INTEGRATED MANAGEMENT OF THE POTATO LEAFHOPPER IN ALFALFA

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Introduction

A fully developed integrated pest management (IPM) system uses all available strategies for a given pest or pest complex in a cropping system; incorporating host plant resistance, biological, cultural and physical controls and chemical control when necessary (Pedigo, 1999). Several such management strategies have been developed in alfalfa for the potato leafhopper (*Empoasca fabae*) (PLH). The first glandular haired varieties of alfalfa, bred for resistance to PLH were released for market in 1997. Field studies of these varieties have been met with varying levels of success. Lefko et al. (2000) observed that established resistant alfalfa stands could tolerate up to 2.5 greater the PLH pressure as a susceptible stand. However, when leafhopper pressure is low, resistant alfalfa has expressed some amount of yield drag (Hogg et al. 1998, Hansen et al. 2002). The presence of grasses in alfalfa fields has also been correlated to a reduction in PLH abundance. Degooyer et al. (1999) showed that both orchardgrass and bromegrass intercropped in alfalfa stands significantly reduced the number of PLH present, but noted it was not enough to keep populations below economic thresholds. Grasses are also promoted as an intercrop with alfalfa for the increase in digestible fibers and decrease in non-fiber carbohydrates they provide, which can help reduce incidence of ruminal acidosis (Lee, 2011).

The present study examined the effects of host plant resistance and orchardgrass intercrop on PLH population in alfalfa, as well as yield and forage quality response to PLH and the respective cropping systems. Effective IPM strategies aim to reduce the use of insecticides but chemical control is still an integral part of a successful IPM plan to reduce economic loss (Summers, 1998). This work also investigated potential yield response of reducing the current potato leafhopper economic thresholds in light of the growing value of the alfalfa crop.

Methods

Multi-year research experiments were established in two locations: one at Arlington, WI Agricultural Research Station (AARS) and two at the US Dairy Forage and Research Center (DFRC) in Prairie du Sac, WI. The AARS field study was spring seeded and the two field studies established at DFRC included a spring and fall seeding stand establishment. At both AARS and DFRC, experiments were arranged in complete randomized block with a 2 x 2 factorial design (4 total whole plot treatments). Factorial treatments were alfalfa variety (PLH-susceptible and PLH-resistant) and orchard grass intercrop (alfalfa intercropped with grass and direct seeded alfalfa).

Seeded May 17, 2010 at AARS, the whole plots were 85’ x 22’ and divided equally into three split plots, 28’ x 22’. Split plot treatments consisting of an untreated control, an insecticide spray at half the current economic threshold (1/2 ET), and an insecticide spray at the current ET (table 1) were included to create a range in PLH density. Pioneer Hi-Bred International, Inc. (Arlington, WI) provided alfalfa seed including susceptible alfalfa 55V48 and resistant alfalfa 53H93 varieties.

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Profit Orchardgrass was purchased from Welter Seed & Honey Co. (Onslow, IA). Seeding rates followed University of Wisconsin-Extension recommended guidelines (Undersander et al. 2004).

At DFRC, the fall seeding was planted August 16, 2011 and the spring seeding was completed April 12, 2012. Each plot was 60' x 30'. Seed was provided by Forage Genetics, International (Nampa, ID) including susceptible alfalfa WL354HQ and resistant alfalfa WL353LH varieties. Profit Orchardgrass was purchased from Welter Seed & Honey Co. and seeding rates followed University of Wisconsin-Extension recommended guidelines (Undersander et al. 2004).

Potato leafhopper populations were monitored weekly in each experiment using a 15-inch diameter sweep net to collect 20 sweep net samples per split plot at AARS, and 20 sweeps per plot at DFRC. At AARS, the pyrethroid insecticide Warrior II (active ingredient lambda-cyhalothrin) was applied at 1.6 oz/acre when PLH reached 1⁄2 ET and ET, to respective split plot treatments (Table 1).

