage of *M. americana* infestation per plot was expressed as the ratio of the mean number of white heads per quadrat to the mean number of grain heads per quadrat. Grain heads were sampled during the milk to soft dough stages (Zadoks scale 75–85 [Zadoks et al. 1974]). Percentages of *M. americana* infestation per plot were transformed (arcsine $\sqrt{x}$) to achieve uniform variance (Ott 1984). Data were subjected to a two-way analysis of variance using CMI and year as factors (PROC ANOVA; SAS Institute 1988). Means were separated using the Student-Nueman-Kuels method (Ott 1984).

Adult *M. americana* were sampled in the spring wheat-alfalfa plots 3 times in June 1991 and 5 times in June and July in both 1992 and 1993 (see Table 2 of Hesler et al. 2000). Samples consisted of 60 pendular sweeps with a 38-cm diam. sweep net along two transects in each plot (30 sweeps per transect). Flies collected along each transect were treated with chloroform in the net, transferred to containers, and identified in the laboratory. The numbers of adult *M. americana* collected per sample within individual treatment plots were analyzed using a repeated measures analysis (PROC MIXED, Littell et al. 1996), with CMI and sampling date as non-random independent variables. A spatial covariance model was used in the analyses for unequally spaced sampling dates. A separate analysis was performed on each year's data, as the number and timing of sampling dates differed among years. Treatment means were separated by using the LSMEANS option (Littell et al. 1996).

Table 2. F values from repeated measures analysis of the number of adult *Meromyza americana* in spring wheat-alfalfa intercrop plots, Brookings, SD.

Source of variation			
Year	SD (df)	CMI (df)	SD x CMI (df)
1991	11.08* (2, 12)	1.56 (2, 4)	1.22 (4, 12)
1992	3.64* (4, 24)	0.43 (2, 4)	0.95 (8, 24)
1993	14.94* (4, 24)	0.40 (2, 4)	1.63 (8, 24)

Asterisks indicate statistical significance ($P < 0.05$).

RESULTS AND DISCUSSION

Larval infestations. The percentage of white heads caused by *M. americana* varied by year (F = 8.03; df = 3, 24; $P < 0.01$), but neither CMI (F = 0.92; df = 2, 24) nor the year-by-CMI interaction (F = 0.83; df = 6, 24) were significant ($P > 0.05$). *M. americana* infestation was greater in 1991 than in other years (Fig. 1). Although we did not directly compare larval infestations in our intercropped spring wheat and alfalfa with those in wheat monocultures, the damage from *M. americana* in our plots was comparable to that reported previously for monoculture wheat fields of eastern South Dakota, where 1 to 3% of wheat heads are typically infested (Gilbertson 1925, Kieckhefer and Morrill 1970). The small but significantly greater infestation in 1991 may have been due to natural variation in annual population cycles of *M. americana*, as plots were treated similarly each year. Kieckhefer and Morrill (1970) have suggested that the degree of synchrony between early growth stages of wheat plants and the life cycle of *M. americana* may influence the levels of larval infestation each year.

Adult *M. americana*. The numbers of adult *M. americana* collected each year varied by sampling date, but, as with larval infestations, neither CMI nor the year-by-CMI interaction were significant (Table 2). Collections of adult *M. americana* were bimodal, with peaks on the first and last sampling dates each year (Fig. 2). This pattern was expected, and it is consistent with the early June and mid-July peaks of these flies previously reported within wheat fields in eastern South Dakota (Gilbertson 1925, Kieckhefer and Morrill 1970). However, the high peaks late in the season contrast with the collection pattern seen by Kieckhefer (1974), in which July peaks were relatively small compared with those earlier in the season. It is unclear why our collection pattern differed from his, but the smaller late-season peaks in his study may have been due to poorer survival of *M. americana* to adulthood or delayed emergence beyond Aug. 1 (his last sampling date).

In summary, our study showed that neither larval infestations nor numbers of adult *M. americana* differed due to CMI. Other studies at the ESDSWRF have shown some effects of CMI on insects (Ellsbury et al. 1997, Hesler et al., 2000) and crop performance (Riedell et al. 1998). In regard to insects, Ellsbury et al. (1998) found greater abundance of a ground beetle, *Harpalus pensylvanicus* (DeGeer), and a greater Hierarchical-Richness Index (a product of ground beetle species rank and relative abundance) in low CMI plots across all crops in the rotation. Hesler et al. (2000) found greater abundance of ladybird beetles in high CMI spring wheat-alfalfa plots in one of four years, but mixed results for one ladybird species, *Hippodamia tredecimpunctata tibialis* (Say). However, Hesler et al. (2000) found no effect of CMI on infestation of spring wheat by cereal aphids.

