Fertilizer and Lime Short Course

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Progress in Upping Soybean Yields

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Soybeans are an important crop in the United States and in Minnesota. In 1968 the U.S. produced its first billion bushel soybean crop. The U.S. average soybean yield was 26.6 bushels per acre in 1968. The Minnesota average soybean yield was 22.0 bushels per acre in 1968 or 4.6 bushels per acre lower than the U.S. average. The average soybean yield in Minnesota in 1954 was 21.5 bushels per acre and the 1969 projected yield is 21.5 bushels per acre indicating that little progress has been made in 15 years. Soybeans are being grown in some areas where they should not be grown as evidenced by yields of 10-15 bushels per acre. However, the acres producing these low yields are a small percentage of the total soybean acreage. The real need for improvement is the 25 bushel yields in areas where 40-50 bushel yields are common. Many factors must be considered under a good soybean management program. Factors such as variety, row spacing, plant population, weed control, proper seedbed preparation and soil fertility must be considered to obtain high yields.

Only the subject of soil fertility will be considered in this discussion. All other factors are managed as near optimum as we know how.

Claims have been made that soybeans do not respond to phosphorus (P) and potassium (K) fertilizers to the same degree as corn. Indications are that this is not true. Soybeans do respond as well as corn to P and K fertilizer and in some cases the response may even be better. The yield increases have to be converted to a dollar basis to get a fair comparison of the responses of soybeans and corn to P and K fertilizer. The large yield increases from fertilizing corn has been from nitrogen. Adding nitrogen fertilizer to soybeans has not been practiced since soybeans are a legume and can fix nitrogen symbiotically from the atmosphere.

Fertilizer treatments consisting of banded starter, starter in contact with the seed and a combination of banded and seed placement were superimposed on broadcast fertilizer treatments at Lamberton, Morris and Waseca. The yields at Morris for 1969 were low due to lack of rainfall as shown in Table 1. The largest response was obtained from broadcast fertilizer applications. Starter fertilizer had little effect on seed yields either with or without broadcast fertilizer. Foliar analyses indicated that the yield increases were from P additions. The soil P level was low and the K level was high. At Lamberton the yields and the responses were largely due to greater rainfall. The largest response was to broadcast fertilizer or combinations of starter and broadcast fertilizer. The soil P level was low and the K level was high. These data illustrate the importance of variety on fertilizer response. The yield increase with Corsoy variety

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Suggestions and assistance in these studies from Dr. W. W. Nelson, Lamberton Station, Dr. S. D. Evans, Morris Station and Dr. R. D. Frazier, Waseca Station are gratefully acknowledged.

was 17 bushels per acre compared to about 10 bushels for Chippewa even though the checks of both varieties yielded about 25 bushels per acre. These data also show the importance of adequate fertility in order for a variety to perform at its maximum. At Waseca seed yields were not increased in most cases by broadcast or starter fertilizer (Table 3). Seed yields were decreased in many cases. The soil P level and the K level were both very high. Based on these studies in 1968 and 1969, our recommendation is to fertilize soybeans just as you would corn. If the soil test values for P and K are high, response to P and K fertilizer is unlikely whether you are growing corn or soybeans. If the soil test values for P or K are low or medium, fertilizer should be part of a good corn or soybean program. Broadcast fertilizer plowed down, preferably, or disced into the soil before planting will give the largest and most consistent response. Banded placement may be used if smaller amounts of fertilizer are used. Deeper placement of fertilizer by plowdown may increase nutrient uptake when compared to fertilizer applied to surface and disced-in or to row fertilizer if the surface few inches of the soil becomes dry due to low rainfall. Seed placement (placing fertilizer in contact with the seed) can reduce plant population and seed yields and is not recommended at the present time.

Well-nodulated soybeans responded to nitrogen (N) fertilizer at Morris but did not respond at Lamberton (Table 4). Yields at Morris were low due to lack of rainfall. The protein content of the seed was also increased at Morris. At Lamberton neither seed yield nor protein content of the seed were affected by adding nitrogen fertilizer. These results indicate that nitrogen fertilizer for soybeans needs further consideration. Results at the present time indicate that the response of soybeans to nitrogen fertilizer is too irregular to make this a standard practice.

Deep placement of fertilizer (6 inches and 14 inches deep) did not increase soybean seed yields at Waseca in 1969. Treatments consisted of 500 pounds of N, 200 pounds P and 300 pounds K per acre in various combinations.

