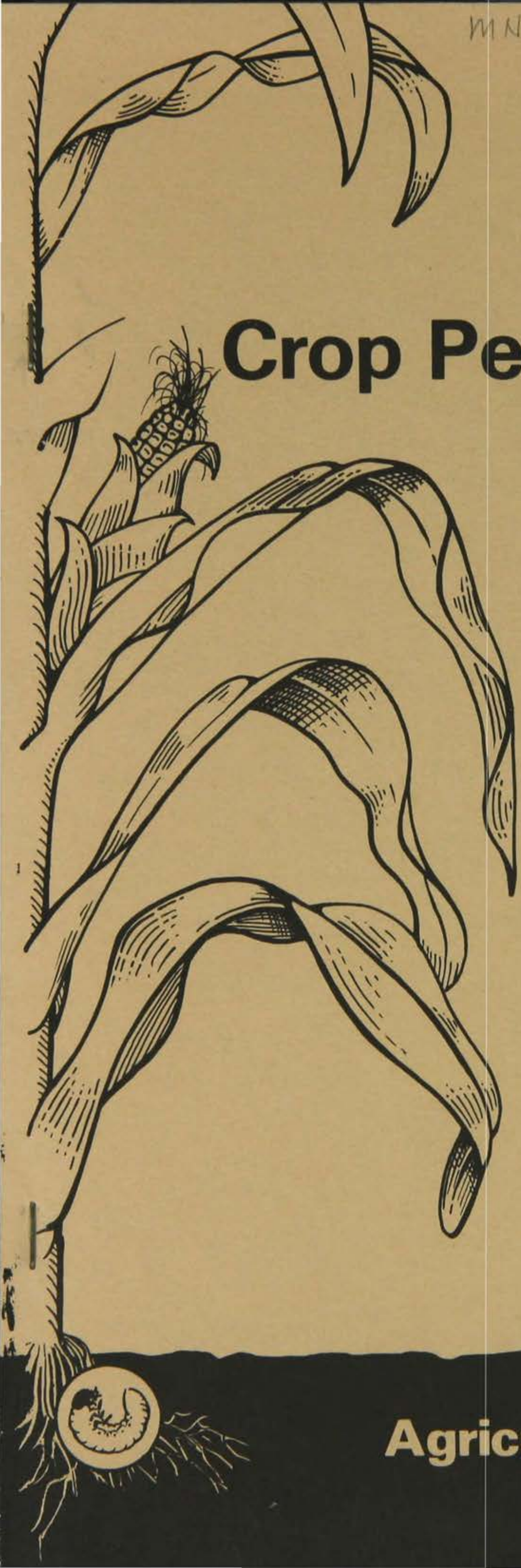

1983 Crop Pest Management Short Course Proceedings

December 8-9

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PROCEEDINGS

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EUROPEAN CORN BORER: BIOLOGY AND CONTROL CONCEPTS[1/]

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INTRODUCTION

The European corn borer, *Ostrinia nubilalis* (Hübner), has significantly affected production of *Zea mays* L. field corn, popcorn, sweet corn, peppers, snap beans, and potatoes.

The European corn borer is an introduced insect species that belongs to the order Lepidoptera. It came to North America nearly 70 years ago, possibly in broom corn imported from central Europe. It was first found in the north-central states in 1921 and spread slowly from southern Michigan and northern Ohio. By the end of 1938, it was only as far west as the western shore of Lake Michigan in Wisconsin.

During most of this early period, the insect had one generation per year. In the late 1930s, however, a two-generation-per-year borer began to appear in the north-central states. This two-generation-per-year borer spread rapidly and soon became dominant in the region. It reached Illinois in 1939, Iowa in 1942, southern Minnesota in 1943, Nebraska in 1944, and South Dakota in 1946. Meanwhile, the single-generation borer spread northward into northern Minnesota, North Dakota, and the Canadian provinces of Quebec, Manitoba, and Saskatchewan.

Three- and four-generation-per-year borers went southward along the Atlantic coast and into Missouri, Arkansas, Kansas, Oklahoma, and the Gulf states (Showers et al., 1983).

LIFE CYCLE

During its lifetime, the borer goes through four stages of development: egg, larva (borer), pupa (transition stage), and moth. The succession of these four stages constitutes a generation. The larva goes through five stadia of growth (first through fifth instar). During the fifth instar, all individuals either prepare to pupate and become adults (moths) or to be in diapause.

Diapause is a physiological condition expressed as suspended development that is governed by daylength, temperature, and genetic composition of a population. Beginning midsummer to autumn, the daylengths shorten, and the temperatures begin to cool. These environmental changes trigger one or more genes sex-linked to the male that allow the larval portion of the population to go into diapause, thus preparing the population for survival during the cold winter.

The borers pass the winter as full-grown larvae in cornstalks, corncobs, weed stems, or spun up in other cornfield debris. Surviving or overwintering borers become active in April or May in the central Corn Belt and develop as outlined in Figure 1.

Spring development of the borer begins when temperatures exceed 50°F (10°C). During the 1950s, researchers began predicting the biological events of the corn borer by using accumulated temperature units called degree-days (Apple, 1952). Accumulations were arbitrarily started after Jan. 1 of each year whenever 50°F (10°C) occurred. However, because of population diversity and environmental factors, these degree-day predictions have not functioned well. Recently researchers began the degree-day accumulations with the capture of the first spring moth in either synthetic pheromone traps or light traps. Predictions of subsequent borer activity based on degree-day accumulation after spring flight have been relatively successful (Showers et al., 1983).

Moths will leave the emergence sites in cornfield debris and fly to patches or strips of dense vegetation, usually grasses, in conservation lanes or near fencerows (Caffrey and Worthley, 1927; Showers et al., 1976). The vegetation in these habitats collects rain droplets and retains dew droplets more effectively than do the leaves of corn plants. Therefore, the proper microclimate exists for feeding, resting, and, most important, mating (DeRozari et al., 1977).

Once in one of these action sites and after drinking from rain or dew droplets, the female moth will begin emitting a sex attractant (pheromone) composed of two isomers of 11-tetradecenyl acetate (Klun et al., 1973). This activity usually begins by 10:00 PM and peaks at 1:00 AM. The combination of the microclimate of the habitat and the emission of pheromone draws large aggregations of borer moths into relatively small areas of dense vegetation (Showers et al., 1976; Sappington and Showers, 1983).

