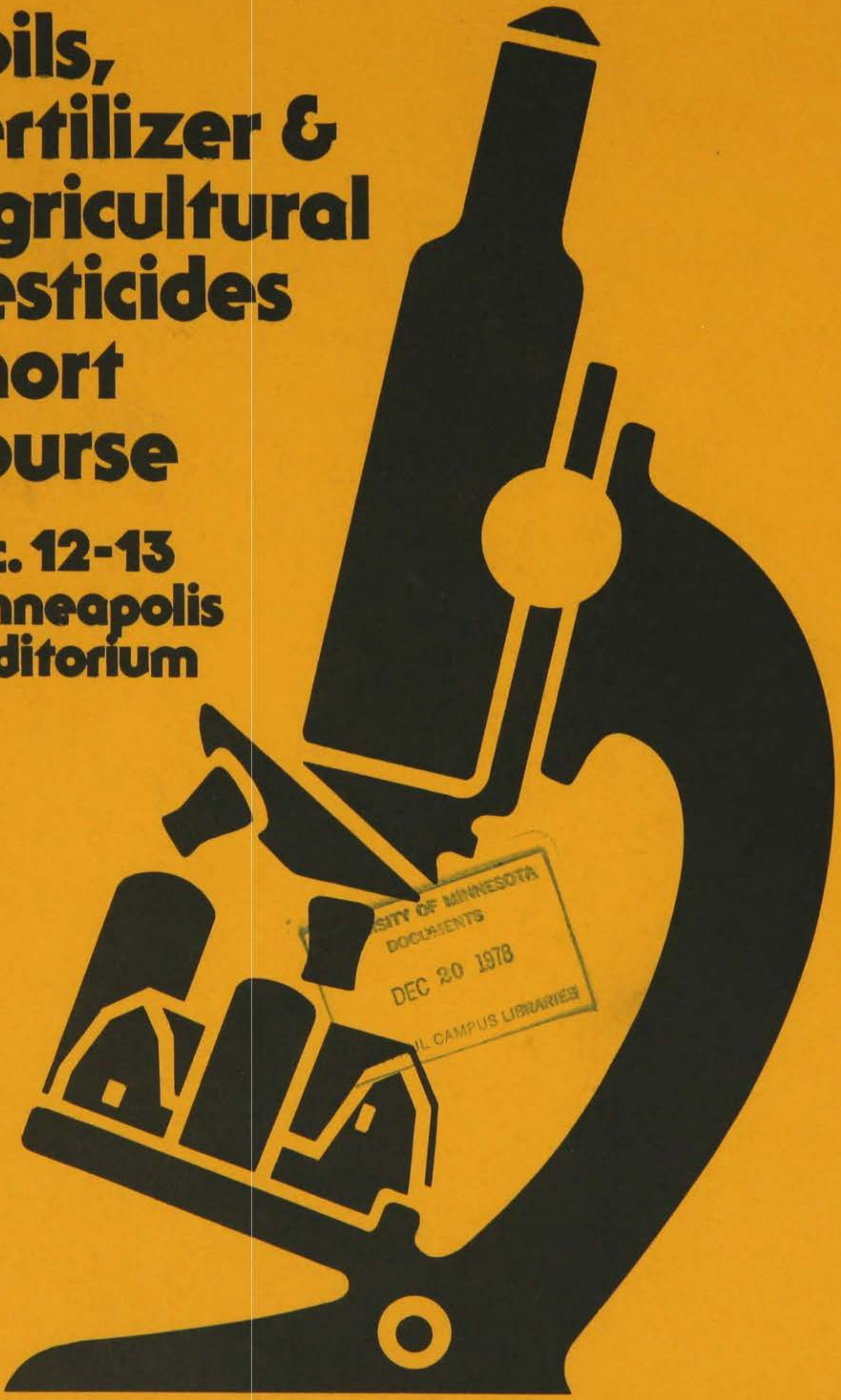
Soils, Fertilizer & Agricultural Pesticides Short Course

Dec. 12-13
Minneapolis Auditorium



Office of Special Programs Educational Series 1—3.

PROCEEDINGS

SOILS, FERTILIZER AND AGRICULTURAL PESTICIDES

SHORT COURSE

December 12-13, 1978
Minneapolis Auditorium

Presented by the
University of Minnesota
Institute of Agriculture, Forestry and Home Economics
Agricultural Experiment Station
Agricultural Extension Service
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1978 CROP YEAR REVIEW AND LOOKING TO 1979

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1978 - a season with dire crop forecasts several times that came out smelling like a ROSE. Our 1978 growing season was set up with a fall in 1977 that was wetter than normal, and total rainfall in 1977 well above average with 9 inches above at Lamberton. With the added moisture in the soil, the spring was slower in warming up than it had been for the last couple years and thus getting into the field later. The mechanization allowed most of the corn and soybeans to be planted close to on time once they could get into the fields.

A dryer than normal May and June in the western half of the state was followed by a wetter than normal July and August. Perhaps a good handle to have on corn and soybean production in Minnesota is the July rain makes the corn and August rain makes the soybeans.

A hot dry spell with maximum temperatures 13 degrees above average the first 10 days of September effectively ended the growing season at the Southwest Experiment Station, Lamberton. A difference in the shower patterns over the summer made the effect of this hot dry spell more pronounced in some areas.

A common question asked at a time like the first week in September is - "What effect will this have on yield?" What one should perhaps answer is "Compared to what?" If however we were to look at the yield potential the first or middle of August, it had to have taken some toll in kernels that didn't quite fill out or soybeans just a little smaller.

However, with mechanization to get the crop in quickly, good seed, excellent fertility, good weed control chemicals, potential for an excellent root system, and a season that was abnormally normal , an excellent crop was produced.

A series of slides show the growth and development of the corn and soybean crops throughout the season.

Looking to 1979 in the crystal ball would indicate more fields have fall tillage than normal, the fall was excellent for fertilization and this should have been accomplished to a large extent. With normal or lower than normal soil moisture, unless the winter has a tremendous snow or a wet spring, spring work will start earlier than 1978. All the inputs into the 1979 crop production system need to be supplied from the very start at near optimum levels if the best crop with the abnormal weather we're likely to have in 1979 happens!!

EFFECT OF PRECEDING CROP ON CORN YIELD

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INTRODUCTION

During the 1950's, 1960's and even into the early 1970's crop production philosophies of both researchers and producers tended to indicate that crops preceding corn had no effect on the following corn crop. The attitude that "continuous corn yields surpassed or equaled yields of corn when in a rotation" prevailed. Shrader (1), in 1968, concluded in a summary of several years of rotation experiments in Iowa, that equal corn yields can be produced from various cropping systems ranging from continuous corn to corn following three or more years of meadow, provided proper fertilizer is applied and weeds, insects and soil erosion are controlled. Experiments at Purdue University (2) showed no effect of the previous crop on corn yields where adequate levels of fertility were maintained.

However, within the past few years research results and the experiences of farmers indicate that the previous crop is having a marked effect on corn yields. Corn yields in replicated trials conducted in 1978 by Tilney Farms in Watonwan County indicated a 10.3 bu/A advantage for corn following soybeans (162.4) as compared continuous corn (152.1) (Personal communication with Edgar Urevig, General Manager, Tilney Farms, Lewisville, MN).

The reasons for these yield differences are not clearly understood and at the present time a great deal of speculation exists. Thus, the purpose of this paper is to present the effects of previous crops on corn yield in Minnesota studies and to speculate on why these effects are occurring.

EXPERIMENTAL PROCEDURES

Four crop sequences (continuous corn, corn-soybean, corn-wheat and corn-wheat + alfalfa) were established in a replicated study in 1974 on a Webster clay loam. Each of the sequence blocks was split into six 15-foot wide strips to evaluate N rates (0, 40, 80, 120, 160 and 200 lb N/A). In the fall of 1974 and 1975, urea was fall-applied and plowed down immediately. Anhydrous ammonia was spring-applied in 1977 and 1978. Wheat has received 50 lb N/A as urea each year. Broadcast P and K (0+50+100 lb $N+P_2O_5+K_2O$/A) was applied annually to all plots. Row P and K (0+30+45 lb $N+P_2O_5+K_2O$/A) was applied to the corn.

Corn has been planted in 30" rows at 26,100 ppA in early May each year. The hybrid was Pioneer 3780 in 1975, 76 and 78 and Pioneer 3709 in 1977. Era wheat and Hodgson soybeans were planted in late April and mid-May, respectively, each year.

A non-winter hardy alfalfa was planted with the wheat in 1974 and 1975. Since then Agate was the alfalfa variety used.

Each year weeds were chemically controlled along with one cultivation. A Lasso-Bladex combination was applied pre-emergence for corn. Soybeans received a Lasso-Amiben pre-emergence treatment. Broadleaf weeds in wheat were controlled with MPCA plus Bromoxynil. Wheat interseeded with alfalfa received no herbicide.

All corn plots regardless of the previous crop received a band-applied insecticide at planting. The insecticide rotation included Furadan in 1974, 1976 and 1978 and Counter in 1975 and 1977.

All plots were moldboard plowed in early November each year.

RESULTS

Yield results from the four years can be split into (a) two "dry" years, 1975 and 1976, when rainfall during the growing season averaged 12.54"--7.14" below normal (Table 1) and (b) two "normal" to moderately wet years, 1977 and 1978, when rainfall averaged 21.90" during the growing seasons (Table 2).

In the "dry" seasons when stress conditions were severe, continuous corn yields averaged only 46 bu/A without N and 66 bu/A with 200 lb N/A (no response to N at rates greater than 160 lb/A in either year). However, when soybeans, wheat or wheat + alfalfa was the previous crop, yields were increased to 84 to 92 bu/A without N and 104 to 108 bu/A with 200 lb N. The approximate 20 bu/A yield response to the 200 lb N treatment did not appear to vary with previous crop. When no N was applied, interseeding of alfalfa with wheat appeared to boost corn yields over wheat alone in 1975 but not in 1976. With adequate N fertilization differences among soybeans, wheat or wheat + alfalfa with respect to corn yields the following year were not significant.

Table 1. Influence of the previous crop on corn yields in two dry years at Waseca.

Corn yield following	1975		1976		1975-76 Avg.	
	lb N/A					
	0	200	0	200	0	200
	bu/A					
Corn	56	83	35	50	46	66
Soybeans	84	111	87	105	86	108
Wheat	83	106	86	101	84	104
Wheat + Alfalfa	96	108	88	102	92	105
May-Sep.[1/] rainfall (inches)	14.10		10.97		12.54	

[1/] 30-year normal = 19.68"

Corn yields were substantially higher in the "normal" to wetter years (Table 2). When no N was applied yields ranged from 93 bu/A with continuous corn to 128 or 129 bu/A with either soybeans, wheat or wheat + alfalfa as previous crops. At the 200 lb N rate yields ranged from 154 bu/A with continuous corn to about 175 bu/A following other previous crops. Again, with adequate N fertilization, differences among soybeans, wheat or wheat + alfalfa with respect to corn yields the following year were not significant. When no N was used, interseeding of alfalfa with wheat as compared to wheat alone boosted yields by 24 bu in 1978 but showed a yield reduction of 27 bu/A in 1977.

Table 2. Influence of the previous crop on corn yields in two average to relatively wet years at Waseca.

Corn yield following	1977		1978		1977-78 Avg.	
	lb N/A					
	0	200	0	200	0	200
	bu/A					
Corn	97	151	89	157	93	154
Soybeans	146	171	110	176	128	174
Wheat	147	171	111	182	129	176
Wheat + Alfalfa	120	163	135	179	128	171
May-Sep.[1/] rainfall (inches)	24.25		19.54		21.90	

[1/] 30-year normal = 19.68"

Looking at these same data expressed as yield increase over continuous corn (Table 3), we find the same magnitude of increase (40 bu/A) due to the three other previous crops whether N was added or not in "dry" years with stress conditions. However, in "normal" years when corn yields without N averaged about 35 bu/A higher following soybeans, wheat or wheat + alfalfa, they averaged only 20 bu higher when more than sufficient N was added (200 lb N/A). This would indicate that fertilizer N is only partially able to reduce the effect of previous crops on corn yield.

Also, corn yield increases attributed to the previous crops (soybeans, wheat or wheat + alfalfa) were greater in the "dry" years under stress conditions than during "normal" years. This would indicate that soil moisture may be a factor in this effect. Under both sets of climatic conditions, soybeans, wheat or wheat + alfalfa appeared equal as a preceding crop to corn.

Table 3. Corn yield increase attributed to the preceding crop as compared to continuous corn at Waseca.

Previous Crop	"Stress" Years (1975-76) lb N/A 0	200	"Normal" Years (1977-78) lb N/A 0	200
	------Yield Increase (bu/A)------			
Soybeans	40	42	35	20
Wheat	38	38	36	22
Wheat + Alfalfa	46	39	35	20
Average:	41	40	35	20

Yields of the preceding crops to corn are shown in Table 4. Respectable yields have been obtained except for soybeans in 1974 which were damaged by the September 3 frost and wheat in 1977 which was due to a late planting date (May 2).

Table 4. Yields of previous crops in the crop sequence - nitrogen rate study at Waseca.

	Year 1974	1975	1976	1977
	----------bu/A----------			
Soybeans	27.0	45.2	43.1	51.0
Wheat	52.7	63.4	56.7	32.1
Wheat + Alfalfa	52.0	59.2	56.8	35.9

Results obtained from an 8-year study at Lancaster, Wisconsin (3) show substantially higher corn yields following soybeans and alfalfa in comparison to continuous corn regardless of N rate (Table 5). At the 0 and 75 lb N rates yields of 2nd and 3rd year corn were better than continuous corn. This difference was negligible at higher N rates.

Table 5. Influence of previous crop on corn yields in an 8-year study (1967-1974) at Lancaster, WI. (3)

Corn yield following	N rate (lb/A) 0	75	150	300
	----------bu/A----------			
Continuous Corn	78	114	125	116
2 years Corn	85	118	126	124
1 year Corn	105	125	126	126
Soybeans	125	132	134	127
1 year Alfalfa	122	133	132	134
2 or more years Alfalfa	130	136	138	132

Data gathered over 5 years by Iowa State University on a Clarion-Webster soil association show corn yields to be higher when the previous crop was soybeans, oats or alfalfa as compared to two or more years of corn (Table 6).

Table 6. Influence of previous crop on corn yields in a 5-year study (1972-1976) on a Clarion-Webster soil association in Iowa.[1/]

Previous crop	Years in previous crop	5-Year Average Corn Yield[2/] (bu/A)
Corn	2 or more	116
Soybeans	1	121
Oats	1	125
Alfalfa	1	131
"	2	129

1/ Personal communication, Regis Voss, Iowa State University from presentation at 1978 North Central American Society of Agronomy meetings, Madison, WI.

2/ All yields were obtained with N rates from 120 to 180 lb/A.

