ORGANIC FARMING RESEARCH FOUNDATION

Project report submitted to the Organic Farming Research Foundation:

Project Title:

Evaluation of Glandular-Haired, Potato Leafhopper Resistant Alfalfa for Organic Farming Systems

FINAL PROJECT REPORT

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Project Summary

When potato leafhopper, *Empoasca fabae* Harris, injury threatens alfalfa, organic farmers cannot protect their crop with insecticides and often suffer considerable crop loss. This experiment evaluated the potential of growing newer, third and fourth generation glandular-haired, potato leafhopper resistant varieties of alfalfa in an organic rotation. Three different varieties of alfalfa were planted, two varieties that have leafhopper resistance traits (a third and a fourth generation having moderate and high resistance, respectively) and one certified organic variety that does not have the resistant trait. Alfalfa was sampled weekly for potato leafhopper. Because of insufficient leafhopper densities during 2005 to obtain meaningful results the first year of the study, either positive or negative, a non-funded extension was obtained to continue the experiment the following year. During the second cutting in 2006, extremely high leafhopper populations developed. Both resistant varieties performed much better than the susceptible alfalfa, with fewer insects, very little leafhopper injury, and much taller plants. During this past year, the site served as a demonstration site for OFFER Field Days held in September. Publications and presentations for meetings, including workshops on organic production for farmers, will be developed.

Introduction

In the northern and eastern portions of this country, the primary insect problem in alfalfa is the potato leafhopper (PLH), *Empoasca fabae* Harris. A piercing-sucking insect, the leafhopper secretes toxic saliva into the plant, which interferes with phloem transfer. This injury results in leaves that are yellowed (known as "hopperburn") and plants that are often greatly stunted.

Because PLH is a yearly pest on alfalfa mostly during the second and third cuttings, usually ranging from a moderate to a severe problem, alfalfa growers contend with them most growing seasons. Conventional alfalfa growers have numerous management tactics to help prevent losses by leafhoppers, mostly choosing to take therapeutic action by using synthetic insecticides. Using well-established economic thresholds, conventional farmers take action when PLH densities reach prescribed levels. The threshold is when the number of adult and immature PLH in a 10-sweep sample is equal or greater than the height of the alfalfa. For example, on 8 inch alfalfa, the threshold is 8 or more leafhoppers.

The concern in this proposal is with certified organic alfalfa production. When PLH threatens their alfalfa during the summer, organic producers cannot use synthetic insecticides to protect their crop, and often suffer significant crop loss during either of the growth cycles if leafhopper populations are high. None of the known organic insecticides offer acceptable control. This proposal evaluated the potential of newer generation glandular-haired, PLH resistant alfalfa varieties in an organic system. Studies from conventional systems indicate the value in using these resistant lines without having to use insecticides.

Varieties with resistance to PLH were initially released in 1997. Early released varieties were not sufficiently resistant, only containing about 30% resistant plants. At that time, their performance was considered poor and few growers took to using them. Since that time, newer, more advanced varieties have been released that have proven to have much higher levels of resistance, between 70-80% resistant plants. Between the release of the first lines and the most recent, we had at least two other generations of resistant varieties which contained between 40-60% resistant plants. In studies from conventional systems, the most recent advanced generation

alfalfa lines have shown outstanding resistance and yield compared with non-resistant varieties whether treated or not. Indeed, we have been able to raise the PLH thresholds on the resistant varieties at least 3X the level of non-resistant lines. For example, on that same 8 inch alfalfa, the threshold on these new resistant lines would be 24 leafhoppers per 10-sweep sample. Although numerous researchers have and continue to examine the exact mechanism of the resistance, the reason for the resistance is still unclear. We know it is because of the glandular-hairs that these lines possess, but no one is sure if its antixenosis, a behavioral effect, or antibiosis, a mortality factor.

Objectives

The primary objective of this proposal was to determine the ability to produce organically grown alfalfa in areas with significant potato leaf hopper pressure and then to share this capability with organic growers.