Normally, the female moths are 48 hours old by the time they are mated and leave the action sites to deposit eggs in the target crops. On warm, calm evenings, these egg-laying activities will begin shortly after sundown and cease by 12 midnight. The females will leave the target crop and return to action sites to feed, rest, possibly remate, and to await another suitable evening for egg laying (Showers et al., 1983).

If the target crop is corn, females of the spring flight are attracted to the tallest fields. The eggs, 15 to 30 in a mass, overlapping like scales of a fish, normally are deposited near the midrib on the underside of corn leaves. Egg masses are flat and are approximately 1/4 inch (6 mm) in diameter. The eggs hatch in 3 to 7 days, depending on weather conditions. Eggs about to hatch have distinct black centers (Caffrey and Worthley, 1927). This is the black head of the larva visible through the translucent egg shell. Each mated female is capable of depositing an average of two egg masses per night for 10 nights. Most masses, however, will be deposited during the first six nights after mating.

If the corn is small (less than 16-inch (40 cm) extended leaf height) when the eggs hatch, most of the small larvae fail to become established because they wander off and die. In many corn hybrids, a primary factor for this behavioral response is a plant aglucone, 2-4-dihydroxy-7-methoxy-1,4-benzoxazin-3-one (DIMBOA) (Klun et al., 1967). The concentrations of DIMBOA in a given corn hybrid usually decrease proportionally to plant growth. A higher proportion of larvae survive on corn in mid-to-late whorl stage (22- to 36-inch (55 to 80 cm) extended leaf height). Usually, corn plants are mid-to-late-whorl when most of the eggs are deposited during the spring borer flight. But, even in the presence of optimal corn plant stage, temperature-related climatic variables, such as moisture stress and evaporation, will kill 22 to 68 percent of the freshly hatched larvae (Chiang et al., 1961; Showers et al., 1978). Those that live, however, move to the whorl to feed and develop. Eventually, they burrow into the stalk of the corn plant where they change to pupae during the summer.

The first-generation moths that emerge in midsummer fly to dense vegetation, primarily foxtailgrass in the Corn Belt, to feed, rest, and mate. These mated females prefer succulent, recently tasseled corn plants on which to deposit eggs that will produce the second generation of borers. If corn plants in commercial vegetable areas have progressed beyond the silking and tasseling stage, the moths will lay eggs on pepper plants or other economically important hosts.

During the silking and tasseling stage of corn growth, most of the egg masses will be laid on the undersides of the two leaves above the ear on the ear husk and on the undersides of the ear leaf and the two leaves below the ear (Showers et al., 1983). During this time of year, depending on weather conditions, the eggs will hatch in 3 to 5 days. About 75 percent of the small larvae will move to the leaf axils to feed on sheath and collar tissue, and the remaining 25 percent to the ear to feed on silks or husk tissue or on pollen collected in these sites (Guthrie et al., 1970).

CONTROL CONCEPTS

A myriad of environmental factors is responsible for the haphazard nature of the variations in populations of European corn borers: agricultural practices, natural enemies, and climatic-factors are the most important (Chiang and Hodson, 1972). The standard procedure for controlling populations of this insect is similar to that for controlling other insect species. A chemical insecticide is applied over the crop to effectively reduce the larval portion of the population. Other concepts are being researched, however, that would remove the thrust of the control procedure from the larvae to the adults (moths) or to integrate insect pathogens with host-plant tolerance and resistance.

The aggregation behavior of the moths is a weak link in the biology of this species that can readily be exploited. Figure 2 demonstrates the relationship of numbers of egg masses on corn plants with the numbers of female moths in the action sites. It is reasonable to assume, therefore, that, if the numbers of females were reduced, the numbers of egg masses would also decline.

Table 1 presents the results of treating grass edges and waterways for adults before larvae are established in the cornfields (Showers et al., 1980).

The susceptability of corn hybrids to leaf feeding during the whorl stage of development has been reduced through crossing resistant inbreds that have been produced through modified recurrent selection techniques (Table 2). Concurrently, corn plant tolerance of European corn borer has steadily increased (Duvick, 1979). Inbreds and single crosses available today are nearly twice as tolerant as were those available 50 years ago (Table 3). These data show that the susceptability to sheath and collar feeding by the borer during pretassel and posttassel corn plant development has declined dramatically.

Recent research shows that thermostable exotoxins (TET) produced by six subspecies of Bacillus thuringiensis are recoverable in supernatant. The TET from three subspecies, B. thuringiensis thuringiensis, tolworthi, and darmstadiensis were very effective against first instars at 33.33 μl of supernatant per ml of diet (Table 4). At 166.67 μl supernatant per ml of diet, however, the percentage mortality decreased. This phenomenon has been attributed to a feeding deterrent (Mohd-Salleh and Lewis, 1982). The application of supernatant containing TET to cornfields for control of first-instar European corn borer differs from application of chemical insecticides only in that TET is a biological insecticide.

Nosema pyrausta is a microsporidium, host specific to the European corn borer. Vairimorpha necatrix, however, is a microsporidium that infects a wide range of lepidopterous hosts (moths). N. pyrausta infects several tissues, but V. necatrix usually is found just in the fat body (Lewis et al. 1983). The results of an experiment to determine the effects of infection of these two microsporidia on numbers of borers per corn plant during pollen shed and numbers of borers per cornstalk after overwintering indicated slight differences between treatments (Table 5). A comparison of the percentage diseased larvae in the "uninfected" check with the various introduced infections suggests that the microsporidia are quite mobile and will come in contact with European corn borers that are several plant rows distant from the original infections (Table 5).

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Table 1. Reduction of European corn borer in cornfields by killing moths in action sites.

Grass edges and grass waterways	Cornfield[a/] Egg masses	ECB/plant cavities (cm)	Yield/plant (g)
2.26 kg AI/ha Carbaryl-4-oil	0.2 b	14.3 b	210.0 a
No treatment	3.3 a	40.8 a	192.1 b

[a/] Means followed by the same letter are similar at the 5% level. Adapted from Showers et al. (1980).