DISCUSSION

Definite reasons for depressed continuous corn yields as compared to corn in a crop sequence are not known. However, we can speculate on a number of factors that could be responsible for these differences. Actually, we can develop a qualitative equation such as

Yield difference = a+b+c+d+e+f+g+h+i+ other factors

where a = soil moisture
b = fallow effect
c = allelopathy
d = microbial activity
e = nutrient availability
f = compaction
g = tilth
h = rootworms
i = nematodes

In some cases all of these factors may play a role whereas in other instances perhaps only one or two factors contribute. For instance, soil moisture may not have any direct influence in years of adequate or surplus rainfall. Also, there may be significant interactions between these factors, i.e., soil moisture and fallow effect, compaction or rootworms. Possible effects of each of these factors are outlined below.

Soil Moisture

Soil moisture has been shown to be higher following soybeans than after corn. Also, any crop that is removed by mid-August, e.g. wheat, does not transpire water for the rest of the season; hence, soil moisture could be recharged more quickly and completely. Therefore, if limited soil moisture conditions exist, more water would be expected to be available following soybeans or wheat.

Fallow

Crop yields have been shown to benefit from fallowing land the previous year. Active growth by wheat and soybeans terminates much earlier than corn. Thus a "rest" period or brief fallow period exists.

Allelopathy

Allelopathy is defined as "the influence of one living plant upon another due to secretion of toxic substances". Perhaps the presence of last year's corn roots and the incorporated above ground residue along with the secretion of toxic substances from these materials as they decompose could inhibit corn root development. On the other hand, as soybean or wheat roots decompose, organic materials may be released creating an environment that is better for corn root growth. This may also enhance the development of microorganisms creating a rhizosphere effect.

Microbial Activity

Increased microbial activity especially following soybeans may have an effect on root growth and nutrient availability.

Nutrient Availability

The availability of nutrients to plant roots may be influenced by both fallowing and microbial activity. Also as the high residue amounts from a corn crop are returned to the soil, perhaps they may tie up certain nutrients.

Compaction

Nearly all corn is planted before soybeans. Many times the soils are much wetter during corn planting and compaction from secondary tillage becomes severe. Also heavier equipment such as silage wagons and manure spreaders may accompany continuous corn production.

Tilth

Soybean producers have noticed for years that soil following a soybean crop has greater tilth. We have also noticed this effect following wheat. This could effect corn root development and growth.

Rootworms

Corn rootworm populations are known to build under continuous corn cropping. Even with the best insecticides, rootworm control is less than 100% and probably more like 80%. Thus, these uncontrolled rootworms may have a depressing effect on corn yields especially in dry years when their feeding on the roots would decrease the ability of the plant to obtain water.

Nematodes

Localized, high infestations of lesion nematodes have been reported in Minnesota especially under continuous corn. These nematodes also affect root growth and perhaps yields.

SUMMARY

Corn yield results indicate significant and economic yield depressions associated with continuous corn as compared to corn in soybean, wheat or wheat + alfalfa sequences. Farmers should take this into account along with the expected price, production costs, workload and their crop use plans (sell or feed) when planning their crop program.

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FERTILIZER NEEDS UNDER CONSERVATION TILLAGE

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INTRODUCTION

Interest in conservation tillage practices as a means of conserving energy and labor, as well as soil and water, has increased considerably over the past decade. Many farmers have been forced by economic pressures into cropping potentially erodable soils more intensively than desirable, often at the expense of traditional soil conservation practices. For whatever reasons, farmers are making less use of the moldboard plow and are trying out different degrees of "minimum" tillage. Practices range all the way from complete no-till to various plow-plant-spray combinations in a single operation.

Energy requirements under different tillage systems have been reviewed by Berge (1975), who points out that the main energy expenditure in any system is that required for artificial drying. Use of earlier maturing varieties or delaying harvest until the moisture content were low enough for safe storage would reduce that energy expenditure. Energy saved in tillage might be partly offset by energy needs in the form of additional herbicides and/or fertilizer. In a field-scale comparison of plowing vs. no-plow corn production in Wisconsin, Berge (1975) obtained 6% higher yields, over a six-year period, with conventional tillage as compared to the no-plow system. However, the no-plow method resulted in a 17% greater energy efficiency when measured in terms of yield per gallon of diesel fuel. (See Table 1).

Conservation tillage systems may affect crop yields by their affects on soil temperature, moisture relationships, rate of mineralization of crop residue, insects and disease, weed competition, soil compaction and fertilizer requirements. Lodging and corn leaf diseases, for example, have been greater on unplowed plots at low K levels than on plowed plots on a Plano silt loam soil in Wisconsin (Karlen *et al*., 1973; Schulte, 1975). The greater incidence of Chocolate Spot (*Pseudomonas syringae*) and percentage of broken stalks in unplowed plots appeared to be due more to reduced K availability in the unplowed plots than to surface debris *per se*. Chocolate Spot and stalk breakage were substantially reduced when ear leaf tissue was increased to 1.6%. However, this level of tissue K required a soil test K level of about 225 kg/ha in unplowed plots, compared to 190 kg/ha for plowed plots (Karlen *et al*., 1973).

Soil temperatures tend to be lower under conservation tillage, and this temperature reduction often depresses corn yields (Burrows and Larson, 1962; VanDoren, 1965; Willis *et al*., 1957). Soil moisture should be increased on sloping soils under conservation tillage as a consequence of increased infiltration and reduced evaporation losses. This increased moisture may reduce yields by delaying planting and keeping some soils cooler longer in the spring, but most workers have reported yield increases (Blevins *et al*., 1971; Harold *et al*., 1967; Moody *et al*., 1963; Triplett *et al*., 1968). Mineralization of crop residues should decrease as tillage decreases owing to poorer incorporation, cooler soil temperature and less stirring of the soil. After one season Bennet *et al*., (1975) found significantly higher levels of total N and mineralized N under untilled quackgrass plots as compared to tilled plots. By the following spring, differences associated with tillage had disappeared. It is generally agreed that increased levels of N are required for conservation tillage (Bandel *et al.*, 1975).

Do different tillage systems require different fertilization practices? This question has not been answered adequately. In early research comparing conservation tillage with conventional tillage, the fertility level was held constant while tillage methods were varied. Nutrient levels were assumed to be adequate, and yield differences were attributed to differences in soil temperature, soil moisture, soil structure or other factors. Little or no incorporation of fertilizer and crop residue is possible with no-till cropping. This should affect nutrient distribution and availability. Phosphorus and K broadcast and left on the soil surface do not move very far from the point of application and, thus, might not be as available to crops as nutrients incorporated into the plow layer. Similarly, crop residues left on the soil surface will not decompose and release nutrients as rapidly as they would if plowed under.

Randall (1977) studied the distribution of N, P and K in the top foot of a Webster clay loam soil under different tillage systems. With continuous chisel plowing, disking or no tillage, nearly half of the P and K was found in the top two inches. Griffith (1974) found that the pH of the upper two inches of soil may drop significantly as a result of broadcast N applications. Just how important this nutrient and pH stratification might be to crop growth is not well known.

EXPERIMENTAL

In 1972, we initiated a study of fertility-disease interactions in corn on plots that previously had been fertilized with different rates of N, P and K. To encourage corn leaf diseases, one set of plots was left unplowed the following years so that some of the debris from the previous crop remained on the soil surface. Aside from the effects of plowing on the incidence of leaf diseases, we observed a drastic yield reduction on the unplowed plots. This yield reduction was greatest on plots without added K, as shown in table 2. The lower yields on the unplowed plots were associated with lower concentrations of potassium in ear leaf tissue sampled at the silking stage. It was apparent that for some reason both the added K and the K already in the soil were less available to the crop when the plots were not plowed.

Plowing had less effect on the N content of the ear leaf tissue than it did on K (Table 3). Only at the highest rate of application (160 lbs N/A) was the difference in N concentrations significant statistically. The yield reduction due to not plowing was actually accentuated somewhat by N fertilization (Table 3). We believe that this is caused by the stimulating effect of N on overall plant growth, thereby aggravating the K deficiency on the unplowed plots. Nitrogen as the nitrate ion is soluble in soil and is moved down into the root zone with percolating rainwater.

The level of available soil P had no influence on yield whether the plots were plowed or not. However, soil P in this Plano silt loam averaged 70 lbs per acre, which is high. Surprisingly, the P concentration of ear leaf tissue was higher in the unplowed plots. This is believed to be a simple dilution effect. That is, the higher yield of dry matter in the plowed plots resulted in a lower P concentration in the ear leaf tissue.

It appears, then, that the availability of K was most strongly affected by plowing. Application of fertilizer in a band alongside and below the row should render the plant nutrients, especially K, more available to the plant than when these nutrients are left on the soil surface. So in 1975 we applied 40 lbs per acre each of N, P_2O_5 and K_2O in a band two inches to the side and two inches below the seed.

The use of row fertilizer greatly reduced the yield difference between plowed and unplowed plots (Figure 1). In fact, row fertilizer used with 160 lbs per acre each of broadcast N and K_2O resulted in a slight yield increase in favor of the unplowed plots. Ear leaf K increased significantly as a result of the row fertilizer application. Neither the N nor the P concentrations of the ear leaf tissue were affected by the row fertilizer, however. Thus, we conclude that the principal benefit of the row fertilizer on this soil was due to the improved K availability.

Aside from the relationship between soil fertility and tillage, we observed also that there was a 30 bushel per acre higher yield on check plots (no fertilizer applied) that were plowed than on the unplowed check plots. Soil penetrometer readings on plowed and unplowed plots taken in April before tillage indicated that soil compaction was considerably higher on the unplowed plots. A compacted soil results in restricted root development, reducing the capacity of the plant to take up K.

In 1978 we initiated a study of fertilizer requirements under three tillage systems -- conventional plow, chisel plow and no till. Within each tillage system we are comparing six rates of N, different soil P and K levels and row fertilizer. Corn yields averaged all fertility treatments were about 10% higher under conventional and chisel plowing than under no tillage (Table 4). Both no till and chisel planted corn responded to starter fertilizer. Corn on conventionally plowed plots responded to starter fertilizer at low levels of soil test P and K (Tables 5, 6).

We conclude that lower K availability in the unplowed soil was the principal reason for the lower corn yields obtained. This reduced availability was a result both of soil compaction and lack of incorporation. A farmer planning to go to conservation tillage, then, should be sure that his soil test levels are medium to high before discarding the moldboard plow. If necessary, corrective applications should be made and plowed down. Thereafter, adequate maintenance fertilizer should be applied to keep the soil test levels near optimum. Some of the maintenance fertilizer should be applied in a band for row crops.

The results obtained in these studies on Plano silt loam at Arlington, Wisconsin, may be unique to this particular soil and climate. Similar results might not be obtained on other soils or in soils that warm up sooner in the spring. We are extending our research to other soil types and hope that this research will enable us to give better fertilizer recommendations for different tillage systems.

Table 1. Influence of plowing on corn yields and energy requirements. (Arlington, WI. After Berge, 1975, updated to 1977).

Year		Grain yield @ 15.5% H_2O	
		Plowed	Not plowed
1969		158	142
1970	NS	146	144
1971	NS	111	106
1972	NS	81	78
1973		128	114
1974	NS	87	82
1975		116	109
1976		125	121
1977		127	125
	Avg.	120	113

NS = no significant yield differences

Energy expended:

	Plowed	Not plowed
Gallons diesel fuel/acre	19.6	15.7
Bushels grain/gal. fuel	6.05	7.08

Table 2. Effects of plowing and added potash on corn yields and K in ear leaf tissue.

K_2O applied annually ('73-'76)	Yield loss from not plowing (Plowed-unplowed)	K in ear leaf tissue	
		Plowed	Unplowed
lbs/A	bu/A	---------%---------	
0	37	0.73	0.59
80	26	1.40	1.04
160	13	1.71	1.42

Table 3. Effects of plowing and added N on corn yields and N in ear leaf tissue.

N applied annually ('73-'76)	Yield loss from not plowing (Plowed-unplowed)	N in ear leaf tissue	
		Plowed	Unplowed
lbs/A	bu/A	---------%----------	
0	20	2.05	2.00
80	28	2.69	2.60
160	28	2.81	2.64

Table 4. Yield of corn grain as influenced by starter fertilizer and tillage. (Arlington, WI, 1978 preliminary data.)

Starter*	Grain yield @ 15.5% moisture			
	No till	Chisel	Plow	Avg.
	----------------bu/A----------------			
None	94	102	110	102
6-36-9	100	109	111	107
8-48-12	106	118	113	112
Avg.	100	110	111	107

*Starter: 133 lbs/A of 6-36-9 (blended); 100 lbs/A of 8-48-12 (mfd.)

Table 5. Effect of soil test P on yield of corn on plowed plots as affected by starter fertilizer.1/

Starter*	Soil test P, lbs/A				
	<40	40-60	61-80	>80	Avg.
	----------------Yield, bu/A----------------				
None	119	123	117	133	123
6-36-9	123	125	121	130	125
8-48-12	124	133	137	135	132
Avg.	122	127	125	132	127

*Starter: 133 lbs/A of 6-36-9; 100 lbs/A of 8-48-12

1/ Arlington, WI. Preliminary 1978 data; low N plots excluded.

Table 6. Effect of soil test K on yield of corn on plowed plots as affected by starter fertilizer.[1/]

Starter*	Soil test K, lbs/A <150	150-200	201-250	>250	Avg.
	---------------------------Yield, bu/A---------------------------				
None	117	126	129	125	124
6-36-9	120	126	129	129	126
8-48-12	130	134	139	123	132
Avg.	122	129	132	126	127

*Starter: 133 lbs/A of 6-36-9; 100 lbs/A of 8-48-12.

1/ Arlington, WI. Preliminary 1978 data; low N plots excluded.

