(1996 trial results continued from page 17.)

these plantings have yet to come into production, current demand for hazelnuts far outstrips domestic supply.

But establishing a nut orchard is a considerable investment in money and time. How can producers efficiently and reliably start hazelnut plantings? PFI cooperators Tom and Irene Frantzen, New Hampton, and Mike Natvig, Cresco, set out in 1995 to answer this question. With funding from PFI *Sustainable Projects* and the Organic Farming Research Foundation, they set out an on-farm trial of hazelnut establishment methods.

There were two approaches to establishing hazelnut transplants that these producers wanted to evaluate; protective tubes and ground maintenance. Tubex® tubes are made of plexiglass and are used to protect young trees and bushes from extremes of weather and browsing deer and rabbits. Elevated humidity inside the tubes reduces stress on the plants during the growing season, and the tubes give some winter protection as well. Traditional methods of establishing transplants have reduced competition from weeds by keeping an area of bare ground around the plants. Sometimes a mulch has been used to accomplish the same thing. Mulch also buffers changes in soil moisture and temperature, and it requires less total labor than maintaining the bare ground.

The Frantzens and Natvigs set out a "two-by-three" factorial experiment. Three methods of ground preparation were included: bare ground, wood chip mulch, and no ground preparation at all. Each of these three methods was tried with and without the Tubex tubes. Each farm had six replications of these six combinations. Table 6 gives results overall for each farm, and it shows the two factors (one a two-level factor and the other a three-level factor) rather than the six individual treatments.

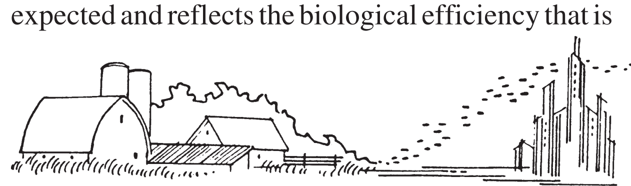
In late June, 1995, these cooperators transplanted their hazelnut seedlings into rows deep-ripped with a single shank chisel. At the end of the 1995 season and again in the autumn of 1996, they measured several growth parameters, including plant height (in centimeters), plant diameter (in millimeters), and the number of bud nodes. Results for 1996 confirm the value of the protective fiberglass tubing, which produced bigger plants with more leaf nodes.

The second-year data also contain information about plant survival through the winter of 1995-1996. Here is where the two farms begin to look different. Mike Natvig lost only one plant out of 72 to winterkill. The Frantzens lost four of 36 where Tubex was used and 29 out of 36 without tubing. The cause of this difference between farms is not clear. The Frantzen planting is in a somewhat poorly drained spot, while Mike's hazelnuts are in well-drained soil. What's more, hazelnuts grow wild around Natvig's planting. There could be native mycorrhizae or other soil microbes at the Natvig site that are contributing to hazelnut health.

The effect of ground maintenance was also different at the two farms. At the Frantzens' there was a tendency (not statistically significant) for healthier plants with the bare ground treatment, and the least vigorous plants were found under mulch. Mulched plants did best of all at Natvig's, with the poorest performance shown by plants receiving no ground maintenance at all. Good research always answers some questions and raises others, and this project is no exception. Still, producers now have some good tips to help them enter into a hazelnut enterprise.

Strip Intercropping: Yields and "Bugs"

Table 7 shows results of strip intercropping trials on the farms of Paul and Karen Mugge, Sutherland, and Jeff and Gayle Olson, Mt. Pleasant. The numbers at the top of the table were collected by the cooperators themselves, while the yields at the bottom of the table were hand harvested by ISU. Corn yielded better in strips than in large, single-crop field blocks, and the corn at the strip borders yielded better than corn in the center of the strips. That was expected and reflects the biological efficiency that is



Tel: (515) 232-5661
Fax: (515) 232-5649
137 Lynn Avenue, Suite 200
Ames, Iowa 50014
Email: info@practicalfarmers.org
Web: www.practicalfarmers.org

TABLE 7. STRIP INTERCROPPING TRIALS

COOPER-ATOR	CROP	DIRECTIO-N	STRIP YIELD	FIELD YIELD	DIFFER-ENCE	COMMENT
MUGGE	CORN	E-W	166.9	158.9	8.0	FIELD BLOCK CORN IN CORN-SB ROTATION YIELDED 140.9
	SOYBEAN	E-W	n/a	n/a	–	COMBINE MONITOR FAILED
	OATS	E-W	85.0	89.0	-4.0	50 BALES STRAW IN BOTH SYSTEMS
OLSON	CORN	SE-NW	165.9	157.7	1.5	BLOCK CROPS WERE NOT CLOSE TO STRIPS
	SOYBEA-NS	SE-NW	34.9	46.2	-11.3	
	OATS	SE-NW	67.9	70.3	-2.4	