Table 2. Average resistance to leaf feeding by the European corn borer[a].

Inbred	Leaf feeding score[b]
WF9	1.3
B73	1.5
MO17	2.0
B37	2.8
A632	4.0
B52	5.9
Oh43	6.4
A619	8.7

[a] Inbreds tested for 4 years.
[b] Classes 1 to 9; 1 = extensive damage, 9 = little or no damage. Adapted from Guthrie et al. (1982).

Table 3. Average tolerance to sheath and collar feeding by the European corn borer[a].

Decade	Feeding scores[b/] Inbreds	Single crosses
1930	2.7	3.4
1940	2.9	2.9
1950	4.1	4.9
1960	4.3	5.8
1970	5.1	6.0

a/ 5 inbreds and 10 single crosses.
b/ Classes 1 to 9; 1 = extensive damage, 9 = little or no damage. Adapted from Duvick, in Guthrie and Berry (1979).

Table 4. Percentage European corn borer neonate mortality from supernatants of six subspecies of *Bacillus thuringiensis*.

	ml supernatant/ml diet			
	days of incubation[a]			
	33.33		166.67	
Subspecies	7	10	7	10
thuringiensis	92.5 a	99.5 a	38.5 a	72.8 a
tolworthi	92.0 a	97.5 a	26.7 ab	61.5 a
darmstadiensis	88.9 a	97.5 a	17.1 b	58.2 a
galleriae	7.6 b	9.1 b	4.6 bc	4.6 b
kurstaki	1.5 b	1.5 b	0.5 c	1.0 b
kenyae	0.5 b	0.5 b	1.0 c	1.0 b

[a] Means within columns followed by the same letter are similar at the 5% level. Adapted from Mohd-Salleh and Lewis (1983).

Table 5. Introduced microsporidia infections of cornfield-reared European corn borer[a/].

Microsporidia	Pollen shedding stage 1978	Pollen shedding stage 1979	Overwintering 1978	Overwintering 1979
Larvae per plant				
Check	8.3	3.1	8.6	1.0
V. necatrix	5.7	2.1	7.4 ab	0.7
N. pyrausta	6.4	2.1	9.3 a	0.6
N. pyrausta + *V. necatrix*	6.3	1.7	6.8 b	0.4
% diseased larvae				
Check	86.9	57.0	81.8	45.4
V. necatrix	92.0 b	62.2 c	92.6	44.5 b
N. pyrausta	97.0 a	87.8 a	94.4	63.3 a
N. pyrausta + *V. necatrix*	97.5 a	79.3 b	91.5	63.9 a

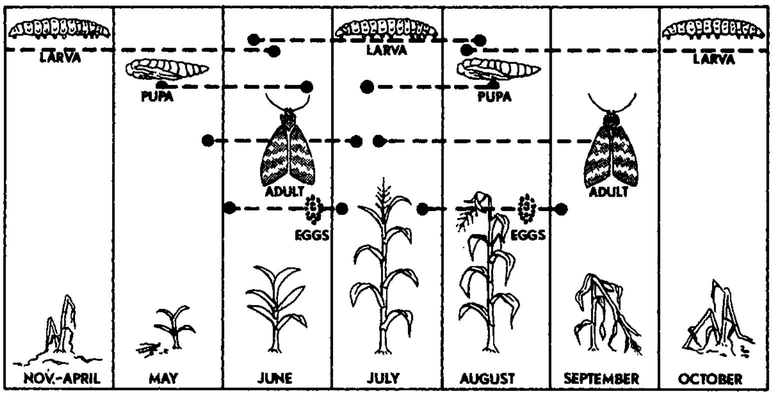
[a/]Means within columns not followed by a letter are similar at the 5% level. Check data for comparison only. Adapted from Lewis et al. (1983).

FOOTNOTES

1/ Journal Paper No. J-11262 of the Iowa Agriculture and Home Economics Experiment Station, Ames, Iowa. Project No. 2513.

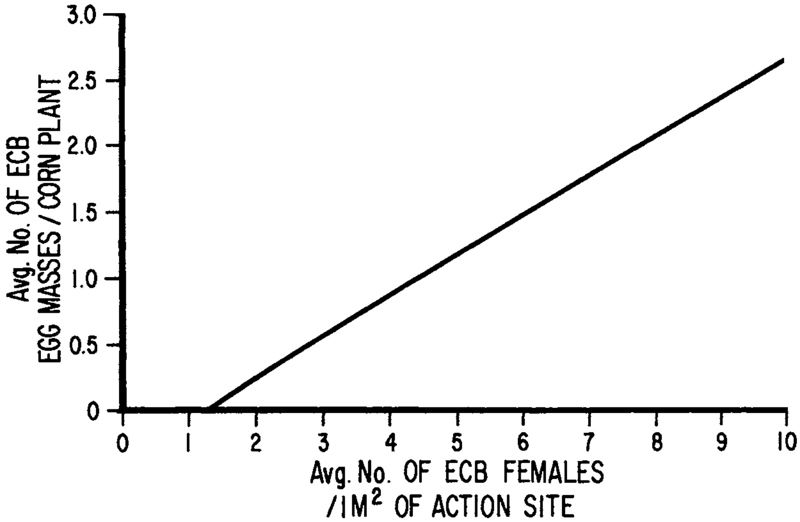
2/ This paper is a summary of his presentation at the University of Minnesota, 1983 Crop Pest Management Short Course.

Figure 1. Tipical life history of the European corn borer.



Seasonal Life History of Two-Generation Form in Iowa

Figure 2. Predicted number of European corn borer egg masses per corn plant based on numbers of female European corn borer moths per meter^2 of dense grass.



MINNESOTA DEPARTMENT OF AGRICULTURE SURVEYS

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The European corn borer, *Ostrinia nubilalis*, has been monitored in field corn since the 1940's. It is probably the best surveyed pest of corn in Minnesota. The following are some of the highlights of corn borer surveys taken by the Minnesota Department of Agriculture.