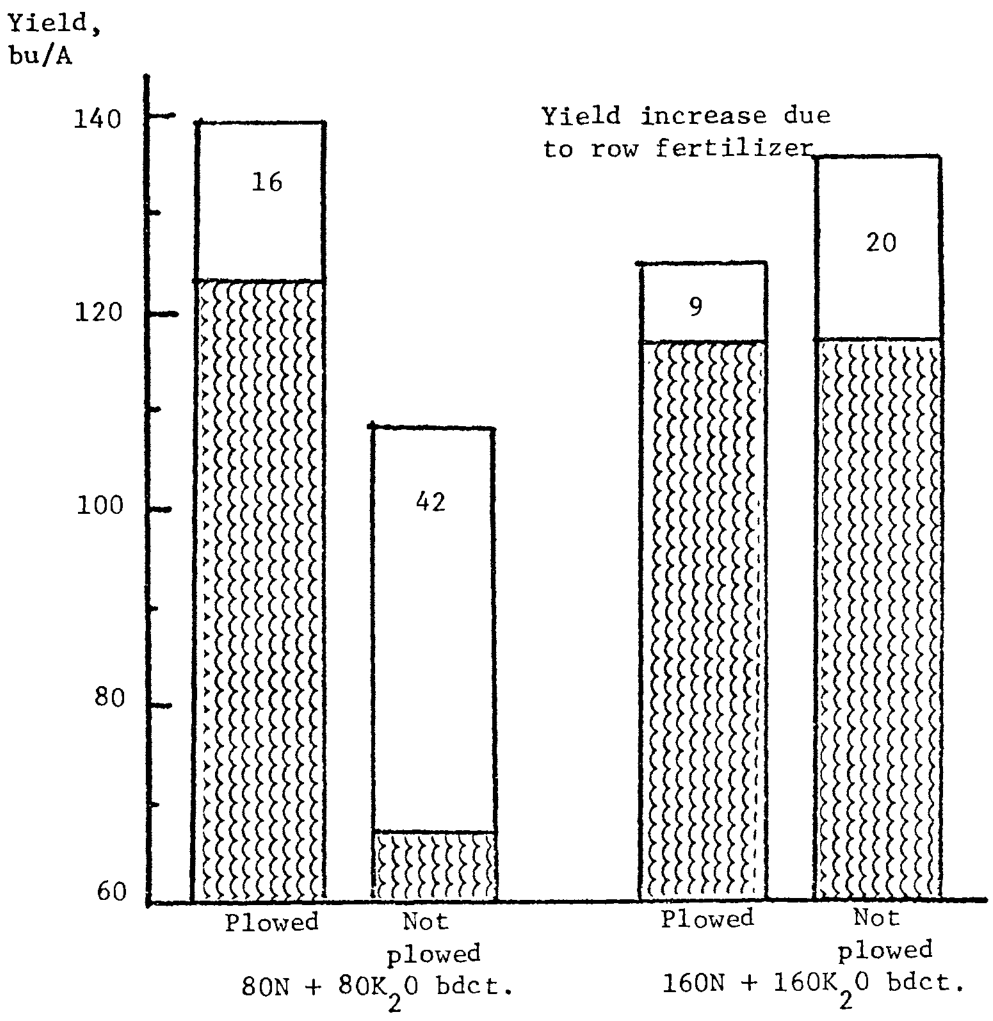

Figure 1. Effect of plowing on crop response to row fertilizer in 1976 (40+40+40, lbs/A).

ENERGY CONSERVATION IN CROP PRODUCTION

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The oil embargo of the mid-1970's, prompted a serious concern about energy use and conservation. Since agriculture is a very visible user of energy, many asked questions about conservation in production agriculture. In response to these concerns the Council for Agricultural Science and Technology (CAST) commissioned a task force to evaluate available information on energy use in agriculture. Their report (3) is the primary basis for this paper.

ENERGY SUPPLY

Most of us were confronted with "out of gas" signs, limits on amount of gas we could purchase, and/or lines at filling stations during the oil embargo. Since those occurrences in the mid-70's most of us have had no difficulty in purchasing oil products. In fact, we have even seen the return of "gas wars" in some areas. This, then, raises the question "is there an energy problem?" The answer to that question depends on who you ask. I am not an expert in energy supplies, and I will not attempt to tell you whether there is or will be an oil shortage in the near future; there is no doubt, though, that there is not an infinite supply of fossil fuels. With this in mind, it behooves all of us to conserve energy whenever this can be done without creating a hardship on society.

CONSEQUENCE OF REDUCED ENERGY SUPPLIES

The total food system from production through the final stages of cooking consumes 16.5% of the energy used in the U.S. Of that 16.5%, production agriculture uses 18%, or 3% of the total energy used in the U.S.A. This is less energy than is required to fuel jet aircraft in this country.

A recent Iowa study indicated that a doubling of energy cost would result in a 13% increase in farm commodity prices. This same study showed that a 5% shortage in fuel supplies to production agriculture would result in a 26% increase in farm commodity prices. These calculations assume continuation of production agriculture as it exists today. These affects would be minimized if conservation was possible.

The U.S. population benefits from the use of energy in agriculture in several ways. Obviously it is one of the best-fed countries in the world. In addition, farmers produce substantial amounts of food and fiber that is exported. During 1978, exports of agricultural products totaled about $27 billion. This compares to oil imports of $44.5 billion. In other words agricultural exports accounted for 60.7% of the oil imports while using only 3% of the total U.S. energy to produce food and fiber for domestic and export markets.

The purpose of agriculture is to capture solar energy in plants and to use the living organisms sustained by the energy to produce needed food and fiber. The use of energy has enhanced the production of useable food and fiber through adequate fertilization and pest control, which has resulted in lower food prices for the consumer. It has allowed this to be accomplished with greater efficiency of human labor. Those people released from the ranks of farm labor are now available to increase the national wealth by producing goods and services in other aspects of the economy.

ENERGY CONSERVATION

The average energy consumption in crop production is shown in Table 1. These figures help determine areas where conservation is most likely and what the impact may be for reduced consumption in any or all of these major production inputs. The largest single energy consumption item in crop production is fertilizer production. Tillage, grain drying and irrigation also require substantial amounts of energy.

Table 1. Energy Consumption in Crop Production.

Operation	% of Total
Machinery manufacturing	2
Pesticides	2-5
Irrigation	6-13
Field operations	10-15
Drying	16
Fertilizer	30-38
Other	15-20

Field operations

Field operations, including tillage and harvesting, consume about 15% of the crop production energy. Suggestions for reducing this energy include the return to animal agriculture (replace tractors with horses), reduce tillage (conservation tillage), and improved operation and maintenance of the existing machinery.

To produce today's crops with 1918 technology would require 61 million horses and mules. To produce this number of animals from the 3 million available in 1975 would require 20 years. Once accomplished, it would require 180 million acres of cropland (1/2 current U.S. cropland) to feed the animals. While this would conserve fossil fuel, it would markedly reduce the amount of food and fiber available to feed the world population and as a consequence food prices would increase. In addition to the horses and mules required we would need an additional 26 million people over what are currently employed in agriculture. That is several million more people than are currently unemployed.

Reduced tillage has been advocated as a means of reducing energy consumption; however, upon close examination one finds that the energy conservation associated with this practice may not be substantial. While it is true that from 3 to 4 gallons per acre of diesel fuel equivalent may be saved by converting to zero-till corn, such a shift is not made without some important compensating management changes. As shown by data from Nebraska (Table 2) increased use of pesticides, particularly herbicides, is usually essential. Wisconsin data indicates the possibility for increased potassium fertilization and Illinois data indicates a need for increased nitrogen fertilization. Increases in fertilization and pesticides will likely more than off-set the energy saved by reducing tillage.

Table 2. Energy to Produce Irrigation Corn. (1)

Operation	Gallons of Diesel Fuel Equivalent per acre	
	Conventional tillage	No-till
Tillage and seeding	4.1	1.0
Fertilizer	30.2	30.2
Herbicide/Insecticide	1.1	1.4
Irrigation	30.9	30.9
Harvest	1.1	1.1
Drying	13.7	13.7
Transportation	3.0	3.0
Total	84.1	81.4

With present technology, many of the reduced tillage systems are not yet fully adapted for use on all soils. Both Illinois and Minnesota research has shown that the no-tillage system does not yield as well as conventional tillage. Farmers are not going to adopt practices without knowing whether their production will equal that achieved by conventional tillage. The greatest benefit of reduced tillage is in soil and water conservation rather than energy conservation. This could, in the long run, lead to energy conservation.

In the short run, improved maintenance and operation of equipment will likely result in the most conservation of energy which can be expected.

Irrigation

Use of energy in irrigation is a vital production input in areas where we cannot grow crops without irrigation. Improved water management, improved efficiency of irrigation systems, and eventual use of solar energy will conserve energy in conventional fuels.

Pesticides

According to a recent estimate, one third of the crop production in the United States is lost to pests, including insects (13%), diseases (12%), and weeds (8%). There is an additional 10% loss of stored foods due to rodents, insects, and microorganisms. The small percentage of the total agricultural production energy being used for pesticides is a very vital part of agricultures energy use.

Three main methods of controlling weeds (the most important pests of crops) are mechanical cultivation, chemical herbicides, and hand labor. In experiments on corn in Minnesota (2), the energy input for weed control was greatest with mechanical cultivation, less with herbicide chemicals, and least with hand labor. The net profit from weed control was greatest with herbicide chemicals, less with mechanical cultivation, and substantially negative with hand labor. Hand labor is not a practical alternative. It costs too much, and its productivity is too low. If hand labor were to be used to control the weeds in the U.S. corn crop, 18 million people would be required; this is four times the total number of people employed on all U.S. farms. Mechanical cultivation and herbicide chemicals are the only reliable economic methods for controlling weeds in crops.

Although insects and diseases cause devastating losses, only a small amount of energy is used to produce and apply the pesticides needed to control them. The principal alternatives to chemical control are use of genetic resistance and crop rotations. Genetic resistance (insect- and disease-resistant crop varieties) has a very low energy cost and is easy to use, but is technically difficult to achieve and often impossible to maintain because of mutation of the pests. Crop rotation is sometimes a highly effective means of pest control, but it may reduce the productivity of the land because of the necessity for growing crops of relatively low economic value. The so-called pest-management technique now being developed attempts to judge the need for pesticides by periodic evaluation of conditions in the field and then applying the appropriate chemicals when conditions and experience indicate that a justifiable economic benefit will result. This technique is analogous to that of testing soils for fertilizer needs, now a well-established practice. The pest-management technique will no doubt become well accepted where economic benefits from it use can be demonstrated.

Fertilizers

The large amount of energy used for fertilizers is consumed mainly in producing nitrogen fertilizers. Nitrogen is the most important limiting nutrient in crop production. Most nitrogen fertilizer is produced by combining nitrogen from the atmosphere with hydrogen from natural gas to form ammonia. From 38,000 to 40,000 cubic feet of natural gas are required to produce one ton of ammonia; 2% of the total amount of natural gas used in the United States goes for ammonia production. The amount of energy used in the average U.S. residence per year is the equivalent of that required to produce about five tons of ammonia; when applied to corn this amount will return enough additional food to meet the minimum energy and protein needs of 275 persons for a year or the energy equivalent to produce 30 tons of ammonia.

The principal alternative for nitrogen fertilizer used in the past was crop rotation, including a legume that fixed substantial amounts of atmospheric nitrogen and left enough in the soil to meet the needs of the following nonlegume. When the cost of nitrogen fertilizer was so greatly reduced after World War II, use of fertilizer nitrogen became more profitable than legume nitrogen. The cheap fertilizer (along with other technological developments) made it profitable to grow a nonlegume "cash crop" during the year or years that would otherwise be devoted to the less profitable legume. At present, the most useful compromise systems are (1) rotating corn and soybeans (a profitable leguminous crop) and (2) growing a leguminous "cover crop" in the winter months in southeastern states. Both systems require less fertilizer nitrogen than is required for a purely nonlegume system. Use of a legume intercrop between rows of a nonlegume "cash crop" has potential, but needs further development. In areas where seasons are long enough to allow a second crop, double cropping will result in harvesting of solar energy for a longer period.

Another alternative for fertilizer is use of organic wastes, including animal manure and sewage sludge. These are not practical substitutes because only small amounts are available. The collectable animal manure is sufficient to fertilize only 18% of the cropland, and the available sewage sludge is sufficient to fertilize only 1% of the cropland. Some sludge from industrial areas contains heavy metals that could be detrimental to crop production.

Since legumes do not require nitrogen fertilization, their fertilizer energy requirement is markedly less than for non-legume crops. Therefore shifting to legume crops would appear to be energy conserving. This shift in cropping patterns would also require a shift in food preference. Instead of steak, we would be eating texturized protein. Calculations made by Drs. Howell and Hanna at the University of Illinois indicate there would be a savings in both energy and dollars if we shifted from beef to texturized protein; however, if one assumes that the money saved would be spent for televisions, cars and other products, there would actually be a net energy loss since the other items would require more energy than is saved by shifting to texturized protein.

Drying

Another important use of energy in agriculture is crop drying. Artificial drying of crops consumes about 16% of the energy used in production agriculture. Although crops used to be dried naturally, much of the corn and certain other crops are now dried artificially. The reasons are principally economic. With corn, artificial drying makes it possible to reduce losses in the field and to grow late-maturing varieties that yield more than the early-maturing varieties that could more easily be dried naturally. Proper use of solar energy is expected to provide a cost-competitive alternative to use of LP gas for crop drying in some areas in the near future.

ENERGY PRODUCTION

Although production agriculture uses energy, it also produces usable energy in amounts considerably greater than those used. Some thought has been given to the potential for using the "biomass", or organic materials produced by plants and animals as a source of energy for other purposes. Biomass materials represent a renewable energy resource. They are low in sulfur and hence present no problem in complying with pollution-control regulations when burned as a source of heat. The residues are beneficial when returned to the land. The disadvantages are the economics of collecting and transporting the bulky materials and the increase in soil and water losses that result when the biomass is removed from the land.

SUMMARY

In summary, there are many ways energy may be conserved in crop production, harvesting, and drying operations. The economies generally represent trade-offs in which production is decreased or in which substantial investment in alternative technologies is required to maintain the production now achieved by inputs of energy. The development of crop varieties resistant to specific insects or diseases is an example of an exceedingly economical way to conserve energy otherwise required to produce and apply the pesticides to control the insects or diseases. Here the limiting factor is the capability to produce the resistant crop varieties. The development of solar-powered engines to replace the gas-, diesel-, and electric-powered devices to pump irrigation water is an example of a technically feasible, but economically uncompetitive way to conserve conventional energy sources. Solar-powered engines now cost too much per unit of output to be acceptable in practice in the United States.

The farmer readily accepts new technologies if they fit into his total production system, if they can be shown to be profitable, and if they do not place him at undue risk.

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PREDICTING NITROGEN AND MICRONUTRIENTS NEEDS BY SOIL TESTS

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Phosphorus, potassium and soil acidity tests have long been used as a satisfactory means of predicting the economical use of lime, phosphorus, and potassium fertilizer. The work published by Roger Bray of Illinois - (1948) established the relationship between soil tests and corn yields. The phosphorus and potassium soil test values and their correlation with crop yields are still valid on most soils today.

Soil tests for predicting nitrogen and micronutrient needs have developed more slowly and in the past have often been of questionable value.

Recent research has shown that certain nitrogen and micronutrient soil tests on the soil can be very helpful in making fertilizer recommendations.

Investigations in Minnesota, North Dakota, Nebraska, and Kansas have shown that a nitrate-nitrogen (NO_3-N) test made on soil samples taken to a minimum of 2 feet can be useful in determining nitrogen rates for most field crops.

The University of Minnesota has used the NO_3-N test as means of making nitrogen recommendations on small grain and sugarbeets in western Minnesota since 1971. Recent research would indicate that the test could also be used for corn in most regions of the state. It is rather certain that there is little likelihood of response to nitrogen fertilizer when the surface 24 inches in the soil profile contains more than 150 lbs. of nitrate-nitrogen. The key to use of this test is obtaining a representative sample to a depth of 2 feet. Farmers with a special interest in a more specific means of adjusting their nitrogen use are finding this test valuable.

Although soil scientists have made remarkable progress in developing soil tests for micronutrients, in the last 10 years considerable difficulty is still being experienced in calibrating tests against plant uptake and plant growth responses.

To date investigations have shown that in Minnesota on <u>certain soils</u> on <u>certain plant</u> species certain micronutrient applications can result in significant increases in crop yields. A summary of the present situation follows:

ZINC

Deficiencies are most frequent in western and south-central Minnesota. Corn is the crop most commonly effected. Associated soil conditions include high pH, high phosphorus and often poor drainage. A reliable soil test is available - (DTPA extractant).

