An Update on Potato Leafhopper Resistance in Alfalfa

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Commercial alfalfa breeders have been very successful incorporating multiple pest resistance into high yielding cultivars. Recently released alfalfa varieties often express high levels of resistance to many diseases, insects and nematodes. However, until recently breeders were unsuccessful in incorporating resistance to potato leafhopper (PLH), a key alfalfa insect pest.

History

Several annual *Medicago* species have a high density of glandular hairs (GH). In various laboratory studies these GH types have demonstrated resistance to both alfalfa weevil and PLH. Attempts to cross alfalfa to these annual relatives have been unsuccessful. Three perennial *Medicago* species also have glandular hairs on leaves and stems: *M. prostrata*, *M. glutinosa* and *M. glandulosa.* Purdue University and the USDA/Kansas State University independently developed GH populations from these three wild relatives of alfalfa. These GH germplasms were released to commercial alfalfa breeders in the early 1980s.

Early evaluation of the original GH germplasms was disappointing. They had poor vigor, were generally ill adapted to conditions in the Midwest, and were susceptible to virtually all major alfalfa diseases. In the mid 1980s crosses between the original GH germplasms and elite commercial varieties, followed by selection for GH expression, resulted in GH populations with improved adaptation and vigor. However, PLH resistance in these populations was very low. In the last decade, incremental improvements in GH germplasm have been made by combining selection to increase PLH resistance with backcrossing to elite commercial germplasm to improve agronomic performance.

The first PLH resistant varieties were released in 1997.

Mechanisms of Resistance

Resistance to potato leafhopper in alfalfa is related to the presence of glandular hairs on the plant. Initial observations suggested the primary mechanism for PLH resistance was entrapment of insects on sticky ends of glandular hairs – like gnats on fly paper. However, many glandular-haired plants have no resistance to PLH, indicating that not all hairs are effective in providing resistance. Entrapment does not appear to be an important mechanism for resistance to PLH in alfalfa.

In a 1990 growth chamber experiment, survival of nymphs and adults on glandular-haired plants (selected for PLH resistance in the field) was significantly lower than on plants from conventional varieties (Hogg and McCaslin, 1992). This was the first of several experiments demonstrating antibiosis. A separate study concluded that antibiosis is likely due to a chemical in the exudate from the glandular hairs (Elden and McCaslin, 1994). In these studies, survival of nymphs was particularly low, suggesting that immature leafhoppers are particularly susceptible to the compound(s) involved in the antibiosis response. This is also supported by results from several field studies, which have shown significantly decreased nymph populations on PLH resistant, glandular-haired varieties compared with susceptible commercial check cultivars.

Dr. Bill Lamp, at the University of Maryland, found evidence of non-preference in oviposition of PLH females on PLH resistant, glandular-haired alfalfa. His study showed that PLH females avoided laying eggs on glandular-haired stems when an alternative was available (Lamp and McCaslin, unpublished).

Lefko,et.al., 1998 compared PLH resistant and susceptible varieties and showed that PLH resistant, glandular-haired varieties had a higher economic threshold for insecticide treatment. The PLH population required to cause economic damage on field plots was twice as high on resistant compared to susceptible varieties. This was the first evidence for tolerance as a mechanism of resistance to PLH in alfalfa.

The research described above shows the complex nature of PLH resistance in alfalfa. Antibiosis, non-preference and tolerance all appear to be components of the resistance mechanism. This also helps explain the complex genetic control of resistance and the challenges facing alfalfa breeders in selecting for improved PLH resistance.

Results from forage yield trials

Results from field tests conducted thus far (public and private) can be generally summarized as follows:

1. PLH resistant varieties show a yield advantage over conventional varieties when PLH populations are above economic threshold. The magnitude of the advantage is directly related to the level of PLH damage in the test.

   Forage Genetics established forage yield trials in five locations in 1996 containing both PLH resistant ("R") and susceptible ("S") entries. These trials were not treated with insecticides in 1997, a year in which PLH populations were very high over a broad geographic area. First generation PLH resistant varieties yielded from 126% of susceptible checks at Ames, Iowa (high PLH pressure) to 96% of susceptible checks at St. Cloud, MN (no PLH pressure).

2. In the absence of PLH damage, PLH resistant varieties are generally no better than conventional checks, and in some cases, may yield a little less. PLH resistant varieties vary in yield potential per se.