FALL 82/SPRING 83 SURVEYS

These surveys provide an indication of corn borer population going into overwintering and their survival. They also provide an opportunity to collect larvae to determine parasitism. Two larval collections were taken, one in the fall of 1982 and one in the spring of 1983. Of the 419 larvae collected in the fall, 177 emerged in the laboratory indicating 42% survival. Of the 317 larvae collected in the spring of 1983, 151 emerged in the laboratory indicating 48% survival. The two collections averaged 45% survival.

PARASITES REARED FROM CORN BORER LARVAE	Fall 1982 Collection	Spring 1983 Collection	Percent Parasitism
Eriborus terebrans	11	9	3.8
Macrocentrus grandii	4	7	4.7

The impact of parasitism on the corn borer population was 8.5%.

SUMMER 83 SURVEY

The Department compiles and interprets data collected from 15 insect black light traps distributed throughout the corn growing regions of the state. These traps provide the times of peak occurrences of moth populations so that detection surveys for eggs and larvae can be initiated. Following light trap peak moth catches during the third week of June our field surveys showed unusually high counts of corn borer egg masses. Based on this development the Department issued a corn borer (first brood) economic infestation alert on July 1, 1983.

Corn borer surveys were continued on a weekly basis for the rest of the season. Two important and unusual developments took place.

1. First brood corn borer development was completed about 7-10 days ahead of schedule. This is in agreement with the accumulated heat unit calculations. Moths emerged at approximately 1400 heat units reached by July 31 in most districts.

2. Second brood corn borer development was completed in record time and in record numbers. Eggs were deposited at approximately 1450 and hatched at 1550 heat units by August 3. Larval development was completed with fifth instar larvae found in most districts by August 28, at 2150 heat unit accumulation.

FALL 83 SURVEY

Table 1. MINNESOTA EUROPEAN CORN BORER FALL SURVEY

Survey Period September 26-30, 1983

District	# Counties	% Infested	# borers/ 100 plants	% shanks infested	% ears on ground
WC	6	90	241	44	7.2
C	7	79	178	40	4.6
EC	6	78	149	37	1.1
SW	6	95	295	64	1.5
SC	6	89	181	57	1.6
SE	5	92	241	59	1.6
STATEWIDE AVERAGE		87	214	50	2.9

A total of 181 corn fields in 36 counties were surveyed. Economic threshold of 200 or more borers per 100 plants was reached in 3 districts by the end of September. Average corn ear drop reached 2.9% with WC and C districts indicating even higher levels. As of October, Minnesota Agricultural Statistics Service reported corn for grain yield reduction from 100 bushels to 85 bushels per acre. Estimated production is 371.5 million bushels. A 3% ear loss at the rate of $3.60 per bushel would amount to over $40 million.

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THE CHANGING SCENE: PHYTOPHTHORA ROOT ROT OF SOYBEANS IN MINNESOTA

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In 1983, numerous reports came in concerning occurrence of Phytophthora root rot in Minnesota soybeans which were supposedly resistant to this disease. Laboratory isolations were made from diseased plants and Phytophthora race 3 was identified by innoculating a series of differential soybean varieties in the greenhouse. This constitutes widespread occurrence of a new race of this fungus in 1983 and many of our varieties that were resistant to race 1 are susceptible to race 3.

In the early 50's a significant root rot disease situation in soybeans developed in Canada and shortly thereafter was observed in the eastern soybean belt of the U.S. The fungus Phytophthora magasperma had made its appearance and a series of studies were begun on factors related to its epidemiology. It was quickly recognized as a disease that would probably persist and increase as the crop was planted more widely. In 1964, root rot disease was found in a commercial field near Mankato, Minnesota; by then there were several soybean varieties already developed elsewhere that were resistant to the fungus.

Jean Lambert, Dick Cooper (Plant breeders in the U of M Agronomy Dept.) and I were careful to avoid over emphasis of the existing economic importance of Phytophthora in Minnesota at the time as its occurrence was exceedingly limited. However, we knew that eventually we would have to deal with it and we would also be obliged to deal with the different races of this fungus that would inevitably follow as the years went by.

Race 1, the original race that occurred in Canada and the U.S., began to change rapidly and within 10 years or so farmers in the eastern sections of the soybean belt no longer could count on protection via race 1 resistant varieties. In Minnesota, we predicted many years could go by without the same magnitude of threat. However, we made available soybean varieties that were resistant to race 1 and recommended judicious use of them, - we encouraged usage only when there was a real probability that Phytophthora might occur. Conditions we considered important were wet and poorly drained soil, compacted soils, and history of Phytophthora occurrence. In this way, we hoped to prolong the useful life to resistant varieties by delaying natural development of additional races of the fungus that could attack them.

In 1979, we were called to a farm near Faribault, Minnesota where race 1 resistant variety was being grown and where Phytophthora had caused significant damage. It turned out to be race 3. Following this occurrence, we became more conservative in predicting the longevity of race 1 resistant varieties in Minnesota. Still, race 1 resistance appeared to protect soybeans over the vast plantings in the state during the following years and only occasionally could we locate an example or report of susceptibility of those varieties resistant to race 1. Late in the 1982 season, we found root rot in two fields planted to varieties that were supposedly resistant to race 1 and one field was devastated. We arranged for plot work on the seriously affected field during the 1983 season and alerted colleagues to watch for occurrence of Phytophthora in 1983.

We had a wet fall in 1982*: For the last 4 months of the year, every month had higher than average rainfall for Central (5.5 inches above the 30 year average), Southwest (5.4 inches above normal), South Central (6.6 inches above normal) and Southeast Minnesota (7.5 inches above normal). Then in the spring of 1983, a similar thing happened - Central Minnesota had 2.1 inches of rainfall above normal during March through June, Southwest was 3.3 inches above, and Southeast was 1.3 above. If we consider just May and June, the months that we think are more critical for the infectious stage of Phytophthora - the differences were even greater all across the southern part of Minnesota. Also, during the planting season, temperatures were about four degrees colder than normal.

In accordance with predictions, the disease developed more severely than normal during the 1983 season and isolation from samples from an assortment of varieties resistant to race 1 revealed that race 3 predominated, but races 4 and 6 were also present. Since we suspect that perhaps 90 percent of the Minnesota plantings are resistant to race 1, it is not surprising that those soybeans coming down with Phytophthora this year were infected with something other than race 1. In nature the fungus can move from one location to another in water and soil; it is not seedborne, thus a grower does not come up with Phytophora in his field by planting seeds grown in some other field.