Table 1. Potato leafhopper insecticide treatment timing at AARS trial (adapted from Cullen et al. 2012).

Alfalfa height	Treatment	PLH/sweep
0-4 inches	½ ET	0.1
0-4 inches	ET	0.2
4-8 inches	½ ET	0.3
4-8 inches	ET	0.5
8-12 inches	½ ET	0.5
8-12 inches	ET	1.0
12+ inches	½ ET	1.0
12+ inches	ET	2.0

Yield data were collected from each plot at each harvest using an Almaco plot harvester. Subsamples were oven dried at 60°C and yields expressed on a dry matter basis. Alfalfa quality (crude protein and neutral detergent fiber) was analyzed by near-infra red reflectance (NIR) methods on dried and ground alfalfa samples. Yield data was not recorded at DFRC.

Results

Potato Leafhopper Response

Host plant resistance suppressed PLH populations at different sampling points over the 5-site years, but most notably at peak leafhopper abundance time points in the seeding years (Figure 1). In general, there were fewer significant differences across sample dates for PLH abundance between varieties in production year stands (Figure 1). The effect of orchardgrass intercropped with alfalfa on potato leafhoppers was minimal. In the seeding years, there was no significant effect of orchard-grass at any sampling point. In production years, the effect of grass varied between locations. At AARS, orchardgrass suppressed PLH at three time points: July 12, 2011 (df=1, 22; F=13.57; p=0.0013), May 22, 2012 (df=1, 18; F=9.62; p=0.0062) and May 30, 2012 (df=1, 18; F=7.03; p=0.00162). Suppression effect ranged from 10-80% between the three sampling dates, but PLH densities were below economic threshold. Orchardgrass in the fall seeding at DFRC had a significant effect on PLH on May 30 (df=1, 10; F=9.28; p=0.0123) and June 6 (df=1, 10; F=7.55;

p=0.0206) at which points PLH were more abundant in plots with grass. Orchardgrass presence and host plant resistance did not have a significant interaction.

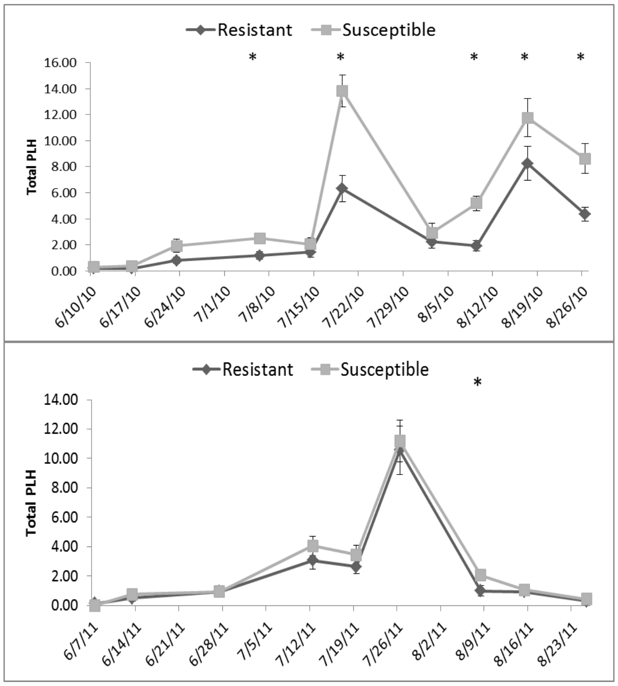


Figure 1. Alfalfa variety effects on potato leafhopper in 2010, seeding year (left) and 2011, 1st production year (right), Arlington , WI. Significant effects are noted with an asterisk at p<0.05.

Yield and Forage Quality Analyses

Yield and forage quality analyses are presented for AARS. Potato leafhopper had a significant negative impact on yield in the second crop of the seeding year (Table 3), which was also the only time that PLH populations reached economic threshold levels across 5 site years of this study. Although insecticide treatment timing did not have a statistically significant effect on yield during the seeding year at the AARS study site, yield trends were marginally higher for plots treated at the established economic threshold than at a reduced (1/2 ET) treatment timing (Table 2).