IRON

Deficiencies can be found in western and south-central Minnesota. Soybeans, flax, and several ornamental plants are effected. Associated soil conditions are high pH, high soluble salts. No reliable test is available.

BORON

Deficiencies occur in north-eastern and east-central Minnesota. Associated soil conditions are low organic matter and drought. No reliable test. Plant analysis is generally preferred.

COPPER

Deficiencies occur on peat soils in northern Minnesota. Associated with newly farmed peat soils. Wheat, oats, and barley are crops most affected. A reliable test is being calibrated.

MAGANESE

To date no deficiencies have been reported in Minnesota.

PRACTICING SOIL TESTING

Soil testing is used to some degree in nearly all parts of the world. The success of its use is related to the amount and quality of research available for the calibration and interpretation of tests.

The ultimate objective of soil testing is economically sound fertilizer recommendations.

Soil testing is a program that depends upon several components of good quality namely:

- Accuracy in field sampling
- Chemical analysis
- Fertilizer research
- Personal judgement

Personal judgement is especially important in todays fertilizer use. Different soils differ a great deal in their production potential. The application of fertilizer nutrients can not substitute for many of the physical and climatic limitations imposed upon us.

The <u>challenge feeding</u> of crops is as important as the individual feeding in livestock. Crops grown on soils of different capabilities must be fertilized according to their potential. The key to economical production is to know the upper limit of your soil production potential and then fertilize and manage the crop to meet that challenge. Farmers should establish their own challenge crop feed lots. Here they can adapt new technology to their farming practices.

There are few soils farmed in Minnesota which do not require fertilizer applications for profitable crop production. On some soils excess fertilizers are being applied. We are now being faced with environmental concerns.

The best way of determining what constitutes adequate but not excessive fertilizer use for high and efficient crop production is a sound soil testing program backed up by good quality research.

PROGRESS WITH NITROGEN INHIBITORS

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The efficient management of fertilizer nitrogen for high yield should be a primary goal for both the fertilizer dealer as well as the producer. Efficient nitrogen management should result in high yields, with greater returns to the producer enabling the producer to more fully utilize his production potential. At the same time, if nitrogen is used effectively for crop production less should remain in the soil, minimizing the environment concerns related to nitrate nitrogen contamination of ground waters.

Nitrogen management must take many things into consideration depending upon geographic location, yield potential, and individual management operations. Such things as rates of nitrogen to apply, forms to be utilized, methods of application, and time of applications must all be addressed. Another relatively recent addition to the nitrogen management picture has been the commercial availability of nitrification inhibitors. Although many chemicals are known to inhibit the nitrification process, there is only one product-N-Serve-(trademark of the Dow Chemical company) which is commercially available as a nitrification inhibitor.

Nitrification Inhibitors and Nitrogen Management

Where do nitrification inhibitors fit into a nitrogen management program? Most of the fertilizer nitrogen which is applied directly to the soil will after an initial reaction be present within the soil as the ammonium form. This includes all of that applied as anhydrous ammonia, urea, 75% of that in 28% N solutions, and 50% of the N in ammonium nitrate. The ammonium form may be utilized by plant roots, but because of it's positive charge will not move a great deal in the soil. Under warm temperatures and adequate moisture conditions certain microorganisms have the ability to transform this ammonium nitrogen into nitrate nitrogen - the process known as nitrification. The nitrate form of nitrogen is also available to plant roots, but because of its negative charge is not held by the clay and organic matter within the soil and is therefore free to move with soil water. If rainfall is excessive, or if the soil has a low water holding capacity, available nitrogen may be lost (Leaching). The nitrate form of nitrogen may also be lost from a soil system through the process of denitrification. Again a microbiological process which is thought to take place most rapidly under warm, moist or saturated soil conditions. The nitrate nitrogen which undergoes transformation is converted to a nitrogen gas and lost to the atmosphere. Under both situations resulting in a net loss of available nitrogen to the plant. As the term therefore implies, nitrification inhibitors are chemicals which interfere with the organisms responsible for the conversion of ammonium nitrogen to nitrate nitrogen. In theory if you slow down the rate of nitrate formation you stand the risk of losing less nitrogen if leaching or denitrification conditions develop. The two extreme conditions where nitrification inhibitors should have their greatest potential are on 1) coarse textured soils, especially those under irrigation, which have a low water holding capacity and which may be susceptable to severe leaching losses and 2) on fine textured soils, where drainage is slow, where "ponding" of water may occur for several days after a rainstorm, or essentially in those areas where denitrification losses may be severe.

Research on Coarse Textured Soils

Yield increases from the addition of fertilizer nitrogen are normally most consistant and most dramatic on irrigated coarse textured soils. Losses of nitrate nitrogen through leaching could also be a significant factor under these conditions. Nitrogen management therefore becomes critical if we are to maintain high yields on these soils. The most efficient manner to apply nitrogen under this situation is to apply the nitrogen according to crop demand. Under irrigation this is often approximated with either side-dress applications or applications through the irrigation water. Depending on the season and the individual management operation many times nitrogen management is not optimum for highest yields. Experiments have been conducted for two year at the irrigated Sand Plains Research Farm at Becker Minnesota to investigated nitrogen management and potential use of nitrification inhibitors.

Timing of Nitrogen Application

To evaluate potential nitrogen losses and the influence of nitrification inhibitors trials were set up to compare single preplant applications to split (1/6 preplant, 1/6 12-18" plant height, 3/6 at sidedressing and 1/6 at tasseling) nitrogen applications. Two nitrification inhibitors N-Serve (Dow Chemical) and Terrazole (experimental chemical of the Olin corporation) were compared to no inhibitor treatment at nitrogen rates of 0, 60, 120, 180 and 240 #N/A applied as urea. The yields obtained in 1978 are presented in Table 1.

Table 1. 1978 Corn grain yields at Becker, MN as influenced by nitrogen rate, time of application and nitrification inhibitor treatment. 1/

Nitrogen and Inhibitor Treatment 2/	Corn Grain Yields 15.5% moisture				
	Nitrogen Rate - #/A				
	0	60	120	180	240
	--bu/A--				
Preplant Applications					
No Inhibitor	59	89	105	136	170
N-Serve		119	150	169	181
Terrazole		98	145	170	186
Split Applications					
No inhibitor		117	167	191	192
N-Serve		127	181	191	190
Terrazole		137	179	196	190

1/ Gary Malzer - Univ. of MN Soil Science Dept.

2/ Inhibitor rates of application = 0.5# active ingredient/A

In 1978 on these course textured soils under irrigation, nitrogen losses were very severe. At normal recommended nitrogen application rates of 180 #N/A management of nitrogen through split applications produced 55 bu/A more corn than single N applications at the same rate. The nitrogen responsible for this yield difference was probably lost through leaching and the amount lost will eventually end up in the underlying aquifer. The benefits of utilizing nitrification inhibitors with single N applications also provided large yield increases. Although the use of nitrification inhibitors did not appear to stop all of the nitrogen loss, highly significant yield gains were obtained. At the lower nitrogen rates yield increases were also obtained when the nitrification inhibitors were utilized with split nitrogen applications. This would suggest that there was some nitrogen loss even with split applications.

Nitrification Inhibitor Rates

Current recommendations for the use of N-Serve normally call for up to 0.5# active ingredient per acre (1 quart). There has been some concern regarding this amount - can we get by with less? Do we need more? Should the climatic conditions influence the rate? The results obtained at Becker MN regarding nitrification inhibitor rate are presented in Table 2.

Table 2. Influence of Nitrification Inhibitor and Nitrification Inhibitor Rate on Corn Grain Yields.[1]

Nitrification Inhibitor [2]	Corn Grain Yield - 15.5% moisture				
	Nitrification Inhibitor Rate #ai/A				
	0	1/8	1/4	1/2	1.0
	bu/A				
N-Serve	104	136	149	141	158
Terrazole	104	116	124	137	152

[1] Gary Malzer, Univ. of MN Soil Science Dept.

[2] Applied with 120# N/A as UREA preplant and incorporated.

These results would suggest that nitrification inhibitor rates are very important. Grain yields increased with increasing inhibitor rates indicating that less nitrogen was being lost. The different chemicals also appear to react differently depending upon the application rate. Further research is warrented to determine what rates would be the best and what influence climatic and/or soil factors might have on the optimum nitrification inhibitor rate.

Incorporation and Nitrogen Form

Results from 1978 have demonstrated that incorporation of both chemicals tested is critical if they are to be effective in inhibiting nitrification (Table 3). Loss of the inhibitor to the atmosphere may take place in a matter of hours or less resulting in essentially no effect of the treatment. Inhibitors also appear to be effective on the ammonium fraction of different nitrogen forms, but will have no influence on that fraction which would be in the nitrate form as demonstrated with 28% N solutions. Spray applications of an inhibitor and incorporation following broadcast application of fertilizer material such as urea appear to be viable techniques for application.

Table 3. Influence of Nitrification Inhibitor Incorporation, Nitrogen[1] form and method of application on corn grain yields - Becker, MN - 1978.

Nitrification Inhibitor Treatment [3]	Corn Grain Yield - 15.5% Moisture; Nitrogen Source [2]: Urea		28% N Soln.	
	Incor.	Non-Incor.	Incor.	Non-Incor.
	bu/A			
No Inhibitor	101	92	78	76
N-Serve	155	83	116	91
Terrazole	144	85	112	83
N-Serve Sprayed-Post-fert.	137	85	-	-
Terrazole Sprayed-Post-fert.	152	90	-	-

1/ Gary Malzer - Univ. of Minn. Soil Science Dept.

2/ 120 #N/A applied preplant.

3/ Inhibitors were applied as coating on urea, mixtures in solution or spray applications following fertilizer application. Inhibitor rates = 0.5 #ai/A.

Research on Fine Textured Soils

Nitrogen management of the fine textured soils of Minnesota must take many other factors into consideration if high yields are to be maintained. Fine textured soils characteristically have higher waterholding capacities and often internal drainage may not be rapid. These soils therefore stay wet longer in the spring, are slow to warm up because of the excess water, and may often slow down field operations in the spring. For this reason it is often advantageous to apply fertilizer nitrogen in the fall. Present recommendations suggest that fall applications of N should be delayed in the fall until soil temperatures fall below 50-55 degrees. This recommendation is made in order to minimize the nitrification of ammonium N to nitrate. In that way if environmental conditions develop which would favor nitrate nitrogen losses through leaching or denitrification less nitrogen would be succeptable to loss. Thus we are looking at the same principal or mode of action related to nitrification inhibitors. Trials were established at the experiment stations at Waseca, Lamberton, Morris, and Crookston to investigate more closely nitrogen management as it pertains to nitrogen rates, timing of nitrogen application, and the interactions of nitrification inhibitors (N-Serve) under these conditions. All experiments were similar with three fall applications and one spring application, with two nitrogen rates at each time either with, or without N-Serve (0.5 #ai/A). Rates of nitrogen application, and timing of application were adjusted at each site to conform with recommended rates and climatic conditions. The experiments as they were established in 1977-78 are presented in Table 4.

Table 4. Nitrogen management experiments on fine textured soils.

	Experiment Location [1]											
	Waseca			Lamberton			Morris			Crookston		
N Rate-#/A	0	75	150	0	50	100	0	40	80	0	40	80
Date of N Application	9/14 11/7		10/14 5/2	9/15 11/1		10/6 5/11	8/25 10/25		9/28 5/17	8/24 10/25		10/2 4/27
N-Serve Rate #ai/A	0		1/2	0		1/2	0		1/2	0		1/2
Test Crop		Corn			Corn			Corn			Wheat	

[1] Malzer, Randall, Nelson, Evans, Varvel

The results form these trials are summarized in tables 5 and 6. The three nitrogen management parameters under investigation have been grouped and averaged over treatments.

Rate of N Application

In general large yield responses to the application of fertilizer nitrogen were not obtained in 1978 at these locations, Table 5. Good responses were obtained at Waseca, with smaller responses at Morris and Crookston, and no response at Lamberton.

Table 5. Influence of Nitrogen rate on grain yields - 1978 [1]

Nitrogen Rate	Grain Yields			
	Location			
	Waseca	Lamberton	Morris	Crookston
	bu/A			
0	131	128	116	33
Med.	167	125	130	45
High	168	127	130	51

[1] Malzer, Randall, Nelson, Evans, and Varvel.

Timing of Nitrogen Application

Some very interesting information was obtained concerning the appropriate time for nitrogen application (Table 6). Trends for the most part were inconsistant within a location, and relatively few similarities were apparent across locations. One generalization that was consistant is that spring applications of nitrogen were not necessarily superior to fall application. The dramatic reductions in corn yields at Lamberton with spring application, especially when overall no nitrogen response was obtained would suggest that there are more factors involved in nitrogen management than just rates and potential losses of fertilizer nitrogen.

Table 6. Timing of Nitrogen Application and it s Influence on Corn Grain Yield. - 1978 [1]

Time of N Application	Grain Yields			
	Location			
	Waseca	Lamberton	Morris	Crookston
	bu/A			
Early Fall	164	131	128	48
Mid Fall	167	124	131	50
Late Fall	171	128	132	46
Spring	168	120	129	48

[1] Malzer, Randall, Nelson, Evans, and Varvel.

Use of Nitrification Inhibitors

As a general result, no positive yield responses were obtained to the use of N-Serve in fall applications across all of the experiments. Positive yield responses of 14 bu/A were however obtained with spring N applications at two locations - Waseca and Lamberton. Further information from Waseca with Terrazole would suggest that the rate of nitrification inhibitor applied (0.5 #ai/A) may not be high enough if used with fall applications. A factor which deserves closer consideration when evaluating the influence of a nitrification inhibitor in a fall application program.

General Summary

Over the past several years it has been demonstrated that both chemicals, N-Serve and Terrazole are effective in delaying the rate at which ammonium N is converted to nitrate nitrogen (nitrification). If environmental conditions develop which are conducive to nitrate nitrogen losses either through leaching and/or denitrification, beneficial yield responses may be obtained with the use of nitrification inhibitors.

Nitrogen management of coarse textured soils under irrigation for high yields was critical in 1978. Large nitrogen losses were incountered resulting in lowered yields. Use of nitrification inhibitors minimized nitrogen losses and resulted in yield increases. Immediate incorporation of the nitrification inhibitor chemicals was critical for effectiveness of the chemical. Rate of nitrification inhibitor use, method of application, and forms of nitrogen material also appear to be important and deserve further study. Use of N-Serve in fall nitrogen application programs gave no positive yield increases in 1978 under the conditions investigated. Positive yield responses were obtained in two out of four locations with N-Serve in spring nitrogen applications. Evidence would suggest that nitrification inhibitor rates higher than those recommended might be necessary for fall applications.

It also appears that nitrogen management and efficient nitrogen use may be influenced by more factors than just rates of application and potential nitrogen losses.

Nitrogen efficiency by corn, with or without irrigation

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Studies have been conducted under dryland and irrigated conditions to determine the efficiency of uptake of fertilizer nitrogen by corn. The fate of the fertilizer nitrogen was determined by tagging it with heavy nitrogen (15-N).