The strategy for controlling Phytophthora in the future is not clear cut. Resistant soybeans, at least the types of race specific resistance we have had in the past, have a limited useful life since the fungus changed on its own and when confronted (pressured?) by massive plantings of resistant soybeans it invariably comes up with a new race that will attack that resistance. The fungus is exceedingly variable and there is evidence that a whole array of variants (races) exist in the environment. The widespread use of race specific resistance increases the speed of change once the resistant variety is released and widely grown.

The relative importance of resistance, temperature, use of chemicals, rotation and other tillage practices, soil drainage, and soil compaction are not well sorted out at this time but are under study. The relationship of "tolerance" or "field resistance" (as compared to single gene resistance to a single race) and its relationship to commercial production is a matter of serious consideration by many in the public and private sectors.

The fall-spring rainfall situation and the cool planting season in 1983 in Minnesota probably accounts for the unusual severity of Phytophthora root rot in the 1983 season and more "normal" seasons should now prevail and ameliorate the problem compared to this year. It is likely, however, that we will need to put more emphasis on control of this disease in the future than we have in the past. We encourage vigilance; several methods of control are being considered and additional research is needed to identify the best method or methods for the grower.

*Data obtained from National Oceanic and Atmospheric Administration

Phytophthora Root Rot - Ward Stienstra

Since 1979, the year race 3 of Phytophthora megaspera (Pm) was found in Minnesota on a farm near Faribault, the continued use of race 1 resistance was in doubt. Experience and research in other states have shown that continued use of race specific resistance, i.e. race 1 resistance failed to control root rot when new Phytophthora races pathogenic to this resistance became widespread. In 1982 and in 1983 more fields in Minnesota were found with races of Phytophthora other than race 1, Chippewa, Cottonwood, Dodge, Jackson, Lyon, Meeker, Mower, Murray, Nobles, Redwood, Rock, Sibley, Steele, Watonwan Counties. (Personal Communication B. Kennedy)

Soybean growers who had Phytophthora Root Rot (PRR) problems in fields with race 1 resistant soybeans in 1983 should rotate to corn in 1984. The solution is not as simple if you plan to plant soybeans again. Race specific resistance, at least the race 1 type of resistance cannot be depended upon in fields where new races of Pm were found. Resistance did offer the best method for controlling Phytophthora. Resistant soybean varieties are not infected by races of Phytophthora to which they are resistant. Race 1 resistance was effective in Minnesota for many years and in some fields may still be a suitable method for disease management. Resistance to races 1-3 and 6-9 is available in Corsoy 79, Wells II, Vickery, and other soybean varieties. The soybean lines with multi-race resistance are more desirable in fields with new races of Pm since in 1983 less damage was found on the multi-race resistant variety Corsoy 79. However, race 4 is now identified in 3 counties (Dodge, Nobles, Redwood) that can attack this type of multi-race resistance. Isolates able to attack multi-race resistance are believed to be a small portion of the race population present in Minnesota and may even be limited to fields with severe PRR history. Multi-race resistance soybean lines should be satisfactory in most of Minnesota in the near future - until race 4 and 5 build up. The rate of development of new races is not predictable but new races ultimately do build up and resistance will no longer be effective. In Ohio, 8 years was required to render race 1 resistance useless. They believe similar build-up can be expected with other races and therefore alternatives to race specific resistance need to be considered. In Minnesota the PRR disease pressure is less severe than Ohio and I would predict rate of resistance development to be slower however, I have no Minnesota data and can only guess.

An alternate to continued use of race specific resistance and multiple race resistance is the use of highly tolerant varieties. It is predicted that 2,048 races of Pm are possible in nature. Not all of these have been found but you can see the problem becomes very large when breeders try to include resistance to all possible races. The highly tolerant soybean plant does not respond to select races of Pm. Tolerant soybean plants have the ability to survive and yield well when infected with Phytophthora. Thus race identification and race specific resistance breeding is by-passed. Highly tolerant varieties have been effective in controlling PRR under mild to moderate disease pressure. A major weakness of tolerant varieties occurs at germination and in seedling stages, while highly tolerant varieties are reported to have little damage from PRR and yield well, they are very susceptible to seedling Phytophthora damping-off. Good stand establishment has been a serious problem from Ohio to Illinois. Replanting costs and reduced yield from delayed planting indicate tolerance alone may not be adequate for Phytophthora management. Captan and Vitavax 200 are not effective in controlling damping-off by Phytophthora. The fungicide Ridomil (Ciba-Geigy), Apion (Gustafson) has shown promise for control of PRR.

Crop production practices also can affect PRR incidence and severity. Drainage, tillage, rotation and fertilization all change levels of PRR. The proper use of production practices can lower Pm damage. This includes tiling to quickly remove excess water, deep plowing to destroy and disperse inoculum, rotation with corn to reduce inoculum and avoiding Ammonium nitrogen just prior to planting. Reduced tillage may also increase the severity of PRR as soils remain cooler and wetter in early stages when plant infection occurs. We must also remember that the fall of '82 was wet and many fields may have not been full plowed. This and wet conditions in May and June '83 may have increased soil compaction which promotes PRR.

Studies with the Phytophthora fungicide - Apion/Ridomil as a seed treatment or a granule over the row at planting time were conducted at several locations. Farmer planted soybeans with and without seed treatment at 3 locations showed little difference in stand on 7/22.

	Plants Per foot of Row	
Location	Treated	No Treatment
1	5.6	5.3
2	7.6	8.3
3	8.3	7.7

At one location, #2 at harvest time plants were collected for analysis. Pods and seeds per plant were determined. Plant stand at harvest (9/27) was nearly the same as found on 7/22. Total seed, seed weight and pods per plant did not vary greatly.

	Treated	No Treatment
#Seed	2547	2569
Seed wt Total	390.4 gms	390.7 gms
#Pods	1078	1090
#Seed/Pod	2.36	2.36
#Seed/Plant	62.12	57.09
#Plants/ft	7.7	8.4

No improvement in yield or stand was observed when resistant soybeans were planted. Disease pressure in these fields was low and the race specific resistance of the soybean was adequate.