In third crop of 2011 yield response to PLH varied by alfalfa variety. The yield of susceptible alfalfa increased with increasing PLH pressure while the yield of resistant alfalfa decreased (Table 7), however, PLH pressure was below economic thresholds in both cases. Yield was significantly affected by variety at the first and second cutting of 2011, in which resistant alfalfa expressed a yield drag (Tables 5 and 6). Alfalfa/grass plots had a lower yield in the second cutting of 2010 (Table 3) likely due to later summer grass stand establishment. However, the first cutting of 2011 had significantly higher yield in plots where grass was present (Table 5).

Table 2. Mean yield by insecticide treatment within each cropping system at AARS on July 26, 2010.

Treatment	Yield (tons/acre)[a]
Susceptible alfalfa - no orchardgrass	
No spray	1.36 ± 0.08[a]
Economic Threshold[b]	1.45 ± 0.08[a]
½ Economic Threshold[c]	1.36 ± 0.08[a]
Susceptible alfalfa - with orchardgrass	
No spray	1.29 ± 0.08[a]
Economic Threshold[b]	1.28 ± 0.08[a]
½ Economic Threshold[c]	1.35 ± 0.08[a]
Resistant alfalfa - no orchardgrass	
No spray	1.31 ± 0.08[a]
Economic Threshold[b]	1.60 ± 0.08[a]
½ Economic Threshold[c]	1.50 ± 0.08[a]
Resistant alfalfa - with orchardgrass	
No spray	1.34 ± 0.08[a]
Economic Threshold[b]	1.44 ± 0.08[a]
½ Economic Threshold[c]	1.38 ± 0.08[a]

[a] Means followed by the same letter not significantly different.
[b] Economic threshold treatment sprayed on July 9; alfalfa height 0-4 inches; PLH/sweep=0.2.
[c] ½ Economic threshold treatment sprayed on July 7; alfalfa height 0-4 inches; PLH/sweep=0.1.

Crude protein was significantly affected by PLH on three cuttings. For the two in which the greatest leafhopper pressure was experienced, July 26, 2010 and August 1, 2011, this effect was negative (Tables 3 and 7). The July 5, 2011 crop had greater crude protein with PLH when their presence had been very low (Table 6). Variety had a significant effect on crude protein at each cutting (Tables 3-7). For all but the July 26, 2010, this effect was such that resistant alfalfa had higher protein levels. Plots without grass had higher crude protein than direct seeded alfalfa (Tables 4-6).

Discussion

At the DFRC site, the spring seeded experiment had higher PLH pressure than the fall seeded experiment. Seeding time interacted significantly with alfalfa variety (Figure 2). Spring seeded susceptible alfalfa had the greatest PLH pressure. By contrast, spring seeded resistant alfalfa had lower pressure similar to both the susceptible and resistant alfalfa in the fall seeded experiment. Because the experiment at DFRC was not designed to test the effect of seeding time on PLH (i.e., the seeding time was not randomized within the blocks), results from the statistical analyses should be inferred with caution (Figure 2).