3. When PLH populations are high, current PLH resistant varieties provide substantial but incomplete protection against the insect. Current "PLH resistant" varieties have resistance levels from 20% to 70%. The level of protection is directly related to the level of resistance in the variety.

   An experiment seeded in 1997 in Ohio and Wisconsin (Ohio State University and Forage Genetics) was harvested in 1997 and 1998 to examine performance of varieties with varying levels of resistance to PLH in a sprayed/unsprayed comparison. During the experiment PLH damage was moderate/low in Wisconsin and high in Ohio. The results (mean of two locations) for four varieties, each representing a PLH resistance group, are summarized in the table below.

Table 1.

Variety Type (PLH resistant)	% Resistant	97-98 Yield DM T/A (No spray)	97-98 Yield DM T/A (Spray)	% Loss
3rd gen resistant	70	7.26	8.09	11%
2nd gen resistant	53	6.81	7.96	17%
1st gen resistant	25	6.52	7.86	21%
Susceptible	0	6.24	8.11	30%

The 3rd generation PLH resistant variety showed the highest level of resistance and the best protection against yield loss caused by PLH. It was also the highest yielding PLH resistant entry in both the sprayed and unsprayed treatment. This shows progress in both general agronomic performance and PLH resistance.

Forage Quality of PLH resistant varieties

Several studies have shown that first generation PLH resistant varieties have improved forage quality when compared with unselected commercial checks. This is evident both with and without PLH damage.

Forage Genetics has evaluated forage quality of PLH resistant populations in both sprayed and unsprayed tests. The results of these trials show that resistant varieties have decreased protein loss under conditions favorable for high PLH damage and that relative feed value of PLH resistant types is superior to conventional varieties under both sprayed and unsprayed conditions (Table 2).

Table 2. Forage quality of several varieties in the second harvest under high PLH pressure – West Salem, Wisconsin (1997)

Variety	Type	PHL % Resistant	% protein unsprayed	% protein sprayed	RFV unsprayed	RFV sprayed
3R22	2nd gen	53	18.4	19.2	158	160
DK121HG	1st gen	33	18.0	19.0	160	159
5454	Suspect	0	16.6	18.5	146	145

In 1997 the University of Wisconsin initiated an animal feeding study to look at fiber content, palatability, and digestibility of Vernal compared to a Forage Genetics, PLH resistant, glandular-haired experimental (Combs, unpublished). Forage samples were taken from the first harvest in 1997 when no PLH damage was evident. RFV was calculated from fiber content, which was measured by standard wet lab procedures. Palatability was measured as dry matter intake in a choice feeding study. In a separate study both rate and extent of digestibility were measured *in situ.* The results of these experiments are summarized in Table 3.

Table 3. Forage quality traits for two types of alfalfa

Trait	GH exp	Vernal
RFV	161	152
% protein	20.2	19.8
DM intake	1.47	0.57
DMD rate	0.067/hour	0.041/hour
DMD extent	77.4	75.3

These results suggest that, from a forage quality perspective, there is something unique about the glandular-haired germplasm. The RFV differences agree with results from several other tests. However, the greatly increased palatability and significantly faster rate of digestion of the GH experimental cannot be explained solely from differences in RFV. Variety differences of this magnitude for these traits have never been documented in alfalfa.

Similar results were obtained in a 1998 milk production experiment examining the forage quality advantage of the PLH resistant variety, TrailBlazer vs. the conventional variety Blazer XL (Luhman, et. al., unpublished). Forage for the study was harvested in 1997 from fields, which were sprayed to control PLH damage. A forage sample of each variety was analyzed and separate rations for each variety were balanced around that analysis. The two resulting rations were fed to dairy cows for a period of ten weeks. The results of this study are summarized in the graphs below.

Over the duration of the study, the ration with the TrailBlazer showed increased DM intake and yielded an increase of 4 lbs. of milk/day over the Blazer XL ration. This, coupled with the UW data, strongly suggest that the FG glandular-haired germplasm has forage quality characteristics that lead to increased animal intake and improved milk production, even in the absence of potato leafhoppers.

Summary

Glandular-haired varieties with potato leafhopper resistance have been developed that provide significant protection against losses caused by this important insect pest. The mechanism of resistance is complex, and includes antibiosis, non-preference and tolerance. New varieties have been developed with improved agronomic performance per se, and increased resistance to PLH. In addition to the insect resistance characteristics, some of these glandular-haired varieties appear to have unique forage quality advantages.

References

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