At another location where a race that can attack Corsoy 79 was found, early stand was improved. Yield difference due to treatment was improved. Corsoy, (a susceptible variety) stand early and late and yield was increased when seed was treated and/or granules were applied.

Treatments	Stand (Plants/ft)		Yield Bu/A
	7/1	8/19	
Corsoy 79			
Seed only	4.3	4.4	36.1
Ridomil Granule			
3 or ai/1000 Row H	4.9	4.5	41.4
6 or ai/1000 Row H	5.0	4.7	38.1
Apion Seed Treatment			
2.66 FL	4.7	4.0	40.3
350 L	4.8	4.2	32.8
Apion Seed Treatment (350L) and Ridomil Granule			
3 or ai/1,000 row ft	4.8	4.9	38.8
6 or ai/1,000 row ft	4.7	4.2	39.3
Corsoy			
Seed only	3.8	3.1	24.4
Ridomil Granule			
3 or ai/1000 row ft	4.0	3.7	29.8
6 or ai/1000 row ft	4.1	3.5	35.2
Apion Seed/Treatment			
25W	4.5	4.2	32.5
2.66 FL	4.3	3.2	33.3
Apion Seed Treatment (2.66FL) and Ridomil Granule			
3 or ai/1,000 row ft	4.5	4.2	36.2
6 or ai/1,000 row ft	5.7	4.3	39.1

FERTILIZING PIK ACRES IN 1984

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The 1983 PIK program had a major impact on crop production in Minnesota. In addition to the effect on commodity prices, the PIK program will also create some changes in fertilizer management recommendations for the 1984 season.

As the 1983 PIK acres are brought back into production in 1984, it would be ideal if we could make some broad, general statements about fertilizing these acres that would fit all situations. There was, however, considerable variability in the management practices that farmers chose to use on their PIK acres. Therefore, fertilizer management suggestions for the 1984 growing season need to be modified to match these varied management practices.

In general, the acres placed in the PIK program were the problem or least productive acres on the farm. Normally these acres would need special attention with respect to fertilizer management in 1984. The fact that these acres were placed in the PIK program only serves to add a few more problems from a fertilizer management standpoint.

MANAGEMENT PRACTICES USED

Those who traveled throughout Minnesota this past summer generally agreed that the management practices used on PIK acres could be classified into 6 main groups. These are:

- Clean residue from a previous crop of corn, soybeans or small grain. Weeds were controlled with chemicals throughout the growing season.
- Weedy stubble from a previous crop of corn, soybeans or small grain. Weeds were not controlled during much of the growing season. Weeds were controlled late in the season by either tillage practices or chemical treatment.
- Small grain was planted. The crop was planted both early and late in the season. Crop was destroyed.
- Bare fallow. Weed control on these acres was accomplished by using one or more tillage practices.
- Planted to sorghum-sudan.
- Planted to soybeans.

Some of these management practices will dictate that some special attention should be given to fertilizer management in 1984.

For those farmers who planted either soybeans or small grains on their PIK acres in 1983, no changes are suggested. The fertilizer program that would normally be used in 1984 should be followed. For these fields, P and K would be applied as suggested from the results of a soil test. The N recommendations would be based on yield goal (soil nitrate test in western Minnesota) and a previous cropping history of either soybeans or small grains.

The fields where there was a substantial growth of weeds throughout the season do not present any special problem from the standpoint of fertilizer management. The N recommendations for these fields would be based on yield goal (soil nitrate test in western Minnesota) and a previous cropping history of small grains.

The use of a starter fertilizer has always been an important management tool for corn production in Minnesota. Past experiences in Minnesota and other states as well as some recent research conducted at four locations throughout the state point out the special importance of the use of a starter fertilizer for corn production on fields where bare fallow was used or where weeds were controlled throughout the growing season in the residue from a previous crop of corn, soybeans, or small grain. In South Dakota studies, the stunted early growth of corn following fallow was eliminated by the use of a starter fertilizer containing N and P.

The statements above which deal with the use of a starter fertilizer will also be appropriate for fields where weeds were controlled throughout the season and the stubble of corn, soybeans, or small grains from the previous year was not disturbed. These fields do not fit the true definition of a fallow situation. From a fertilizer management standpoint, however, these fields would resemble the fallow situation.

In areas of Minnesota where a soil test indicates a possible need for zinc fertilizer, there would be no objection to applying a small amount of zinc (about 1 lb/acre) in the starter. Remember that zinc deficiencies generally occur in western and southwestern Minnesota and are often associated with soils that have a high pH (> 7.5). It would certainly be advisable to get a soil test for zinc if there is any doubt.

The acres planted to sorghum-sudan present some special problems. It appears that most farmers who planted this crop plowed it under before the middle of September. As this relatively large amount of plant material is incorporated into the soil and starts to decompose, there is a high potential for immobilization of a significant amount of soil N. Even though decomposition takes place and there is some mineralization, it is highly probable that the amount of N that is immobilized will be larger than the amount released through mineralization. Therefore, it is anticipated that there will be some deficit of soil N when this crop is plowed under. To compensate for this anticipated deficit, it is suggested that N rates for corn be increased by 40-50 lb/acre on fields where sorghum-sudan was grown in 1983. In arriving at N recommendations for these fields, corn should be considered as the previous crop. The additional N suggested can be applied when the farmer would normally apply N in his individual fertilizer management program.

THE SOIL NITRATE TEST AS A MANAGEMENT TOOL

The soil nitrate test can be an important tool in arriving at N recommendations for corn in western Minnesota. This test will be especially important for the fields that were placed in the PIK program. This soil test is an easy way to determine if carryover N is either higher or lower than levels which are typical.

If the nitrate test shows that there are high levels of carryover N in the soil, rates of fertilizer N can be reduced for crop production in 1984. If, however, there are lower levels of carryover N in the root zone, N rates which are higher than normal may be needed to get the best yields. The sorghum-sudan may have depleted the amount of nitrate-nitrogen in soils in 1983. So, it is especially important to sample these fields in western Minnesota for residual or carryover nitrogen.