STRIP ORIENTATION:		
NORTH-SOUTH	OLSON	OLSON
ROW	YIELD	STAND
(W)	(SOY)	(SOY)
1	173.8	23,631
2	156.0	26,136
3	152.3	24,285
4	161.5	26,027
5	146.8	24,720
6	163.2	26,572
(E)	(OATS)	(OATS)
STRIP AVG.:	158.9	25,229
BLOCK:	n/a	n/a

STRIP ORIENTATION:			
EAST-WEST	MUGGE	MUGGE	MUGGE
ROW	YIELD	STAND	ADJUSTED YIELD
(S)	(SOY)	(SOY)	(SOY)
1	199.1	31,363	184.7
2	165.4	27,225	164.2
3	152.7	28,205	148.4
4	131.7	24,612	138.9
5	159.3	27,770	156.4
6	185.3	32,235	168.1
(N)	(OATS)	(OATS)	(OATS)
STRIP AVG.:	165.6	28,568	160.1
BLOCK:	149.5	23,486	160.3

part of strip intercropping's attraction. Paul planted 28,000 seeds per acre in his sole-crop blocks and about 35,000 in corn strips. The low harvest stand measured in row 4 of the strips makes him wonder if he might have had a faulty planter unit.

Soybean yields apparently suffered in strips at Olsons', and the unreliability of the combine monitor

Tel: (515) 232-5661
Fax: (515) 232-5649
137 Lynn Avenue, Suite 200
Ames, Iowa 50014
Email: info@practicalfarmers.org
Web: www.practicalfarmers.org

forced Paul Mugge to throw out his soybean data. Soybean yields averaged the same or slightly higher in strips over three years of comparisons by six cooperators, and corn yields averaged ten bushels higher in strips than field blocks for those 18 site-years.

The current challenge in strip intercropping appears to be bugs. Maybe strips are no more vulnerable to insects than is sole-cropping, but PFI is working with entomologists and agronomists from ISU and South Dakota State University to answer related questions. There were three suspected culprits in 1996: grasshoppers, common stalkborers, and corn rootworm beetles.

Paul and Karen Mugge, in northwest Iowa, have had problems with grasshoppers on the whole farm for the past two years. Paul has observed grasshoppers eating oat regrowth after small grains harvest, and these hungry pests moved right over into the soybeans after finishing off the oat strips. Failure of the combine monitor prevented Paul from measuring the effect of grasshoppers on soybean strips. Intercropped corn yields next to oat strips were still higher than in the center of the corn strips.

Common stalkborer may also have used strips as highways to travel into the field from the grassy borders where their eggs hatch. Any stray grass left between strips can also harbor these stalkborer eggs and young larvae. PFI coordinator Rick Exner and

Rootworms in Strip Intercropping

Michael Ellsbury, South Dakota State University

Investigations continued on the Mugge Farm on the possibility of rootworm damage in the strip system. Soil was sampled for eggs, adult emergence was monitored, and root damage was rated on a 1 to 9 scale. As in 1995, rootworm eggs were found in the soybean strip but in smaller numbers. There were few rootworm eggs in the soil where corn was planted. We found evidence of only minor rootworm damage to the first row of corn caused by larvae migrating underground from the soybean strip. Root damage and adult emergence were much lower in 1996 than in 1995. It is interesting to note that 1996 yield in the outer corn row was higher than that in the other five rows. We speculate that overwinter mortality and a cool wet spring may have reduced numbers of surviving rootworms.

Three barrier treatments were tried at the corn/soybean interface to test their effect on rootworm movement into the outer corn row. These treatments included: Counter® soil insecticide, crambe oilseed meal, and a tillage treatment in which the soil was ripped to about 9 inches depth with a cultivator shank (Figure 4). The oilseed meal treatment was included because research has shown this material to be toxic and repellent to soil-dwelling insects. The tillage treatment was intended to disrupt old root channels and soil pore structure that could be used by rootworm larvae moving toward corn roots. Evidently the tillage treatment had the opposite effect, since root damage was highest and yields lowest in the areas that were ripped (Figure 1). Very few emerging adults were observed in any of the treatments. This suggests to us that compaction of soil at the corn/soybean interface may be a means of limiting rootworm movement into the first corn row.