When fall and spring applied nitrogen (urea) was compared, about 15% more of the nutrient was taken up by corn from a spring application (W. Central Exp. Sta.). About ½ of the applied nitrogen was found in the above ground portion of the plant (mature), and about 25% remained in the soil in the top 2'. Thus about 75% of the applied nitrogen was accounted for.

Increasing rates of application of nitrogen (ammonium sulfate) from 120 lbs. N/A to 240, resulted in decreased uptake of nitrogen by corn (S. Central Exp. Sta.). About ½ of the nitrogen came from the fertilizer when 120 lbs. N/A was applied; the heaviest rate was 25% less efficient.

Experiments on irrigated corn at Park Rapids showed that corn plants absorbed 50% of the nitrogen applied (as ammonium nitrate) in a split application. The soil contained 25% of the nitrogen in the fall after corn harvest; the amount found in the soil the next spring was reduced to 18%.

Over 50% of the nitrogen (urea) was recovered in irrigated corn when the fertilizer was applied in several increments from planting time to tasseling (CMIRD, Staples). When all the fertilizer was applied at one time (planting), only 30% of the nitrogen was found in the plant. Whether the nitrogen was applied at one time, or in split applications, the amount retained in the soil was about 20%.

Studies on time of nitrogen applications to irrigated corn showed that nitrogen was used most efficiently when applied to corn about 2 feet in height, (CMIRD, Staples).

WHERE DO THE GRANULES GO?

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The recommended placement of insecticides for corn rootworm larval control is a 6- to 7-inch band over the row and lightly incorporated. This provides a zone of protection from larval damage around the primary root region at the base of the plant. By not concentrating the insecticide in the seed furrow, there is the added advantage of separating potentially phytotoxic chemicals from the seed and seedling. To produce the desired application for rootworm control, corn planters are equipped with some type of "bander" that works in conjunction with an arrangement of press wheel, drag chain, or spring tines to apply and incorporate the insecticide.

Recently, planter manufacturers have introduced planters with improved furrow opening and closing devices. A representative of an agricultural chemical industry that markets an insecticide for soil insect control in corn reported to us that with the increased use of the new planters, they had received more complaints of seedling corn being damaged by their insecticide. To determine if there was a difference among planters in where they positioned insecticides with respect to the seed we studied the placement of insecticides by 3 corn planters. The more traditional planter that we looked at was the John Deere Model 71 unit planter. The other 2 planters, representing the newer plateless planters, were the International Harvester Cyclo® planter and the John Deere Max-Emerge®.

The planters were tested during the fall of 1977 after several rains had thoroughly moistened the soil. The granules used were untreated clay granules, supplied by Mobil Oil Company, that are used as a carrier for their 10% granular insecticide formulation of Mocap®. The granules were coated with a bright-yellow fluorescent spray paint and applied to the field at the recommended rate of 10 pounds per acre. Holes were dug across the rows to provide a cross section of the seed-furrow area. Pictures of the granules' positions were taken at night using an ultra-violet light to cause the granules to fluoresce so that they could be recorded on high-speed film using a timed exposure of 1 to 2 minutes.

The John Deere unit planter was equipped with split-disc furrow openers, a single furrow closing disc mounted on the left side of the unit, and a press wheel to firm the seedbed. During the first trial, all 3 planters were equipped with drag chains for incorporation of the insecticide.

The photograph of the furrow region of the Model 71 unit planter shows that the insecticide has been incorporated above the seed. It also shows, however, that when the disc closer moved soil from the left to the right to close the seed furrow, it also threw the granule band to the right of the seed furrow. The amount of displacement of the insecticide band could be reduced by adjusting the amount of soil that was moved by the disc.

The International Harvester Cyclo planter was equipped with disc furrow openers, a pair of knife furrow closers, and a press wheel to firm the seedbed. The knife closers were mounted quite far back and were actually somewhat behind the insecticide bander. This meant that the seed furrow was not completely closed at the time the bander passed over it. The photographs of the insecticide placement show that the insecticide was incorporated above the seed. The moist soil, however, encouraged the seed furrow to remain open until after the bander had passed. The knives closed it just ahead of the press wheel. This permitted a fair amount of the insecticide to fall into the seed furrow region.

The John Deere Max-Emerge planter was equipped with split-disc furrow openers. With the Max-Emerge planter, the seed furrow is closed and the seedbed firmed at the same time by the 2 wheels set at an angle at the rear of the planter. The lack of a closing device allowed the seed furrow formed in the moist soil to remain open until the bander had passed over it, and it was closed by the compaction wheels. This allowed the granules to fall into the seed furrow with the seed. To prevent the granules from falling over the open furrow, the bander was moved to the rear of the planter. John Deere markets a bracket that allows the bander to be mounted in the rear by the herbicide bander. This applies the insecticide after the furrow has been closed by the compaction wheels and it eliminates the granules from the seed furrow.

Once the rains began in the fall, the soils did not dry out enough to allow the planters to be used in dry soil conditions. We did conduct studies, however, in the laboratory in which the Max-Emerge planter units were operated in a bin of soil. This allowed the soil moisture to be controlled. Tests run using dry soil conditions showed that the seed furrow crumbled in after passage of the opener. The furrow had slid shut sufficiently by the time the bander passed over it to preclude the granules from falling into the furrow.

It appears, therefore, that the probability of applying phytotoxic chemicals in such a way as to damage corn seedlings is dependent upon a combination of soil moisture conditions, and the equipment used and its adjustment. When using equipment that is not designed to close the seed furrow ahead of the insecticide bander in moist soil conditions, crop damage may result from phytotoxic insecticides. Under these situations, it would be advisable to move the insecticide bander behind the compaction or press wheels. This will insure that the seed furrow is completely closed before the insecticide is applied. The insecticide can still be incorporated using a drag chain or spring tine incorporator mounted behind the bander.

INTEGRATED PEST MANAGEMENT FROM A FARMER'S VIEWPOINT

John T. Reese
Licking County, Ohio

I would like to take a look at the history of pest management (referred to as PM) in Licking County. PM started in our county in 1973 as a pilot project for a U.S.D.A. study of PM in the U.S. That year 31 cooperators participated with some 2200 acres of corn.

Licking County was selected primarily as a no-till project for corn. Pilot projects across the U.S. were to help establish guidelines for future PM programs. In 1976 there were PM programs in 28 states involving 20 different crops. These programs were administered by CES, grower cooperatives and private consultants. PM programs continued to develop and in 1978 there were programs in 35 states involving 25 crops. Many programs are multi-disciplinary involving a complex of pests and in some cases two or more crops.

The goal of CES PM programs is to teach farmers and ranchers how to carry out more effective pest control, protect natural pest enemies, implement where feasible non-chemical means of controlling pests and apply pesticides on an as needed basis. In order to carry out such a complex program, CES has had to develop innovative and new systems of developing PM information to farmers. The County Agent, Extension Specialists and local farm leadership organized grower associations to assist in carrying out the program. The grower associations are responsible for recruiting scouts, collecting fees, paying scouts, keeping records and operating the association. State CES is responsible for training growers, scouts and private consultants who provide advice to farmers on PM decisions. Scouts are trained in identification of pests, techniques in monitoring field populations and record keeping. A qualified professional who is either an Extension Specialist, County Agent or private consultant then discusses the scout's findings with the grower. The grower has the final responsibility for the type of pest control decision he carries out.

My background in farming began some 46 years ago, being born and raised on a farm in Licking County (25 miles east of Columbus, Ohio). Vo. Ag. and FFA projects were a good start in building a farm business. I was afforded the opportunity of attending Ohio State, majoring in Agronomy and working part-time with research during my four years there. At present my son Jerry and I own, rent and operate some 700 acres of a general family farm, more specifically corn, wheat, hay and cow-calf enterprises.

My involvement in PM started in 1973 as a member of our State Advisory Committee, organized through CES to guide and direct PM in Ohio. During the first three pilot years, Licking County was the only Ohio County involved. Since then PM has grown in Ohio to include some 40,000 acres in 27 counties for 4 crops.

During the next three years (76-77-78), following our pilot project, Licking County has continued PM on its own. Our program has involved our County Agent, a scout supervisor and a full-time secretary. The scout supervisor and secretary are paid by CES state and federal monies; the scouts are paid by the cooperators. Please refer to Table I for additional Licking County data.

TABLE I
LICKING COUNTY (OHIO) PM DATA

	Producers	Fields	Acres	Cost/A
1973	31	178	2200	$.25
1974	41	264	4100	.75
1975	49	322	5500	1.50
1976	48	296	5000	3.50-4.00
1977	42	281	4800	3.50-4.00
1978	42	225	4700	3.50-4.00

In Ohio our scout training program is one of the most intensive in the U.S. Each county, private consultant or private industry interviews and hires their own scouts. The scouts then have a two week training period, starting the first week of April. This training includes both classroom and field work for weed and insect identification. At the end of their successful completion of training they report to their respective employers and begin contacting the cooperators they will be working for during the summer.

By appointments they meet the cooperator on his farm and physically identify and number the fields to be scouted. The farmer and scout determine a good place to leave the weekly reports.

As soon as possible and before planting the scout will make a dig in each field to determine what insects are present and at what populations. A weed survey may be taken if the cooperator so desires. After a field is in the PM program these above mentioned surveys may not be necessary, as last year's weekly reports can be used to determine what pest may be present. Only new fields each year will need spring surveys.

As soon as each field is planted, the cooperator mails a card to the County Agent, identifying the field and date planted. Approximately 72 hours after planting the scout makes a seed drop count and observes any insect damage to the seed. Each week thereafter the scout visits each field, leaving a report with the cooperator. These reports are on the County Agent's desk the next day. The scout "red flags" any potential problem. If any problems need immediate attention the County Agent notifies the cooperator and makes the necessary recommendations. This process continues until mid-July. One option the cooperator has is to have a leaf sample taken at tasseling time to be sent to the lab for analysis. This sample is taken in place of that week's scout report. The lab fee is $7.50.

Let's take a look at a calendar year's schedule of events for PM in Licking County.

September 1978	Sign up for 1979
October 1978	Yield checks
November 1978	Soil samples
December 1978	Recommendations made (weeds, insects, fertilizer)
Jan. & Feb. 1979	Educational meetings Local Comm. planning meeting Scout hiring

April 1979	Scout training First contact of scout and farmer
May-Aug. 1979	Weekly reports Scout supervisor alerts scouts for potential problems Additional scout training ½ day/week

Weekly reports continue until about the middle of August. Adult rootworm counts during August are very helpful for next year's recommendations. This year we had some heavy corn bore infestation and the weekly reports kept me on top of the situation, indicating which fields needed treatment and which did not.

With my farming operation, including 300 acres of corn in some 20 fields, some as far as 4 miles from home, I don't have the time to look at each field as often as needed, nor do I have the expertise to adequately identify all the pests that might be a potential problem.

I feel there are two major considerations that make our PM program workable and acceptable to farmers.

1. The integrity of the scout to do an excellent job of reporting. This is stressed with each scout from the time they are interviewed right on through the summer. The scouts are supervised each day plus some on the job training of ½ day per week.

2. The PM program for each county is initiated at the local level. Nothing allows a farmer to be more receptive to a program than one that he has asked for. The local committee can be comprised of farmers, local agri-businessmen, ag industry people and the County Agent.

In summary, let me point out some of the advantages and benefits of a PM program.

1. It has been a very good management tool. Having positive identification of pests has taken the guess work out of making intelligent decisions.

2. The soil fertility information that is available through PM program helps take the guess work out of crop production.

3. Having my herbicide and insecticide recommendations available for next year (usually in December) makes planning ahead much easier.

4. After being in the program for a few years I have developed excellent field histories. We now have a desk-top computer that can store each field history (5 years) on a 30¢ tape and then with updated information can give recommendations.

5. During the winter months with all the good information I have available, it is a real pleasure to sit at my desk and make some intelligent decisions for next year's crops. In 1978 my recommendations indicated I had 100 acres of corn that needed no insecticide, 100 acres that needed a specific insecticide and 100 acres that I could use any one of four insecticides.

6. Our PM program has been an excellent educational tool for CES, making good information available to me to make intelligent decisions for a specific crop, in a specific field at the right time.

7. Many farmers are able to take their recommendations to their local dealer when ordering chemicals. This again helps take the guess work out of crop production.

8. Without question, PM allows for more efficient and effective use of pesticides.

9. Farmers are willing to use recommendations knowing they are based on data from their own farm.

MINNESOTA'S CROP PEST MANAGEMENT PROGRAM

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Minnesota's Crop Pest Management (CPM) Program is a plan to adapt the principles of integrated pest management to Minnesota crops, pest problems and environmental situation. The program is planned to be consistent with the U. S. Department of Agriculture policy on management of pest problems as stated in December 1977 by Secretary Bergland as follows: "It is the policy of the U. S. Department of Agriculture to develop, practice, and encourage the use of integrated pest management methods, systems, and strategies that are practical, effective, and energy efficient. The policy is to seek adequate protection against significant pests with the least hazard to man, his possessions, wildlife and the natural environment. Additional natural controls and selective measures to achieve these goals will be developed and adopted as rapidly as possible." The statement further expresses that "a principal mission of the Department is to assure an adequate supply of high quality food and fiber and a high quality environment for the American people." (1)

Our CPM program also is consistent with the mission of the Minnesota Agricultural Extension Service. (2) Part of the mission is that "the resources and capabilities of the Agricultural Extension Service are directed at assisting people to develop skills, understandings, attitudes, and abilities that will contribute to:

- Efficient and effective production of an adequate and high quality food and fiber supply to meet state, national, and world food and fiber needs.
- Conservation and efficient use of natural resources and energy.
- Improvement of the environment through wise resource management and sound decision-making."

Minnesota's CPM program was initiated in 1978 and is funded by federal pest management funds administered by the U.S.D.A. Science and Education Administration. These funds will pay for staffing and operation of the program except for scouting costs which will be paid by the growers.

The CPM program is a broad-based monitoring program in crop production that is planned to effectively manage pests in an economic and safe manner. All crop pests--diseases, insects, nematodes, weeds, etc.--are included. Systematic observation of fields by scouts to determine the presence of pests, properly identify the pests and to determine the level of infestation will provide an objective basis for making recommendations on pest control practices to growers. Increasing production and improving the economics of control practices will be major factors in determining pest control recommendations. Environmental and health risks will be considered in making pest control recommendations and in evaluating the use of pesticides compared to alternative control practices.

The goals for the CPM program can be summarized as follows:

1. To improve crop production assistance to growers by tailoring recommendations to specific field situations.

2. To encourage the adoption of integrated pest management practices. This includes implementing a pest monitoring program, using non-chemical control practices where feasible and economical, encouraging judicious and safe use of pesticides, reducing pesticide use where feasible by using only according to need, avoiding unnecessary applications, and using appropriate chemicals at proper rates and at the most effective time.