MANAGING N FERTILIZER

The grower may also want to consider some changes in the way that N is managed on PIK acres. It is obvious that weed control will be a major problem for these fields in 1984. So, some may want to consider combining their herbicide with some liquid N (weed and feed concept) as an aid in weed control. There may also be problems with the application of anhydrous ammonia where the sorghum-sudan was either disked or plowed under. Application equipment may collect some of the residue which, in turn, may cause problems with application. For these fields, a broadcast application of urea with some incorporation would be a reasonable alternative.

It should be noted that the above discussion has focused on fertilizer management for corn planted on PIK acres. If other crops are to be planted, fertilizer management presents no special problems. For other crops, fertilizer should be applied as suggested from the results of a soil test. Again, the importance of collecting soil samples from PIK acres is emphasized.

SUMMARY

As growers look ahead to fertilizing PIK acres in 1984, there are some important points to remember. These are:

1. The PIK acres were usually the least productive on the farm. They normally would need special attention. The PIK program underscores this need for attention.

2. Soil testing has always been an important management tool. The collection of soil samples is especially important for the PIK acres.

3. The use of a starter fertilizer for corn production has been widely used throughout Minnesota in the past. Experience tells us that starter fertilizer may be especially important for the bare fallow fields and the fields where crop stubble was kept free of weeds throughout the growing season.

4. Traditional N rates should be increased by 40-50 lb./acre where sorghum-sudan was planted then plowed under in 1983.

POTENTIAL WEED PROBLEMS ON PIK ACRES

D. W. Kidder
Area Extension Agent
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Many of the acres idled in the 1983 PIK program will require some special weed control considerations in 1984. The two major concerns involve high numbers of weed seeds in the soil and increased vigor of perennial weed stands. On acres where weeds were kept down with combinations of tillage, mowing, herbicides, and cover crops, 1984 will probably be little different from other years, but the following are several reasons why special problems may have developed:

1. Necessary weed control practices may not have been used because the cost seemed too high to justify on set aside acres.

2. Weed control operations may not have been properly timed, allowing many weeds to go to seed before control.

3. Perennial weed stands gained in vigor, even though annual weeds were prevented from going to seed with mowing or burn-down herbicide application.

4. Weeds in a solid seeded cover crop were often not sprayed, and allowed to go to seed.

5. Perennial grass or legume cover crops will need to be controlled in 1984, as well as annual cover crops which were allowed to produce seed.

Allowing a few weeds to go to seed on PIK acres will greatly increase the number of weed seeds in the soil. Annual weeds growing without competition are capable of producing an average of 10,000 seeds per plant in a single growing season. A black nightshade plant can have 1,000 berries, each with 50 seeds, a foxtail head may produce 1,000 seeds and a pigweed plant 100,000 seeds. Fields with poor weed control may contain up to 10,000 seeds per square yard capable of emerging. Next year's herbicide treatment may be overwhelmed by these large populations of weed seed. If next year's herbicide gives 95% control, there may still be 500 weeds per square yard emerging in the field. In these situations an early postemergence and possibly later postemergence herbicide treatment will be essential in addition to preplant or preemergence treatments.

Stands of perennial weeds such as milkweed, nutsedge, Canada thistle, perennial sowthistle, and quackgrass can increase in vigor and spread through lateral roots under reduced tillage. It takes two to three years of tillage and herbicide treatment to bring most healthy stands of perennial weeds under control. If a perennial crop, such as alfalfa, was used as a cover crop in 1983, mold board plowing may be the best way to prepare the land for 1984. Where a no-till crop is planned, herbicides such as

2,4-D, dicamba, paraquat, or glyphosate must be used to control the previous year's perennial crop. If a sorghum-sudan grass cover crop was allowed to produce seed before plowing or mowing, it may be preferable to plant soybeans rather than corn, in 1984, so more herbicide options are available.

Fields which were trashy or weedy in 1983 were attractive egg laying sites for some insect pests. Scouting fields early in the season for pests like cutworm and stalk borers will be particularly important. One unique advantage exists for those who had poor weed control on their PIK acres. Accurate weed maps can be constructed for these fields detailing the weed species and densities present. Weed maps are essential for developing the most effective and economic weed control plans for each individual field. In the past, growers have reported as much as $35/A reduced herbicide costs by knowing the identity, location, and density of their specific weed pests.

PLANT RESISTANCE TO HERBICIDES IN MINNESOTA

Richard Behrens
Extension Agronomist - Weeds
University of Minnesota

Herbicide use in Minnesota has been very extensive. It now involves applications to over 15 million acres of cropland each year. The phenoxy herbicides, mainly 2,4-D and MCPA, were the first to be widely used, since the 1940's, with major usage on small grains and corn. In 1982 the phenoxy herbicides were used on over 6 million acres in Minnesota. In the 1950's three other herbicide families were discovered and introduced. The amide herbicides, first represented by CDAA (Randox), now includes propachlor (Ramrod) and alachlor (Lasso) and metolachlor (Dual). Usage of these compounds has been increasing for 25 years on corn and soybeans. In excess of 5 million acres are now treated with the amides each year in Minnesota. Members of the triazine family of herbicides represented by atrazine and cyanazine (Bladex), used in corn and metribuzin in soybeans, have been used extensively for over 20 years. In 1982 these herbicides were used on approximately 3.3 million acres of corn and soybeans. A final herbicide family, used fairly extensively in Minnesota since the late 1950's, is the thiocarbamate family with EPTC and butylate being the major compounds. In 1982 these herbicides were used on approximately 800,000 acres of corn. The dinitroaniline herbicide family first came into commercial use in the early 1960's and usage has been very extensive for 20 years. Currently, herbicides from this family are used on nearly 4 million acres of soybeans, wheat, and other minor crops.

I have outlined the extensive, long-term usage of these herbicide families because it is encouraging to know that with such long term widespread usage of these herbicide families, only two cases of weed resistance to a herbicide have been confirmed in Minnesota. The first case, verified in the winter of 1982 using seed collected in August, 1982, was that of atrazine-resistant common lambsquarters found in southeastern Minnesota (Fillmore County). Verification of a second atrazine-resistant strain of common lambsquarters, found in east-central Minnesota (Goodhue County) was also completed in the winter, 1982. A third common lambsquarters seed sample collected in west central Wisconsin was found to be atrazine-resistant in tests conducted during the spring of 1983.