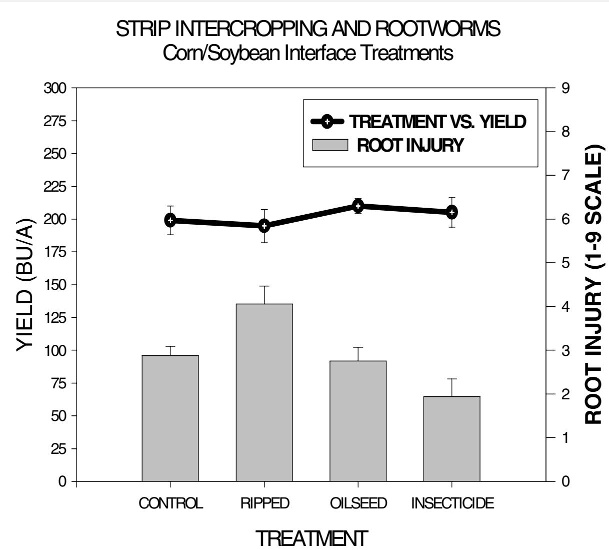


Figure 4. Comparison of rootworm barrier methods on corn in strip row bordering previous corn strip.

Tel: (515) 232-5661
Fax: (515) 232-5649
137 Lynn Avenue, Suite 200
Ames, Iowa 50014
Email: info@practicalfarmers.org
Web: www.practicalfarmers.org

ISU entomologist Kris Giles applied an experimental biological control for stalkborers when they were migrating out of field borders on Jeff and Gayle Olson's farm. That information is being evaluated. Next year New Melleray Abbey may use its flame cultivator to singe the grass in field borders where stalkborers reside in spring.

Finally, SDSU entomologist Mike Ellsbury continued his study of corn rootworms in strip intercropping. In 1995, Mike found evidence that western corn rootworm larvae were migrating underground into the first row of a corn strip next to the previous year's corn. In 1996, those data did not show strong trends. However, Mike did test several methods for interrupting the rootworm migration, and those results appear in the side-bar and Figure 4.

IPM Projects: Learning to Work with the Agricultural Ecosystem

In addition to PFI projects with management of insects in strip intercropping, cooperators have been working in two projects that seek to expand the toolbox for insect management in corn and alfalfa. In 1995, PFI and ISU entomologists began a two-year investigation of biological control of the alfalfa weevil and the European corn borer. With support from the Leopold Center for Sustainable Agriculture, each year two farms worked on alfalfa weevil and two farms concentrated on corn borer. Integrated Pest Management (IPM) involves field sampling for pests to see if they have reached the threshold at which treatment is justified. "Treatment," as we understand more about the ecology of insects, increasingly includes more practices than spraying insecticide. Among these, "biological controls" manage pests by manipulating the agroecosystem.

Part of IPM research today is refining those thresholds. There are good economic reasons for this. Let's say you have scouted your hay field and found an average of two alfalfa weevil larvae per stem. Present guidelines say that is the threshold above which you will suffer losses if you don't do something. (Incidentally, a certain amount of insect feeding actually stimulates alfalfa leaf production, and that response also happens to peak at two larvae per stem.) But what if you knew half those alfalfa weevil larvae would be dead in a week? You might take a wait-and-see approach.

In fact, several organisms can devastate weevil populations. A variety of tiny wasps lay their eggs in the weevil larvae, and a common fungus, *Zoopthora phytonomi*, attacks the larvae under the right conditions. If farmers could make their own judgements about the "health" of alfalfa weevil populations, they could often save money and avoid insecticides, which may be harder on the weevil's enemies than on the alfalfa weevil itself. The study was designed to see if farmers can learn the necessary skills. The answer according to this project is "yes." As Figures 5 and 6 show, there was very good agreement between the scouting information collected by PFI cooperators and ISU entomologist Kris Giles.

Biological control was the other focus of the project. One promising biocontrol is the use of unharvested strips described by Jeff Klinge and Mark and Julie Roose. Findings from this project are leading to more research on these unharvested strips. Corn borer biocontrol was addressed both by the Leopold Center study, as reported by Joe Fitzgerald, and by the SARE-funded (Sustainable Agriculture Research and Education, USDA) research described by Dennis McLaughlin, Ron and LaDonna Brunk, and Doug Alert and Margaret Smith. ISU Entomologist Les Lewis also provides background on that project in the following pages.

Corn Borer Control with the Fungus *Beauveria*

Les Lewis, ISU

Beauveria bassiana (say "bo-vária") is a widely distributed fungus that kills insects including the European corn borer, *Ostrinia nubilalis*. Recent research at the USDA-ARS, Corn Insects Research Unit demonstrated what we call an endophytic relationship between *B. bassiana* and corn plants. *Beauveria bassiana* applied to corn in the V7 stage of plant development enters the plant,

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