3. To increase the effectiveness and economy of the use of pesticides.

4. To increase crop production through increased yields and reduced crop losses due to pests.

5. To improve the economics of crop production and increase grower profits.

6. To avoid undesirable environmental consequences and improve safety in the use of pesticides.

7. To provide educational and research support for CPM.

8. To encourage the development of a private CPM industry.

Extension is in a position to aid in the development and adoption of integrated pest management programs. We can create awareness, develop interest, set up trial pest management programs, evaluate programs and encourage adoption. Extension will be involved primarily in delivering educational programs related to pest management. But, initially we also will be heavily involved in the service aspects of organizing local groups, training scouts, managing scouting programs, assembling and analyzing data, and developing recommendations. IPM practices cannot be uniformly applied over the whole country. The principles of IPM must be adapted to local crop-pest situations with due concern for local environmental and health considerations. Extension is in a unique position to relate to local situations to develop and implement IPM programs.

A primary function of Extension in IPM programs will be to encourage development of private IPM services. There is a rapidly growing interest among cooperatives, dealers, companies and private consultants to expand their services in the area of pest management. In the future, scouting services and consulting with farmers will be done largely by private business and backed up by data systems, research and educational programs from Extension and universities. Extension does not have the resources to provide individualized pest management services to the majority of farmers. If pest management is going to be widely adopted, it will be because growers are convinced of the benefits and are willing to pay for the services that can be provided by a large private sector involvement.

Chart 1 is a diagram of the organization that is supporting the CPM program in Minnesota. An Extension advisory committee consisting of County Extension Directors, Area Extension Agents, and Extension Specialists is responsible for planning and giving direction to the program. The program is administered at the State level by a CPM coordinator. In 1979, programs are being developed on irrigated corn primarily in Dakota County, on sunflowers in Big Stone, Traverse, Stevens and Grant Counties, and on potatoes in West Polk and Marshall Counties. A technical support committee consisting of Extension Specialists in Entomology, Plant Pathology, Weed Science, Agronomy, Horticulture and Agricultural Economics is responsible for developing the technical information, educational programs and methodology related to CPM for each of the crops involved.

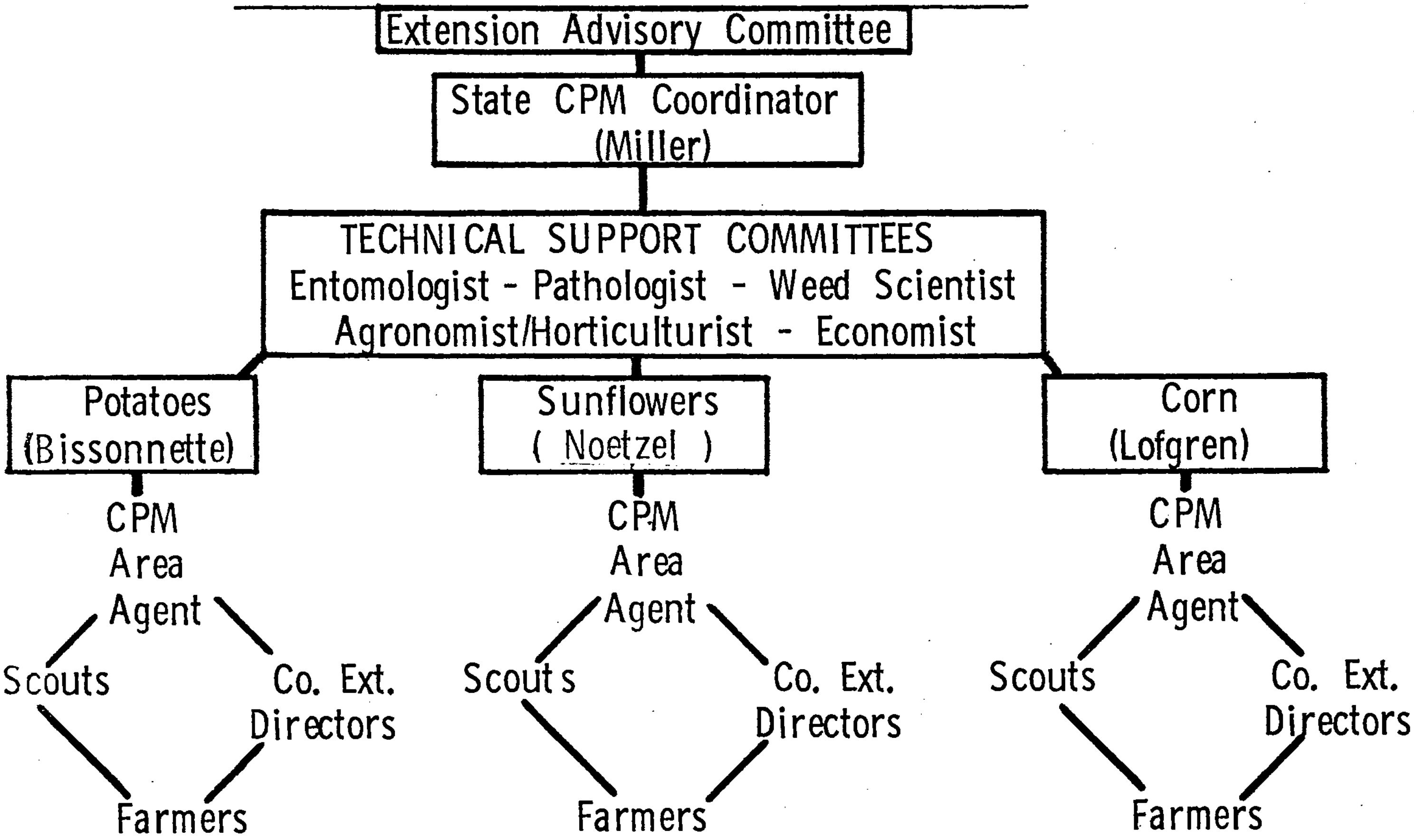
In each of the local areas, an Area Extension Agent for Crop Pest Management gives leadership to developing and conducting the program. The Area Agent assists growers in organizing programs, conducts CPM educational programs, trains and supervises scouts, manages the data system, makes recommendations to growers and provides information to County Extension Agents and the public. County Extension Agents in the area are involved in organizing programs within their counties, conducting educational programs and extending information to the public.

Scouts will be involved in walking fields on a regular schedule to detect, identify and determine the level of diseases, insects, weeds, etc. and to take soil and crop samples as needed. They will report their findings to the grower and to the Area Extension Agent-CPM who will recommend control practices based on the scout's reports. Scouts are recruited from college courses related to Crop Production and given special training prior to going to the field. Scouting costs are paid by growers.

The farmers involved in a CPM program may organize in several ways to develop their program. They may organize as a cooperative, a corporation, a committee, etc., or use an existing organization to plan, manage and implement the program. A local advisory committee consisting of farmers and industry representatives is organized in each involved county to work with the County Extension Director and Area Extension Agent-CPM to develop programs according to local needs.

The future of CPM in Minnesota will be determined by the careful evaluation of these initial programs. Crop yields, economics, grower profits, effectiveness of pest control practices, and success in avoiding undesirable environmental and health problems will all be major considerations in deciding the future of CPM programs. In the near future, farmers will want expansion to the other crops on their farms to develop a total farm pest management program. As the technology is developed expansion undoubtedly will come through further involvement of private industry.

CHART 1. MINNESOTA CROP PEST MANAGEMENT (CPM)



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Grass Control in Small Grains

Richard Behrens, Professor
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In Minnesota, yield losses of small grains from weeds are substantial. They are greater in the higher yielding, semidwarf wheats because these widely grown short-strawed grains are less competitive with weeds than the older, taller varieties (Table 1). Semidwarf barleys are being developed and are likely to be less competitive with weeds also.

Since small grains are grown in close spaced plantings, cultivation is not very useful in controlling weeds. The use of herbicides to control broadleaf weeds in small grains is a well established, successful practice which has greatly reduced grain yield losses from weeds of this type. Grassy weeds growing in small grains cause yield losses, also. But, the development of herbicides to control grassy weeds in grass crops has been difficult to accomplish. We, at the University of Minnesota, have made a special effort to develop herbicide treatments which will control grassy weeds, especially wild oats and the foxtail species. In recent years several herbicide treatments have been studied that show promise for control of these weeds. I would like to summarize the herbicide treatment now available or soon to become available for the control of grassy weeds in small grains.

Wild Oat Control

Considering the severity of infestation and the acres infested wild oat is rated as the third worst weed in small grains in Minnesota on a state-wide basis (1). However, wild oat is a serious weed only in the Northwestern part of Minnesota (2). In that area, the major small grain producing area of the state, wild oat causes greater yield losses than any other weed.

Crop management and tillage can be used to control wild oats and reduce the severity of infestations. The objectives of these practices are to reduce the number of wild oat seeds in the soil, to kill early emerging wild oat seedlings, and to prevent maturation of wild oat seed. Fallow, delayed seeding, harvesting the crop for hay before the wild oats ripens, and growing highly competitive crops are the management and tillage practices now being used. These practices result in a lower economic return from small grains and, therefore, are used by farmers only when the wild oat infestation is very heavy. The increase in acreages of row crops, especially sugarbeets and sunflowers, in Northwestern Minnesota in recent years may result in reduced wild oat infestations because row cultivation removes most of the wild oats from these crops. In other areas of Minnesota where row crop acreages are extensive, wild oat has been eliminated as a serious weed.

Chemicals, triallate (Far-go) and barban (Carbyne), have been used for wild oat control in wheat and barley for approximately 15 years. However, there are limitations in the use of these chemicals. Uniform incorporation of triallate in the soil, which is necessary to prevent crop stand reductions and to obtain satisfactory wild oat control, has been a problem for some farmers. Application of barban during the short period when most of the wild oats is in the two-leaf stage is difficult to accomplish, especially if unfavorable weather occurs.

Recently, postemergence applications of a new herbicide, difenzoquat (Avenge), have been cleared for wild oat control in wheat and barley. Control is best when difenzoquat is applied to wild oats in the 3-to 5-leaf stage. This herbicide adds to the time period for treating wild oat. Barley has more tolerance than wheat to difenzoquat. Use on wheat is restricted to varieties which are listed on the difenzoquat label.

Diclofop (Hoelon) may soon receive federal approval for use in wheat and barley to control wild oats. Approval is anticipated before the 1979 growing season. Postemergence applications of diclofop to wild oats in the 2-to 4-leaf stage had given the best control. Wheat tolerance to diclofop is somewhat greater than that of barley, though clearance is expected for both crops. The addition of this herbicide will be additional means of attacking wild oat infestations.

Foxtail Control

Green and yellow foxtail have been rated on a state-wide basis as the worst problem weeds in small grains (1). The density of foxtail infestations vary considerably from year to year. The heaviest infestations occur when grains are planted later in the growing season. Foxtails are a greater problem in wheat than in barley which is a more vigorous competitor. There have been no herbicides available for the control of foxtails in small grains until very recently. In 1977, trifluralin (Treflan) was cleared in Minnesota for use in preemergence incorporated applications to wheat. This chemical gave good green foxtail control. To avoid wheat injury, the wheat must be planted at least 2 inches deep and the trifluralin must be uniformly incorporated at a shallower depth so that it does not contact the wheat seed. Flexible-tined or spike-toothed harrows are recommended for incorporation. Clearance for trifluralin use in barley is expected soon.

In 1978, the first postemergence herbicide treatment that controls foxtail in small grains became available. This chemical, propanil (Stampede), was used in spring wheat. Occasionally, leaf burn and chlorosis caused by propanil will reduce wheat growth temporarily but wheat recovery is usually rapid and complete. Propanil usage in 1978 was on a temporary, emergency basis to control very serious green foxtail infestations which developed in Northwestern Minnesota. Propanil gave excellent control of these infestations. A request for federal clearance has been submitted which is expected to be approved before the 1979 growing season. Clearances for propanil use in barley and oat will be submitted in the near future.

Several other compounds have also shown promise for controlling foxtail in small grains in our experiments. Propachlor, used in preemergence or delayed preemergence applications, has given satisfactory foxtail control in wheat, barley and oats in several years of evaluation. A request for clearance of propachlor is now being prepared. Diclofop (Hoelon), has given effective control of green foxtail as well as wild oats in our tests. As indicated above, diclofop may be cleared for use in 1979. Another compound being considered for foxtail control in small grains is profluralin (Tolban). The method of profluralin application and its effectiveness on the foxtails is similar to that of trifluralin.

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Table 1. Summary of wheat yields from 11 experiments completed from 1970 to 1974 at Crookston, Morris, Rosemount, and Stephen, Minnesota

Wheat height	Wheat yield as percent of weed free check		
	Weed free	Foxtails only	Foxtails plus broadleafs
Normal (Chris)	100	91	79
Semi-dwarf (Era)	100	87	74

VOLUNTEER CORN CONTROL

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SUMMARY

Soybeans following corn in rotation can be infested with volunteer corn. The severity of the volunteer corn problem varies greatly from year to year and was particularly severe throughout much of the Corn-Belt in 1978. Mechanical cultivation controls volunteer corn between soybean rows, and hoeing or hand-pulling is used for control in the soybean rows. Several herbicides of the dinitroanaline class [trifluralin (Treflan[1]) and profluralin (Tolban[1]) are examples] inhibit the growth of corn when they are used for weed control in soybeans, but the degree of corn control with these herbicides is far from satisfactory.

We have conducted research on volunteer corn control beginning with greenhouse studies in the winter of 1972-73 and continuing in the field each year since then. Primarily we have been working with diclofop (Hoelon[1]) which has controlled corn and other annual grasses selectively in soybeans when sprayed over-the-top of both soybeans and weeds. We have found that the parentage of the hybrid causing a volunteer corn problem can be important in determining the degree of control obtained with diclofop. Volunteer corn from some hybrids may be somewhat tolerant of diclofop, whereas, volunteer corn from other hybrids may be very susceptible. Corn, in general, is so susceptible to diclofop that the parentage of the corn may be a problem only when diclofop is not applied at the proper rate, at the proper time or where environmental factors are unfavorable for herbicide activity. Diclofop may be registered in time for use in soybeans in 1979.

Another herbicide having promise for volunteer corn control is glyphosate (Roundup[1]). It may be used as a spot-spray for volunteer corn in soybeans, but because it is not selective, it will kill or injure any soybeans contacted by the spray. Research by others suggests that glyphosate might be used to selectively control volunteer corn in soybeans if the glyphosate were applied with special devices (such as recirculating sprayers or roller applicators) that put the herbicide solution on the corn overtopping the soybeans, allowing little or no herbicide to reach the soybeans. In our research, we have found that the parentage of volunteer corn can be a factor in the degree of its control by glyphosate. But, as was the case with diclofop, corn is so susceptible to glyphosate that corn parentage probably will not be important under conditions suitable for herbicidal activity. The use of glyphosate with the types of devices mentioned above may be registered in 1979.

Hence, in 1979, there may be two herbicides available for volunteer corn control in soybeans. However, we cannot be certain at this time what the registration status will be for next season. Be sure that any herbicide treatment you plan to use is registered and legal.

[1]Treflan, Tolban, Hoelon, and Roundup are registered trade names of herbicides. Trade names are included only for identification. Mention of a trademark or

proprietary product does not constitute a guarantee or warranty of the product by the U.S. Department of Agriculture, or the University of Minnesota, and does not imply its approval to the exclusion of other products that may also be suitable.