These discoveries have been widely publicized. Minnesota farmers and county agricultural agents have been encouraged to report any weed infestations suspected of being triazine resistant. However, there were no reports of resistance during the 1983 growing season. Since county agent and public awareness of the resistance problem was substantial, the lack of reports on new problem areas indicates to me that the distribution of triazine-resistant common lambsquarters populations is not widespread in Minnesota.

Continuous corn production for many years combined with the use of atrazine only for weed control is known to favor the development of triazine resistance. To retard the development of herbicide resistant weeds there are a number of management practices that should be utilized. Herbicide rotation, crop rotation, and use of tillage-herbicide combinations are practices that will delay the onset of herbicide resistance in weeds. In weed control all of these possibilities should be utilized to minimize the development of herbicide resistant weeds.

Seeds of suspected herbicide resistant weeds will be tested if seed samples are forwarded to: R. Behrens, Agronomy Department, University of Minnesota, St. Paul, MN 55108.

MINNESOTA PESTICIDE INFORMATION CENTER

The Minnesota Pesticide Information Center (MPIC) is a computerized research and information distribution service utilizing the latest in micro and main frame computer technology. MPIC is a unique, new approach to answering questions about pesticides and distributing information to the public.

MPIC will help pesticide applicators keep up to date on pesticide use, registration, suspension and cancellation information. Staying informed is the key to staying legal. Using or recommending a pesticide for an unregistered use could have serious and embarrassing consequences. Unfortunately, the problem does not stop there. Applicators also often request immediate answers to complex questions such as:

- *What products are registered federally and in my state to control pest "A" on crop "B"?
- *Is a particular product registered for use in my state?
- *What is the toxicity of this pesticide and what formulations can I buy?
- *Is a product registered for use on one crop also registered for use on another crop?

In the past there were three basic options to answering pesticide related questions, either you knew the answer, searched for the label(s), or called someone else. Now there is a fourth option, computerized pesticide information.

Computerized information is far easier to update and maintain current than printed literature and can be searched quickly and economically. However, without computer equipment and trained computer operators these advantages cannot be exploited. The concept of MPIC is to provide the University, Extension and the public access to computerized pesticide information through a self supporting service.

MPIC does not make pesticide recommendations. MPIC maintains the hardware, software and personnel necessary to search the data base(s). The search costs are charged to the user along with a service charge, which is used to pay data base membership, telephone rental and ID fees.

The primary data base MPIC uses is the National Pesticide Information Retrieval System (NPIRS). This system contains pesticide label, registration and tolerance data. NPIRS is updated weekly by computer tapes directly from EPA; thus, is a very important and up-to-date pesticide information source. The data base contains information on about 44,000 pesticide products registered with the EPA and over 5,000 products registered in Minnesota. Product names, names and percentages of active ingredients, names and addresses of manufacturers and other registrants, sites (crops) and pests, classification for each registered pesticide, EPA and Minnesota registration numbers are readily available through NPIRS.

The NPIRS data base has given us a significant advantage during the last 16 months. Particularly useful, is the ability to find what is registered in Minnesota rather than just what is registered at the federal level. To date, more than 95 hours of time has been accumulated on the system answering questions and accumulating data for publications. However, the resources of computerized data on pesticides does not end with the NPIRS system.

While developing NPIRS and gainning experience with its use, we discovered other resources just as valuable . One that we are offering now is a pair of electronic information services from Occupational Health Services, INC (OHS). These data bases, HAZARDLINE™ and ENVIRONMENTAL HEALTH NEWS™ are interactive, time-shared computer databanks providing comprehensive chemical risk information. HAZARDLINE™ provides information designed to protect the health of the worker and maintain the environment. It lists government standards and court decisions on over 1500 substances including pesticides. ENVIRONMENTAL HEALTH NEWS™ is a news service that monitors related government and court actions, major scientific and medical findings and other pertinent news events. OHS will be adding another service in January called PESTLINE that will be totally devoted to pesticides. It includes both EPA/FDA data, plus a great deal of international toxicology.

Our plans for the future also include adding 5 data bases maintained by the National Library of Medicine (NLM).

1. The MEDLARS data base is the computerized literature retrieval service of the NLM.
2. CHEMLINE is a computerized chemical dictionary.
3. TDB is a toxicology data bank.
4. TOXLINE has toxicology information online.
5. RTECS Registry of Toxic Effects of Chemical Substances is the NLM's online, interactive version of the National Institute of Occupational Safety and Health (NIOSH) publication, Registry of Toxic Effects of Chemical Substances.

Access to the information MPIC offers is easily obtained. A visit to Ron Gardner in room 228 Hodson Hall on the St. Paul campus or a telephone call (612) 373-1202 usually is all that's required. The cost of doing a search through MPIC is based on connect time. That means, each minute connected to a data base costs a base amount for each system. It must be stated up front, it is extremely difficult to estimate the cost of each search. Each search is different and requires a different and unknown amount of time to perform; hence, the exact cost is unknown. Usually searches cost between $10 and $60 on NPIRS. The costs of OHS are likely to be relatively lower as the connect time is generally shorter.

The value of using computerized data retrieval and news systems, shares the same initial acceptance problems as did the IPM concept and field scouting. It must be experienced to be appreciated. Everyone that has taken the time to search NPIRS has learned something new in the process and in some cases NPIRS was the only way of collecting the desired information. So I encourage you to put this resource to use for the benefit of your profession and your clientele.

Additional information can be obtained by calling or writing the following:

MINNESOTA PESTICIDE INFORMATION CENTER
MPIC

Ronald D. Gardner
University of Minnesota
219 Hodson Hall
1980 Folwell Av
St. Paul, Mn 55108
(612) 373-1202

NPIRS

James White
User Services Manager
Entomology Hall, Purdue University
West Lafayette, IN 47907
(317) 494-6614

Occupation Health Services, Inc
HAZARDLINE™, ENVIRONMENTAL HEALTH NEWS™

Robert S. Florida
(800) 223-8978

National Library of Medicine

Bethesda, Maryland 20209
(800) 638-8480