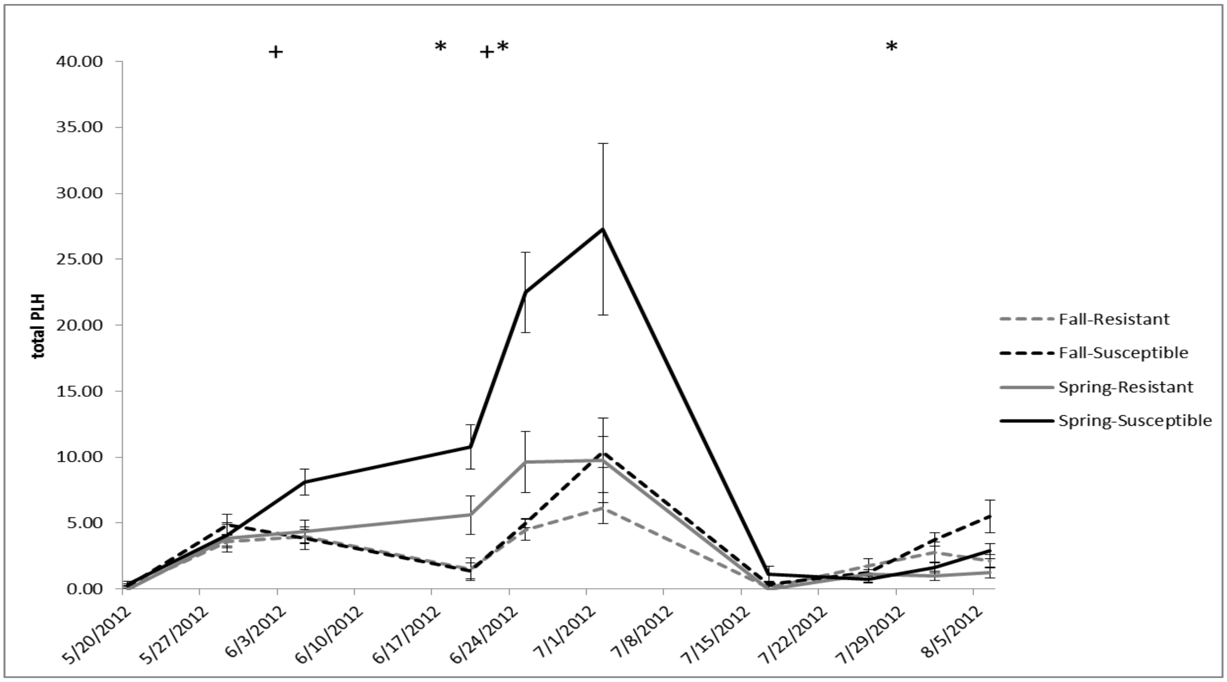
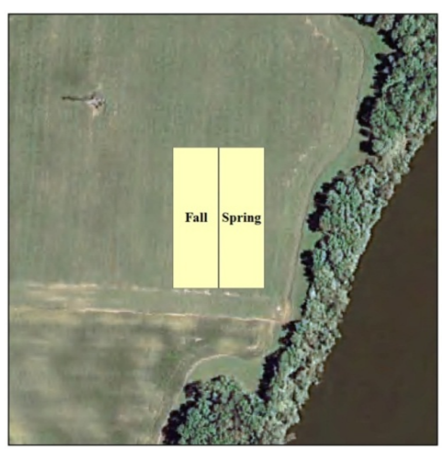


Figure 2. Seeding time and variety effects on potato leafhoppers at DFRC in 2012. Spring seeding was in seeding year and fall seeding was in 1st production year. Significant effects of seeding are noted with an asterisk and significant interactions between seeding and variety are noted with a plus sign.

There are other factors that could have led to this significant seeding time and seeding time x variety interaction effect but they do not seem to explain the observed results. For example, the trials were located adjacent to each other in a field with uniform cropping history and nutrient management history (figure 3). The only unique management between the two trials is that prior to seeding in the spring, the area was sprayed with Roundup herbicide (active ingredient glyphosate). Another possible factor is location within the field. Higher densities of PLH are found along field margins (Flinn et al. 1990a). However, both spring and fall seeded trials were located within a fall seeded field (figure 3) and the border between the field edge and the spring seeded trial had similar PLH pressure to the fall seeded research trial. Lastly, PLH abundance has been studied in relation to weed density. The spring seeding had considerably greater weed density than the fall seeding, but the relationship between weed density and PLH depends on the weed composition. The most prevalent weed by visual estimation was lambsquarters and this plant has been found not to promote PLH growth (Lamp et al. 1984a)

Figure 3. Layout of trials by seeding at DFRC in 2012. The crop surrounding both trials is fall seeded alfalfa.