NEW HERBICIDES - 1979

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Many new corn and soybean herbicides have been introduced in the last several years. Ten years ago (1968), our Extension Cultural and Chemical Weed Control bulletin listed six herbicides that were suggested for weed control in corn and six that were suggested for weed control in soybeans. In 1978, we had twelve herbicides and various combinations of these listed for weed control in corn and fourteen herbicides that can be used in various combinations listed for use in soybeans. In small grains and forage crops, there has been less rapid development and release of herbicides during the last ten years. In small grains, three herbicides were available for broadleaf weed control and three herbicides were available for wild oat control in 1968. Ten years later, we listed four herbicides and combinations of these for broadleaf weed control and four herbicides for wild oat control in small grains. In grass pastures, three herbicides were available for broadleaf weed control in 1968, and five were available in 1978. During the last year or two, very few new herbicides have been cleared for use in any crop due primarily to more stringent Environmental Protection Agency procedures and restrictions. During the last few years, however, there has been more of an effort made to develop and clear herbicides to deal with specific weed problems and in many, selectivity differences between crop and weed have been small. For example, broadleaf control in soybeans was furthered greatly by the development of bentazon (Basagran) and annual grass control in wheat was possible in 1978 with two herbicides, trifluralin (Treflan) and propanil (Stampede 3). Herbicides such as these, which enable us to take annual broadleaf weeds out of an annual broadleaf crop and annual grass weeds out of an annual grass crop certainly make important additions to our chemical weed control "tool kit".

New herbicides or herbicide combinations that have been cleared for use in field crops in Minnesota since last year or on which clearance is pending, will be discussed briefly under the crop headings which follow.

SMALL GRAINS

During 1978, difenzoquat (Avenge), was granted an additional supplemental label for use in a tank-mix combination with 2,4-D amine or ester on barley, winter wheat, Era spring wheat and all varieties of durum wheat except Lakota and Wascona to control wild oat and 2,4-D susceptible broadleaf weeds. For effective wild oat control difenzoquat should be applied at rates of 5/8 to 1 pound per acre depending on density of wild oat when the majority of the wild oat are in the 3-to 5-leaf stage. For optimum broadleaf weed control and crop safety, 2,4-D is labelled for application at the tillering stage (4 to 5-leaf stage) of the small grain. The tank-mix combination of difenzoquat and 2,4-D should be applied in conformity to both labels as nearly as possible. An addendum to the difenzoquat label has been submitted for 1979 to permit its' use on the additional semi-dwarf spring wheat varieties of Olaf, Kitt and Butte. However, as of December, 1978, this additional labelling has not been granted.

The herbicide propanil (Stampede 3) was granted an emergency state label under Section 18 of FIFRA for the control of green and yellow foxtail in spring wheat in Minnesota during 1978. Propanil controlled most annual grass weeds and some broadleaf weeds resulting in increased wheat yields in several trials. Temporary injury to wheat, evident as leaf burn or yellowing, slowed early growth and resulted in a several day delay in maturity in some trials. A label has been submitted to EPA for clearance of propanil in hard red spring wheat in Minnesota as a postemergence application at 1 1/2 pounds per acre when weeds are in the 2-to 4-leaf stage. As of December, 1978, propanil has not been cleared on spring wheat in Minnesota.

In 1978, trifluralin (Treflan) was cleared on a special local need label (FIFRA, Section 24-C) in Minnesota for postplanting and preemergence use on spring wheat to control annual grasses such as green and yellow foxtail. The label directs that wheat shall be planted 2 to 3 inches deep in a firm seedbed. Trifluralin should be applied after planting and incorporated shallowly with a spike-tooth or flexible-tined harrow so that the chemical layer is above the wheat seed. Shallow planting or too-deep incorporation of trifluralin may result in wheat injury, especially on coarser textured soils low in organic matter. This label will remain in effect for 1979 on spring wheat in Minnesota.

A state label for a tank mix combination of trifluralin (Treflan) and triallate (Far-go) in wheat was granted in Minnesota during 1978 for the control of foxtail species and wild oat. The suggested rate of trifluralin in the mixture is 1/2 pound per acre on coarse and medium-textured soils and 3/4 pound per acre on fine-textured soils. The suggested rate for triallate is 1 pound per acre. Seeding and application instructions should be according to the trifluralin label.

A promising new herbicide, diclofop (Hoelon) has been tested and a label has been submitted to EPA for its use on wheat and barley to control foxtail and wild oat. In numerous tests, diclofop applied postemergence to yellow and green foxtail and wild oat in the 2-to 4-leaf stage has given effective control with little or no injury to the crop. As of December, 1978, label clearance for diclofop on wheat and barley, has not been granted.

New label instructions for barban (Carbyne) for winter wheat, now permit a second barban application, if needed, to control a second flush of wild oats. Each application should be made when the majority of the emerged wild oat are in the 2-leaf stage; the rate of each application should be 1/4 pound per acre. The interval between first and second application of barban is usually 7 to 14 days but may be longer under some growing conditions. If conditions do not permit sequential applications of barban, when winter wheat is in the 2-leaf stage, a single application of 1/2 pound per acre may be applied when wild oat is in the 4-leaf stage.

FLAX

Asulam (Asulox) was granted emergency use in 1978 in four counties of northwestern Minnesota for wild oat control and foxtail and wild buckwheat suppression in flax under a FIFRA, Section 18 label. Results were generally good but some lodging or injury of flax was evident at some locations. Restrictions in effect in 1978 did not allow any crop other than flax to be planted for 1 year after treatment. Efforts are being made to clear asulam for weed control in flax at rates of 1 to 1 1/4 pounds per acre when the flax is 2 to 6 inches tall and when wild oat is in the 3-to 4-leaf stage. However, as of December, 1978, asulam is not cleared and should not be used on flax in 1979 unless full or emergency clearance is obtained.

ALFALFA ESTABLISHMENT

Profluralin (Tolban) was cleared during 1978 under a FIFRA, Section 24-C, state label in Minnesota for controlling most annual grass weeds and a few annual broadleaf weeds in alfalfa as they germinate. Established weeds are not controlled. Profluralin is similar to benefin (Balan) and EPTC (Eptam) which have previously been available for weed control during alfalfa establishment. Profluralin should be used preplanting at 1/2 to 1 pound per acre depending on soil type and should be thoroughly incorporated immediately or at least within 4 hours into the top 2 to 3 inches of soil. Label clearance of this compound will continue in effect in Minnesota for 1979.

ESTABLISHED ALFALFA

Metribuzin (Sencor, Lexone) was cleared during 1978 for application either fall or spring to dormant alfalfa established for one year or more for the control of certain grass and broadleaf weeds. Rates of 1/2 to 1 pound are suggested depending on weeds to be controlled (see label). Low rates may be used for partial reduction of forage grass stands in an alfalfa-grass mixture. Do not graze or harvest within 28 days after application.

DRY EDIBLE BEANS

A tank mixture of EPTC (Eptam) with profluralin (Tolban) was labelled for preplanting incorporation use on kidney, navy and pinto beans during 1978. Rates of EPTC range from 3 to 3.9 pounds per acre and profluralin rates range from 1/2 to 1 pound per acre both depending on soil type. Do not use this mixture on Adzuki beans. Under abnormal weather conditions, stunting may occur on some varieties from use of this tank mixture.

CORN

Metolachlor (Dual), was previously labelled as a 6 pound per gallon emulsifiable concentrate for use on corn, either alone or in combination with atrazine. A label change for 1979 eliminates the requirement to grow only corn for 18 months after application and allows rotation to small grains 4 1/2 months after treatment, or to corn, soybeans, root crops or small grains the following spring after treatment. In addition, a new 8 pound per gallon formulation has been cleared for bulk use only in 1979 on corn grown for grain, excluding popcorn.

A new formulation of atrazine (Aatrex Nine-O, CIBA-GEIGY), a water dispersible granule, has been labelled for use in corn and sorghum for 1979.

An atrazine-metolachlor liquid formulation (Bicep) is cleared for use on corn grown for grain in 1979. The mixture contains 2 pounds atrazine and 2 1/2 pounds metolachlor per gallon. Suggested rates are 1 pound atrazine plus 1 1/4 pounds metolachlor (1/2 gallon of product) per acre on coarse textured soils with low organic matter, 2 pounds atrazine plus 2 1/2 pounds of metolachlor (1 gallon of product) per acre on fine-textured soils high in organic matter. The herbicide combination may be applied either preplanting incorporated or preemergence. Limitations on the combination are: Do not use on sweet corn or popcorn. Do not graze or feed forage and fodder to livestock or use for silage. Do not use in Wisconsin. Corn or soybeans may be planted on treated ground the following year if applied before June 10. If applied after June 10, plant only corn the following year. Small grains may be planted 15 months after treatment. Other crops may be planted 18 months after treatment.

SOYBEANS

Profluralin (Tolban) previously labelled for weed control in soybeans as a preplanting incorporated herbicide has been granted additional label to be used in combination with overlay treatments of linuron (Lorox) and naptalam and dinoseb (Dyanap) in soybeans. Rates of 1/2 to 1 pound per acre of trifluralin should be used with proper label rates of the overlay treatment depending on soil type. In addition profluralin has been cleared as a tank mixture or overlay application with metribuzin (Sencor, Lexone) in soybeans. As a tank mixture, it should be incorporated according to the profluralim label.

SUGAR BEETS

Ethofumesate (Nortron) was cleared during 1978 for preemergence control of several annual grass and broadleaf weeds in sugar beets. Rates are 1 7/8 to 3 3/4 pounds per acre depending on soil type. Ethofumesate may also be tank mixed with pyrazon (Pyramin) but the Pyramin wettable powder should be mixed with water first and the emulsifiable concentrate of ethofumesate added with adequate agitation being maintained in the tank. Ethofumesate requires at least one-half inch of rainfall after application to activate the herbicide. In drier areas of limited rainfall, it is recommended that ethofumesate be applied before or at the time of planting and incorporated into the soil to a depth of 1 to 2 inches.

Note: For a complete update on new and previously cleared herbicides in field crops, refer to the new Extension Bulletin 400, Cultural and Chemical Weed Control in Field Crops, which will be available from County Extension Offices and the University of Minnesota Bulletin Room after January 1, 1979.

Disease Control - Fungicide Treatment of Field Crops

H.L. Bissonnette
Extension Plant Pathologist
University of Minnesota

Controlling plant diseases in field crops - anyone knows that you can't afford such a practice! What do plant diseases do anyway? So plant diseases are always around "its" just part of growing a crop.

The application of a fungicide treatment to control a disease in a field crop is as simple as a seed treatment. Two years ago in Minnesota we experienced an epidemic disease situation with covered smut on oats. The practical result of this epidemic was the loss of the variety Froker. Fields of oats, were observed with as much as 30% infected heads. A simple seed treatment applied to the outside of the seed would have prevented the crop loss and the loss of high yielding variety. As a fertilizer - Ag. Chemical dealers, what are you doing to help your customers avoid such crop losses?

Fungicides are chemicals that will inhibit or kill living fungi on plants. The site of action may be on the seed surface, on the stem or leaf, on the roots, fruits or other vegetative parts of the plant. Some fungicides are systemic , as such the site of activity may be inside the plant part.

In order for fungicides to do their thing, the chemical must be applied to the area of the plant that needs protection. The methods of application may be a high pressure - high volume ground sprayer that applies 40 to 80 gallons of water per crop acre, or a post harvest dip of the apple as it goes into storage. In recent years more fungicide applications to field crops are being made with Agricultural aircraft that are capable of spraying a 50 foot swath at 110 miles per hour, using 5 gallons of water per acre.

The application of fungicides whether by ground sprayers or aircraft must result in a uniform distribution of the chemical on the plant surface. A high pressure ground sprayer applies the chemical to the plant in a hydraulic system, e.g. using water to carry the fungicides to the plant parts. Early in the season 40 gallons of water may be sufficient for covering a potato crop. While later, when a full canopy exists 80 or more gallons of water may be required for coverage. Aircraft utilize a high volume of air to carry the fungicide to the plants. The saturated air is filled with the particles of fungicide that contact the plant parts. In either case we cannot cheat on the amount of water being used. Short changing the carrying agent usually results in poor control when a disease is present.

One of the more perplexing problems involving fungicide application is timing. When should the treatment be made? How often? The timing of fungicide applications depends on the nature of the particular disease, the type of fungicide being used, and the weather conditions or environment. In general, the fungicides used on field crops are of 2 types; protectants and systemics. The protectant fungicides must be in place on the plant prior to the infection process. As the name suggests, such chemicals protect the plant part from infection by the germinating fungus spores or inoculum. This type of chemical does not penetrate the plant, is not translocated within the plant and will not kill or inhibit the development of the fungus once it has entered the plant. The systemic fungicide, in addition to protecting the plant is absorbed by the plant, may be tranlocated in the plant and stored in various parts of the plant. Systemic fungicides may act against the fungi after infection has occurred. In contrast to protectant chemicals systemics may have a longer life, and often have a very specific or limited spectrum of pathogens that they control. So in practice both types of fungicides are needed.

In addition to seed treatment, which is often a most important fungicide use, there are several diseases of field crops that can be controlled or their severity reduced with proper fungicide use.

Major Field Crop Diseases that can be Controlled with Fungicides

Crops	Diseases
Cereals	Seedling Blight
(Wheat - Barley - Oats)	Damping Off Smuts Leaf Spots Leaf Rust
Sugar Beets	Seedling Blight Damping Off Mildew Cercospora Leaf Spot
Potatoes	Seed Piece Decay Early Blight Late Blight Rhizoctonia Blight Storage Rots
Corn	Seedling Blight Rust Leaf Spots

Crops	Diseases
Soybeans	Stem & Pod Blights Stem Canker
Dry Beans	Seedling Blight Rust Sclerotinia Bacterial Blight

Scab was a serious disease problem in 1978 wheat crop, grown in the south half of the state. If some of the scabby grain is used for seeding the 1979 crop without the benefit of seed treatment we might expect a great deal of seedling blight resulting in poor stands. The occurrance of covered smut on oats and semi-loose smut on barley also remains a threat. Seed treatment of the cereal crops is a necessary part of every cereal growers cropping plan. As a chemical dealer, with the best interest of your customers in mind, will you recommend seed treatment? Will you have the necessary equipment available?

The Leaf Spot diseases of wheat and barley (mostly septoria) can account for crop losses of as much as 30%. Where a crop is expected to produce 50 bushels per acre, the loss can be 15 bushels per acre. Usually the control practice cost less than $10.00 per acre.

In 1978 Early Blight of potatoes accounted for a loss of 60 cwt of US. No. 1 potatoes per acre in the Red River Valley Demonstration plots. The cost of 4 fungicide applications would be less than $20.00 per acre.

Plant diseases are a part of crop production practices. We can ignore crop losses resulting from plant diseases as has been our history. Or we can recognize that plant diseases do occur and engage disease control practices to reduce crop loss. Which in the long run will return greater yeilds to the growers for his production input.