Specific experimental objectives were:

1. Determine if glandular-haired, PLH resistant alfalfa can be produced organically,
2. Determine if organically grown glandular-haired, PLH resistant alfalfa can reduce PLH density,
3. Compare yield and quality of organically grown glandular-haired, PLH resistant alfalfa with non-PLH resistant organically grown alfalfa, and
4. Demonstrate the ability for glandular-haired, PLH resistant alfalfa to produce a higher yield of alfalfa with less PLH injury to organic growers.

However, numerous impediments, as will be explained in the methods and materials section, began quickly and caused a change to the overall study.

Methods and Materials

In August 2004, alfalfa was fall planted near Wooster, OH, on certified organic research land operated by the OARDC (Ohio Agricultural Research and Development Center) and certified by the Ohio Ecological Food and Farming Association (OEFFA). This land is part of the Organic Food & Farming Education & Research Program (OFFER, http://www.oardc.ohio-state.edu/offer/). Three alfalfa varieties were planted, Great Harvest (an organically produced, non-PLH resistant variety), and Doebler Predator and Pioneer 54H91 (both glandular-haired PLH resistant varieties). Doebler Predator is a third generation resistant variety that will be referred to as a moderately resistant line (Res-M), while 54H91 is a recently released, fourth generation line considered highly resistant (Res-H). While both of these lines are normally grown on conventional land, we were able to obtain a seed lot of non-treated seed from the companies. Pioneer 54H91 was planted with and without BSG (Bio-Seed-Gard), an OMRI organic certified seed treatment. BSG is a seed treatment that was obtained from the organic producer who supplied us with Doebler Predator seed, who had asked us if we would treat half the 54H91 (the more resistant line) to see if there was an additional advantage in using this seed treatment. BSG, as the supplier states, is a dry blend of microorganisms including *Mycorrhiza* and *Trichoderma* along with a complete nutrient package, to support the initial growth stages of these beneficial species and promote soil life for nutrient cycling in the root rhizosphere.

Plots measured about 20 × 150 ft. The original intent had been to plant 4 replications with the treatments randomly assigned within each replication. However, after planting the first plot with the equipment available, it became evident that we could not adequately control the flow of seed and would run out of seed soon after planting two replications. Thus, we modified

the plot layout by planting only two plots of each treatment, although one of the treatments had enough seed for three plots. We planted red clover in the remaining plots to make sure a legume was planted throughout the field (red clover is not a host for the potato leafhopper). Because of the lack of adequate replications (only 2), we made the decision at the beginning of the study NOT to conduct analyses of variance, feeling it would be inappropriate. (Our lab has always maintained the need for a minimum of three replications before conducting any such analyses, and has used at least 4 replications in 90% of all studies). Thus no data analyses were done.

Weekly sweep-net samples were taken in each plot from the time the alfalfa reached sufficient height to sweep net sample, until just before harvesting. Sampling began following the first alfalfa cutting when PLH are known to occur. Each sample consisted of 10-sweeps of the sweep-net. Samples were bagged and returned to the laboratory for PLH counting. During each sample, observations were taken on leafhopper injury (yellowing score) and plant height. Our intent was to take harvest data using a small plot thresher that we thought would be available from another department. However, because of the distance from where the plot thresher was located (about 5 mile), we were not able to take plot harvest data. The plot thresher is an old machine which we were told was not taken off the farm where it was located because of its age and inability to travel any distance. However, because plant height at alfalfa harvest maturity is correlated with yield, we felt this would be adequate as plant heights are often used as a yield indicator when actual yield data are not available.