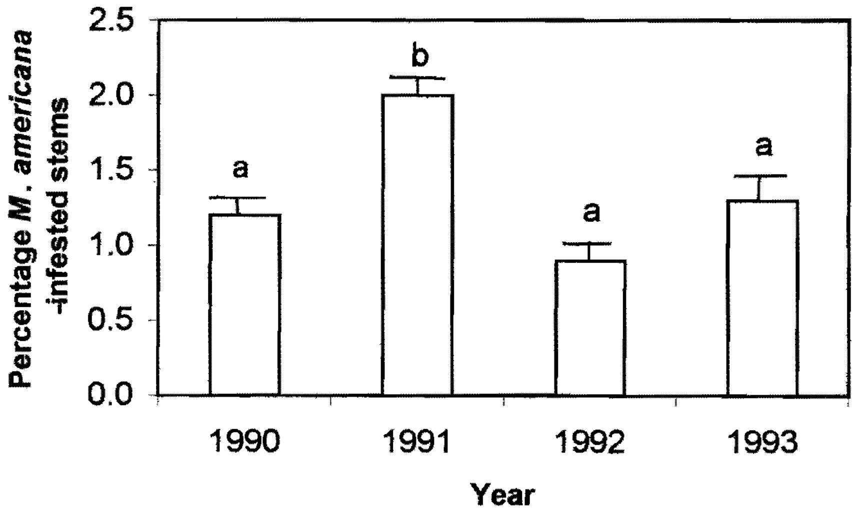

Figure 1. Percentage (mean ± SE) of spring wheat plants with white heads caused by *Meromyza americana* infestation (n = 9). Means with the same letter are not significantly different.

As Riedell et al. (1998) noted, CMI treatments in experiments at the ESDSWRF were used to investigate effects at the crop management systems level. Each CMI treatment was a combination of different levels of tillage and N fertilizer and herbicide use, and the particular combinations used in our study did not lead to differences in *M. americana* infestation. N fertilization, grassy weed control through tillage and herbicide use, and crop rotation may all influence infestation levels of *M. americana*, but the relative importance of each is unknown. N fertilization generally increases infestation levels of phytophagous pests (van Emden 1966, McNeill and Southwood 1978, Mattson 1980), whereas the control of grassy weeds within and around wheat fields limits infestation by *M. americana* in wheat (Gilbertson 1925). Practices (e.g., N fertilization) that could promote greater infestations by *M. americana* may offset those that limit them (e.g., grassy weed control). Also, crop rotation, common to all treatments in our study, may be an overriding factor in limiting infestation by *M. americana* (Gilbertson 1925). Thus, crop rotation, which suppresses populations of *M. americana*, may possibly have masked any effects of CMI in our study. Our inability to clearly define the relative contribution of individual factors within CMI levels demonstrates a limitation to interpreting research at the crop management systems level. Future studies that partition and compare the effects of individual crop management factors may be useful for determining the relative importance of each in limiting infestation by *M. americana*. These reductionist approaches to research on insect pests can be complementary to cropping systems approaches. Together, they may lead to a better overall understanding of the factors involved in infestations of spring wheat by *M. americana*.

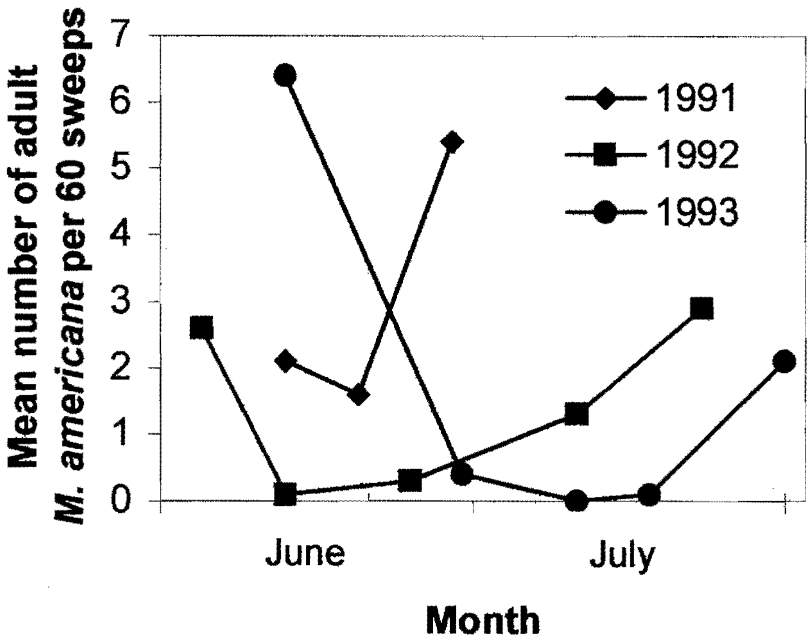

Figure 2. Mean number of adult *Meromyza americana* collected from spring wheat-alfalfa intercrop plots (n = 9 samples per date, 60 sweeps per sample) at the Eastern South Dakota Soil and Water Research Farm, Brookings, 1991–1993. Error bars omitted for clarity.

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