David M. Noetzel
Extension Entomologist

I. Sunflower Insects 1978

A. Seasonal Summary

Pest insect numbers in sunflowers were in general markedly reduced in 1978. Lower numbers of stem weevils, sunflower moth, and seed weevils suggest that some environmental factor other than acreage affects those insects in a similar manner. Cutworms (primarily dark-sided cutworm) and sunflower midge numbers increased in 1978.

Losses due to cutworms were the greatest in ten years. Fields were damaged throughout the state, but major replanting took place in west central Minnesota where in excess of 20% of the acreage was destroyed. A series of trials (Section B - Cutworm Control) comparing a number of new insecticides with the presently labeled toxaphene were carried out.

Sunflower midge damage was somewhat increased over 1977. Noticeable injury occurred in the Wheaton to Breckenridge area and in the Warren vicinity. These were both areas of heavy May and June rainfall.

Stem weevils were so low in numbers that they were difficult to find. Most of the sunflower stalk breakage in 1978 was not related to their presence and/or abundance.

Some have asked questions about the relationship of "premature ripening" disease to stem weevil presence. There is no data showing such a relationship and indeed many fields were free of weevil injury yet had from 16 to 100% infected stalks due to "premature ripening" in 1978.

Sunflower moth adult numbers were very low with just occasional observations of larvae. A certain age group (e.g., planting date) of sunflowers contained what little infestation there was. This shortened oviposition period has now been observed both in 1977 and 1978 in Minnesota.

Seed weevil abundance was also greatly reduced. The few fields which contained infestations were sampled in order to attempt to relate larval damage to the seed yield decrease. Random samples were taken from four infested fields. Seed weights per 100 seeds as field sampled were taken and the weights (i.e., reduction due to larval feeding) recorded. Then 100 undamaged seeds were weighed, and the percent reduction was based on these latter weights.

Relationship of percent seed weevil damage and percent yield reduction.

Field No.	Percent Damaged Seed	Percent Yield Reduction for Each 10% of Damaged Seed
1	8	5.41
2	13	3.32
3	23	1.09
4	34	2.35
From ND (1977 progress report)	16	2.47
Average		2.93

The data suggest that there may be a variation in percent yield reduction with constant infestations due to variety or some other factor. This merits further examination before definitive thresholds are established.

B. Cutworm Control

The major insect problem in sunflowers the past three years, and probably since sunflowers became extensively grown in the upper midwest, has been cutworms. The Minnesota acreages destroyed by cutworms during 1975-1978 were estimated to be at least 15,000, 5,000, 56,000 and 110,000 respectively. Replanting costs were about $5.00 per acre replanted. Control needs were estimated to be an acreage equal to that destroyed each year at an estimated treatment cost also of $5.00 per acre. Losses thus were estimated to be $150,000, $50,000, $560,000 and $1,100,000 per respective year. This is an annual average loss of nearly one half million dollars.

Toxaphene, the only insecticide presently labeled for cutworm control in sunflowers, has performed rather erratically over the years. A more dependable insecticide for cutworm control is an important industry need.

The extensive cutworm outbreak in 1978 [primarily the darksided cutworm, Euxoa messoria (Harris)] provided the opportunity to compare presently available insecticides with some potential materials for cutworm control.

All of the reported information is from 6 row x 30' plots with treatments randomly arranged and replicated four times. We did not have time to obtain quantitative samples of cutworms but did determine that the darksided cutworm was the dominant species. The cutworm populations as indicated by the percent stand reductions were moderate.

Both granules and sprays were applied in the morning in a 10-12" band over the row. Granules were not worked in until the normal cultivation of the field took place. Sprays were applied by hand at the rate of 20 gallons of total material per acre.

Cutworm control: Westberg field - Hoffman, Minnesota.

Chemical Formulation and Rate (AI/A)	Percent Reduction in Plant Stand
Pydrin spray (0.2 lb)	3
Sevin bait (1 lb)*	4
Lorsban spray (1½ lb)	4
Mocap granules (1 lb)	9
Toxaphene spray (1½ lb)	13
Nematak granules (1½ lb)	16
Check	10
Check	11

*5% Sevin in apple pomace

Cutworm control: Sellin field - Buffalo, Minnesota.

Chemical Formulation and Rate (AI/A)	Percent Reduction in Plant Stand
Sevin bait (1 lb)	7
Pydrin spray (0.2 lb)	10
Lorsban spray (1½ lb)	12
Check	33

Cutworm control: Rob Holland field - Clearwater, Minnesota.

Chemical Formulation and Rate (AI/A)	Percent Change in Plant Stand
Lorsban spray (3 lb)	+11
Pydrin spray (0.2 lb)	+6
Toxaphene spray (2 lb)	+4
Sevin bait (1 lb)	+2
Lorsban spray (1½ lb)	+1
Mocap granular (1 lb)	0

Rob Holland field - Clearwater, Minnesota (continued)

Nematak (1½ lb)	-2
Check	-1

Pydrin, Lorsban, and Sevin bait at the rates used performed about equally well. Granular applications were less effective than sprays or bait. Toxaphene was only slightly superior to no treatment at all. It would appear that Lorsban or Pydrin sprays and Sevin bait are excellent candidates for consideration in future cutworm control in sunflower.

C. Seed Weevil Control

Although populations of sunflower seed weevils (*Smicronyx fulvus* and *S. sordidus*) were dramatically reduced in 1978 as compared to 1977 a few fields in the Clinton, Graceville, Beardsley area did have numbers sufficient to cause grower concern. Preliminary control experiments were carried out in 1977 which showed that a single application of ½ lb per acre of methidathion (Supracide) reduced the number of seeds infested by weevil larvae by nearly 60%.

A similar trial was carried out in 1978. Adult weevil counts reached a total of 17 per plant (total of both species and both sexes) when nearly all plants in the field had some florets in bloom (i.e., 100% bloom). Seed infestation levels in the untreated area were 31% and 7.6% in the treated. This was a statistically significant reduction.

Sunflower seed weevil (*Smicronyx fulvus* & *S. sordidus*) control and related yield reductions; a preliminary study.

Treated			Untreated		
Plot No.	% Seeds Infested	Wt in gms/ 100 Seeds	Plot No.	% Seeds Infested	Wt in gms/ 100 Seeds
1	2	4.39	1	31	3.71
2	3	3.42	2	34	4.34
3	27	4.58	3	33	4.35
4	4	4.04	4	19	4.06
5	2	4.48	5	38	3.89
Ave.	7.6	4.18	Ave.	31.0	4.07

Plot data did not show any yield differences nor even a clear trend with the amount of seed injury observed. We then took weights per 100 seeds from treated vs. untreated areas and found about a 2.5% yield difference. This too was not significant at the 10% level.

Yield reduction in sunflowers due to seed weevil activity does not appear to be very great. Methidathion (Supracide) is acceptably effective against the two weevil species. However, treatment for weevil control will have to take place during the early period of sunflower bloom. Because insect pollination is still necessary for most hybrids and oil content is increased as a consequence of pollinator activity, it's desirable to avoid insecticide applications while the sunflower is in bloom.

DMN/df
11/21/78

CORN ROOTWORM CONTROL - 1978 INSECTICIDE TRIALS

Southern Experiment Station
Waseca, MN

John A. Lofgren, Extension Entomologist and
William Lueschen, Agronomist, Southern Experiment Station

Planted May 17, Basal treatments June 26, all treatments in 7" band at planting time unless noted otherwise.

Treatment (product per 1000 ft. of row except where noted)			Average Root Damage Rating (1-6)	Average Yield (Bu/A)
Amaze (Oftanol)	15G	8 oz.	2.0	146
Amaze	20G	6 oz.	2.0	147
Nem A Tak	15G	12 oz.	2.0	150
Nem A Tak	15G	8 oz.	2.1	136
Counter	15G	8 oz.	2.1	141
Thimet	15G	8 oz.	2.1	145
Nem A Tak	2L	5 fl. oz.	2.2	131
Mocap	6E	6 lb. AI/A ppi	2.2	138
Dyfonate	20G	6 oz.	2.3	149
Furadan	10G	12 oz.	2.3	150
Mocap	6E	2 lb. AI/A ppi	2.4	142
Mocap	10G	12 oz.	2.4	141
Counter	15G	8 oz. in furrow	2.4	142
San 326	5G	24 oz.	2.4	139
Furadan	4F	2.5 fl. oz. Basal	2.5	136
Mocap	6E	4 lb. AI/A ppi	2.5	146
San 6626	5G	24 oz.	2.7	131
Lorsban	15G	8 oz.	2.8	146
Nem A Tak	2L	3.75 fl. oz.	2.8	138
NC 6897	10G	12 oz.	2.8	136
Amaze	15G	8 oz. Basal	2.9	132
Amaze	20G	6 oz. Basal	3.4	133
Furadan	10G	12 oz. Basal	3.4	138
Check			3.6	131

Furadan History Field
(four years continuous Furadan applications followed by four years of plots using various insecticides but no further over-all Furadan treatment)

Amaze	15G	8 oz.	2.0	141
Amaze	20G	6 oz.	2.0	138
Counter	15G	8 oz.	2.1	141
Check			3.3	133
Furadan	10G	12 oz.	3.7	136
NC 6897	10G	12 oz.	3.9	137

Southwest Experiment Station
Lamberton, MN

John A. Lofgren, Extension Entomologist and
Harlan Ford, Agronomist, Southwest Experiment Station

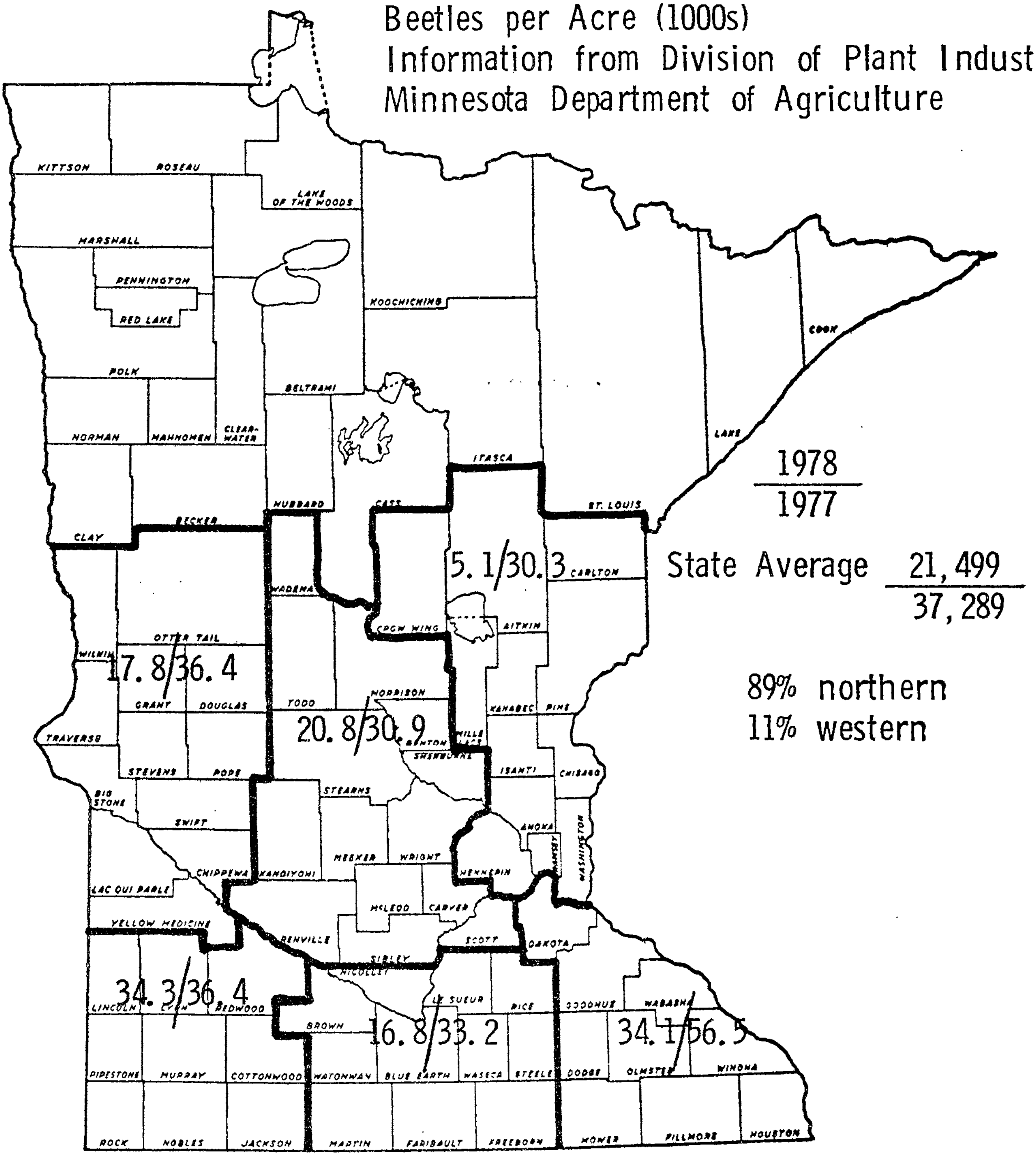
Planted May 16, Basal treatments June 21, all treatments in 7" band at planting time unless noted otherwise.

Treatment (product per 1000 ft. of row except where noted)			Average Root Damage Rating (1-6)	Average Yield (Bu/A)
Amaze	20G	6 oz.	1.6	121
Counter	15G	8 oz.	1.6	124
Furadan	10G	12 oz.	1.6	126
Amaze	15G	8 oz.	1.7	124
Amaze	20G	6 oz. Basal	1.8	131
Counter	15G	12 oz.	1.8	127
Counter	15G	8 oz. Basal	1.8	127
Furadan	10G	12 oz. Basal	1.8	121
Lorsban	15G	8 oz.	1.8	125
Mocap	6E	6 lb. AI/A ppi	1.8	127
Nem A Tak	15G	8 oz.	1.8	126
Nem A Tak	15G	6 oz.	1.8	131
GCP 6361	10G	12 oz.	1.8	125
Thimet	15G	8 oz.	1.8	125
Amaze	15G	8 oz. Basal	1.9	131
Dotan	10G	12 oz.	1.9	129
Mocap	6E	4 lb. AI/A ppi	1.9	125
Mocap	10G	12 oz.	1.9	124
Counter	15G	8 oz. in furrow	2.0	120
Furadan	4F	2.5 fl. oz. Basal	2.0	125
Dotan	10G	9 oz.	2.0	124
GCP 6361	10G	6 oz.	2.0	125
Nem A Tak	2L	5 fl. oz.	2.0	123
Nem A Tak	2L	3.75 fl. oz.	2.0	118
Thimet	15G	8 oz. Basal	2.0	127
Counter	15G	6 oz.	2.1	125
Mocap	6E	2 lb. AI/A ppi	2.1	121
NC 6897	10G	12 oz.	2.1	122
Check			2.3	113
Dyfonate	20G	6 oz.	2.4	129

11/78
JAL/df

Corn Rootworm Adult Survey 1978

Beetles per Acre (1000s)
Information from Division of Plant Industry
Minnesota Department of Agriculture



European Cornborer Fall Survey

Borers per 100 plants
Information from Division of Plant Industry
Minnesota Department of Agriculture