Our plan was to determine other components associated with alfalfa production, including quality. However, because of a lack on insects and any injury the first year, data were not taken. We were granted a non-funded extension to extend the study an extra year in the hope that leafhopper populations would be higher in 2006. The plots established in the fall of 2004 became the plots for 2005 and 2006. The sampling procedures were the same in each year. Each year, weekly sweep-net samples were taken in each plot from the time the alfalfa reached sufficient height to sweep net sample, until just before harvesting. Sampling began each summer following the first alfalfa cutting when PLH are known to occur. Because the difference in plant height and PLH injury between susceptible alfalfa and the resistant alfalfa was so great during the second cutting of the second year, we decided that there was no need for such data knowing the information already available on PLH damaged and non-damaged alfalfa. It is already known and accepted that alfalfa quality is greatly reduced in leafhopper damaged alfalfa.

Project Results

During the first year of the study, 2005, potato leafhopper did not reach nor approach economic levels on any sample date during any cutting. Densities were well below thresholds, usually <8 leafhoppers during each cutting, throughout the summer. There was never any sign of injury or height differences. At the end of the summer, the study was considered a complete failure because of lack of insect pressure. Thus, no data are provided for 2005.

In the second year of the study, PLH achieved very large densities during the second cutting in July (Table 1). These were very high potato leafhopper populations, extremely higher than normal. Sampling from 5 July through 25 July showed the development of the population. (As mentioned in the methods, because of the lack of adequate replications, no statistical analyses were done. However, we believe that there is much to gain on examining the averages, and with the observed PLH damage to the alfalfa, believe that our conclusions are appropriate.)

Adults collected on 5 July were similar in all treatments with an average around 38 PLH per 10-sweep sample. At this time, with alfalfa at a height of approximately 8 inches, the normal threshold on susceptible alfalfa would be 8 PLH. Using our 3X threshold for resistant alfalfa, the level would be 24 PLH. All treatments were considered above threshold, including the resistant alfalfa. Few nymphs were collected on this date. The following sample, 14 July, the populations were again similar to those on the first sampling date. On both these dates, yellowing began to be seen in the susceptible alfalfa, but not the resistant.

On the third sample date, 19 July, the adult populations on the resistant alfalfa varieties began to fall, ranging from about 19 PLH on 54H91 with BSG, 25 PLH on the other two resistant treatments, and 40 on the susceptible line. The populations on resistant varieties by this time were below the threshold of 3X normal, which on 15 inches alfalfa would be 45 PLH per sample. The numbers on the susceptible were well above threshold. Although nymphs started to become more numerous, they were still low on this date.

On the final sample date, 25 July, when the alfalfa was about 25 inches tall (at least on the resistant alfalfa), the number of adult PLH was similar on all varieties, ranging between 21 and 31 per sample. However, nymph densities rose dramatically, with a low of 10 nymphs per sample on 54H91 with BSG and 37 nymphs on the susceptible. Adding adults and nymphs, the susceptible averaged about 62 total PLH while the highest resistant treatment was 32 total PLH. Again, with the differences in thresholds, the susceptible alfalfa was well over threshold while the resistant alfalfa was below threshold.

The presence of more PLH on the susceptible variety corresponded to higher injury ratings and plant stunting (Table 2). The susceptible variety had ratings of 6.5 and 9.0 on 17 July and 3 Aug, respectively. These levels of injury are exemplified by extreme yellowing (80-90% yellow) and stunting. The plant height for the susceptible was only 15 inches on 26 July. This compared to both 54H91 treatments with injury ratings of ≤ 1.5 both dates, exemplified by very slight yellowing (5-10% yellow). This amount of yellowing was most likely from the 10-20% of the non-resistant individual plants present in the mixture. The two 54H91 treatments were about 25 inches in height. Predator, which is a less resistant variety, had an injury rating between 2.5 and 3.5, some yellowing (30-40%), with an average height of 21 inches, a few inches less than 54H91. (It should be noted that since obtaining Predator seed, a more advanced fourth generation variety, Predator II, has come on the market with higher levels of resistance). There appeared to be no differences between 54H91 with and without BSG.

These were very high potato leafhopper populations, much higher than normal, during this second cutting. All samples were over threshold for regularly-grown alfalfa, and on July 5, probably higher than the 3X threshold for glandular-haired alfalfa. However, note that while susceptible alfalfa was greatly stunted and yellow, we still had good height and less injury with resistant alfalfa. Note the fewer adults by July 19 on resistant alfalfa, and the fewer nymphs that developed on the resistant material.