Previous studies of resistant alfalfa have shown that the resistant trait is not expressed until the after the seeding year (Lefko et al., 2000). However, the present work shows that the resistant alfalfa effectively suppressed PLH during the seeding year. The mechanism responsible for resistance in alfalfa has been studied and discussed at length. Results from other field trials led researchers to conclude that mechanism(s) responsible are likely antibiosis (Hogg et al., 1998) and/or tolerance (Lefko et al., 2000). At our DFRC location, the mechanism may be nonpreference, considering the lower abundance of PLH found in resistant alfalfa compared to susceptible, as seen in Figures 1, left and 2. However, this phenomenon did not correlate with a yield benefit in resistant alfalfa, which may again have been due to the overall low PLH pressure.

Resistant alfalfa did express a yield drag for two of the four cuttings in 2011, which is congruent with previous findings in the absence of PLH or under low PLH pressure (McCaslin, 1998; Hansen et al., 2002). The presence of orchardgrass suppressed PLH on only a couple of sampling dates and two of the three sampling dates were before peak PLH abundance. Previous researches have observed this but in other works the effect of the grass on PLH abundance is more consistent (e.g., Lamp et al., 1984; Roda et al., 1997; Degooyer et al., 1999). It is possible that the low overall PLH populations obscured the grass effect.

It is documented in the literature that PLH feeding reduces crude protein in alfalfa (Flinn et al., 1990b). In the present study, PLH feeding had a negative effect on protein in two of the five harvests analyzed and had a positive effect on one of the harvests. Resistant alfalfa had a slight but statistically greater crude protein content at five of the six harvests analyzed. Hansen et al. (2002) similarly found resistant alfalfa to have higher protein levels while Dellinger et al. (2006) saw no difference in crude protein between a resistant and susceptible variety. Considering the connection between PLH feeding and a reduction in crude protein, the greater content of crude protein in resistant alfalfa may be mediated through the decreased feeding that occurs on resistant alfalfa compared to susceptible alfalfa. The presence of orchardgrass increased NDF which is one of the benefits of including it in dairy rations.

Takeaway Points

- Potato leafhoppers only had an impact on yield when established economic threshold populations were reached.
- Resistant alfalfa significantly suppressed potato leafhopper in the seeding year even when pest pressure was low.
- The effect of orchardgrass intercropped with alfalfa on potato leafhoppers was minimal.

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Table 3: Effects of potato leafhopper, alfalfa variety and grass presence on yield, crude protein and neutral detergent fiber on second crop, 2010 (July 26). Estimates for PLH are slopes for the regression and estimates for alfalfa variety and orchardgrass presence are y-intercepts. Significant effects on in **bold type**.

Independent Variable	Dependant Variable											
	Yield (tons/acre)				Crude Protein (%)				NDF (%)			
	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F
PLH	**-0.05**	**1**	**4.45**	**0.0378**	**-0.26**	**1**	**5.96**	**0.0168**	-0.42	1	2.98	0.0882
Alfalfa variety		1	1.16	0.284		**1**	**5.92**	**0.0172**		1	0.26	0.6141
Resistant	1.45				27.17				33.83			
Susceptible	1.40				27.69				34.08			
Orchardgrass presence		**1**	**4.01**	**0.0484**		1	1.03	0.3139		1	0.78	0.3792
Yes	**1.40**				27.69				34.08			
No	**1.49**				27.49				34.49			
Error		89				81				81		

Table 4: Effects of potato leafhopper, alfalfa variety and grass presence on yield, crude protein and neutral detergent fiber on third crop, 2010 (September 7). Estimates for PLH are slopes for the regression and estimates for alfalfa variety and orchardgrass presence are y-intercepts. Significant effects on in **bold type**.

Independent Variable	Dependant Variable											
	Yield (tons/acre)				Crude Protein (%)				NDF (%)			
	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F
PLH	-0.01	1	1.57	0.2131	0.02	1	0.19	0.6599	-0.13	1	1.23	0.2704
Alfalfa variety		1	0.02	0.902		**1**	**11.42**	**0.0011**		**1**	**7.16**	**0.0089**
Resistant	1.17				**23.96**				**42.03**			
Susceptible	1.17				**23.11**				**43.74**			
Orchardgrass presence		1	0.62	0.4342		**1**	**10.75**	**0.0015**		**1**	**9.9**	**0.0022**
Yes	1.17				**23.11**				**43.74**			
No	1.15				**23.89**				**41.86**			
Error		89				89				89		

Table 5: Effects of potato leafhopper, alfalfa variety and grass presence on yield, crude protein and neutral detergent fiber on first crop, 2011 (June 1). Estimates for PLH are slopes for the regression and estimates for alfalfa variety and orchardgrass presence are y-intercepts. Significant effects on in **bold type**.

	Dependant Variable											
Independent Variable	Yield (tons/acre)				Crude Protein (%)				NDF (%)			
	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F
PLH	0.00	1	0.02	0.8789	-0.14	1	2.83	0.096	**0.36**	**1**	**4.33**	**0.0404**
Alfalfa variety		**1**	**17.29**	**<.0001**		**1**	**4.36**	**0.0397**		1	2.57	0.1128
Resistant	**2.94**				**21.67**				40.83			
Susceptible	**3.12**				**22.16**				40.05			
Orchardgrass presence		**1**	**6.92**	**0.01**		**1**	**160.71**	**<.0001**		**1**	**176.98**	**<.0001**
Yes	**3.12**				**22.16**				**40.05**			
No	**3.02**				**24.84**				**34.14**			
Error		89				89				89		

Table 6: Effects of potato leafhopper, alfalfa variety and grass presence on yield, crude protein and neutral detergent fiber on second crop, 2011 (July 5). Estimates for PLH are slopes for the regression and estimates for alfalfa variety and orchardgrass presence are y-intercepts. Significant effects on in **bold type**.

	Dependant Variable											
Independent Variable	Yield (tons/acre)				Crude Protein (%)				NDF (%)			
	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F
PLH	0.03	1	0.69	0.4083	**0.59**	**1**	**8.91**	**0.0037**	**-1.22**	**1**	**5.73**	**0.0188**
Alfalfa variety		**1**	**28.46**	**<.0001**		**1**	**5.34**	**0.0231**		1	0.02	0.9015
Resistant	**2.08**				**22.14**				40.88			
Susceptible	**2.25**				**21.78**				40.83			
Orchardgrass presence		1	0.8	0.3725		**1**	**11.88**	**0.0009**		**1**	**21.79**	**<.0001**
Yes	2.25				**21.78**				**40.83**			
No	2.28				**22.32**				**38.92**			
Error		89				88				88		

Table 7: Effects of potato leafhopper, alfalfa variety and grass presence on yield, crude protein and neutral detergent fiber on third crop, 2011 (August 1). PLH had a significant interaction with alfalfa variety so individual slopes are given for each variety. Estimates for alfalfa variety and orchardgrass presence are y-intercepts. Significant effects on in **bold type**.

	Dependant Variable											
Independent Variable	Yield (tons/acre)				Crude Protein (%)				NDF (%)			
	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F	Estimate	df	F	Pr>F
PLH		1	0.03	0.8659	**-0.08**	**1**	**4.51**	**0.0364**	0.04	1	0.3	0.588
PLH*Alfalfa variety		**1**	**13.46**	**0.0004**								
*Resistant	**-0.02**											
*Susceptible	**0.02**											
Alfalfa variety		1	0.67	0.4143		**1**	**16.86**	**<.0001**		1	1.05	0.3076
Resistant	1.63				**25.89**				37.68			
Susceptible	1.59				**25.11**				38.11			
Orchardgrass presence		1	2.77	0.0998		1	3.49	0.0651		**1**	**8.74**	**0.004**
Yes	1.59				25.11				**38.11**			
No	1.63				25.47				**36.85**			
Error		87				87				87		