Following harvest of this growth cycle, leafhoppers did not reach high levels again, being more similar to 2005 (always < 8 PLH per sample). No data are presented for this time period.

Table 1. Potato leafhopper densities on organically grown alfalfa on four sample dates during the second cutting in 2006.

		Number PLH per 10 sweeps							
		July 5		July 14		July 19		July 25	
Variety	PLH	A	N	A	N	A	N	A	N
Great Harvest	Sus	39.0	0.5	41.0	1.5	40.5	7.2	25.2	36.7
54H91 w BSG	Res-H	40.8	1.0	34.8	0.0	18.8	2.8	22.3	10.5
54H91 w/o BSG	Res-H	38.2	0.7	42.7	0.8	26.8	3.8	21.2	18.3
Predator	Res-M	39.0	0.8	43.8	1.0	24.5	6.5	31.3	23.3

Sus = susceptible variety, Res-H = highly resistant variety, Res-M = moderately resistant variety
PLH = potato leafhopper, A = adults, N = nymphs

Table 2. Injury ratings (from two dates) and plant height near harvest maturity on organically grown alfalfa during the second cutting 2006.

		Injury Ratings[a]		Plant Height
Variety	PLH	July 17	Aug 3	July 26
Great Harvest	Sus	6.5	9.0	15”
54H91 w BSG	Res-H	0.5	1.0	26”
54H91 w/o BSG	Res-H	1.0	1.5	25”
Predator	Res-M	2.5	3.5	21”

[a] Injury rating: 0 = no injury observed to 10 = completely yellowed and stunted
Sus = susceptible variety, Res-H = highly resistant variety, Res-M = moderately resistant variety
PLH = potato leafhopper, A = adults, N = nymphs

Conclusions and Discussion

Because of numerous problems that occurred at the beginning of this study and the lack of an insect population the first year (of an original single year study), the work did not go as planned. However, by obtaining a non-funded extension of the grant, we obtained very useful information during the second cutting cycle the following year.

We were able to show the ability of advanced generation, glandular-haired potato leafhopper alfalfa to produce a much better crop than regular, non-resistant alfalfa. This improvement was demonstrated by the near total lack of leafhopper injury (yellowing) and plants attaining between 25 and 30 inches in height (the normal height at harvest), while the non-

resistant alfalfa was very stunted, at best 15 inches in height, and nearly entirely yellowed. As mentioned, the literature indicates that quality is much lower in PLH damaged alfalfa. Past experience has been that most growers, conventional or organic, would not have bothered to harvest this yellow, stunted alfalfa. This is the best evidence that this resistant alfalfa has a use in organic alfalfa production (as well as in conventional production systems where we already promote its use).

Although not reported herein, we have also been examining various organic insecticides (e.g., Neemix, Pyganic, etc.) for control of the leafhopper, and have not been able to obtain meaningful reductions in insect numbers. Our belief is that the only way for organic alfalfa growers to adequately manage the potato leafhopper is to use advanced generation, glandular-haired potato leafhopper resistant alfalfa. Although the seed is initially more costly, the improved management of this insect and subsequent higher yields and ability to always get a harvest should overcome any additional cost pressure.

Outreach

We discussed this technology at the most recent OFFER Field Days in September 2006 in Wooster, OH. Along with additional work we are conducting in other organically grown field crops (especially organic soybeans), we intend to discuss leafhopper resistant alfalfa at all our meetings, whether for organically produced crops or for conventional growers. We will also develop literature as part of an overall program towards managing insect pests in organic field crop production. We are also updating the OFFER website with information on this technology.

Addenda

Included is a single PowerPoint slide that shows close-up pictures of the varieties with and without the leafhopper injury. Also, various slides showing the differences in varieties are enclosed. They can be used as needed in any form or fashion.