Using micronutrients as soil and foliar treatments with sulfate and chelate sources had little effect on soybean seed yield at Waseca and Clear Lake.

The sooner the soil is built up to a high level of fertility, the sooner we will see higher soybean yields. The level of fertility in the soil must be built up in order to obtain respectable soybean yields. In order to make maximum use of fertilizer and soil fertility levels, newer varieties with higher yield potentials must be coupled with good management practices. Good management is like a chain - no better than the weakest link.

Table 1. Effect on soybean seed yield when different fertilizer placements were applied to soybeans grown at Morris, Minnesota in 1969.

Row fertilizer	Chippewa 64		Merit	
	No broadcast bu/acre	Broadcast bu/acre	No Broadcast bu/acre	Broadcast bu/acre
Check	17.7	22.2	18.4	23.1
Band (2" x 2")	20.1	22.0	18.2	23.1
Seed placement	21.2	23.2	20.5	24.5
Band & seed placement	21.3	20.8	17.8	21.8

Fertilizer rates:	Band	10 + 20 + 10	Soil test values:	pH 7.7
	Seed placement	4 + 8 + 4		P 7 (lbs/A)
	Broadcast	0 + 60 + 30		K 300 (lbs/A)

Table 2. Effect on soybean seed yields when different fertilizer placements were applied to soybeans grown at Lamberton, Minnesota in 1969.

Row fertilizer	Chippewa 64		Corsoy	
	No broadcast bu/acre	Broadcast bu/acre	No broadcast bu/acre	Broadcast bu/acre
Check	25.5	33.7	25.8	39.8
Band (2" x 2")	33.5	35.8	36.9	42.4
Seed placement	32.6	35.4	34.7	40.3
Band & seed placement	34.2	36.1	41.0	43.5

Fertilizer rates:	Band	10 + 20 + 10	Soil test values:	pH 5.7
	Seed placement	4 + 8 + 4		P 10 (lbs/A)
	Broadcast	0 + 60 + 30		K 290 (lbs/A)

Table 3. Effect on soybean seed yields when different fertilizer placements were applied to soybeans grown at Waseca, Minnesota in 1969.

Row fertilizer	Chippewa 64		Corsoy	
	No broadcast bu/acre	Broadcast bu/acre	No broadcast bu/acre	Broadcast bu/acre
Check	38.1	37.2	43.9	40.2
Band (2" x 2")	40.5	34.6	43.6	39.1
Seed placement	37.2	34.8	42.4	41.9
Band & seed placement	37.9	37.0	40.7	41.7

Fertilizer rates:			Soil test values:	
	Band	16 + 40 + 53		pH 7.1
	Seed placement	4 + 8 + 12		P 71 (lbs/A)
	Broadcast	0 +100 +150		K 333 (lbs/A)

Table 4. Effect on soybean seed yield, protein and oil content when different nitrogen fertilizer sources were applied to Chippewa 64 soybeans in 1968 at the rate of 150 pounds of N per acre.

Morris:	Seed yield bu/acre	Protein %	Oil %
Check	17.7	41.2	21.6
Ammonium nitrate	19.4	45.4	19.0
Urea	23.7	44.8	21.7
Urea + sulfur	21.2	44.2	20.6
S-coated urea	20.9	42.8	20.9
Lamberton:			
Check	28.2	40.8	21.4
Ammonium nitrate	27.7	40.9	21.5
Urea	27.9	40.1	21.3
Urea + sulfur	28.2	41.6	21.5
S-coated urea	29.1	40.1	21.5

PRODUCING HIGH CORN YIELDS

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To ask a soil scientist to discuss attaining top corn yields is to assume that the key to corn production success lies only in the area of soil science. While I do believe that soil scientists do have much to say about corn production that isn't well understood today, I don't believe that we have the only words of wisdom.

Consult any of today's growers' guides published by seed corn companies, fertilizer and agricultural chemical companies or the agricultural colleges of the corn belt, and you'll see that many different aspects of corn production are stressed, and rightly so. As we continue to push crop yields upward by manipulating the soil, its fertility, the genetics of the corn and the environment of the crop, we necessarily must be extremely careful in our management.

The technology we use must be carefully used. Timing, methods, and interrelationships become critical. Top-notch producers are always experimenting with new technology. Those who continue to be top-notch are masters of management.

There are nine plant growth factors which must be considered--each one is critical in attaining top corn production.

They are:

1. Genetic factors (variety)
2. Moisture supply
3. Air (in soil and above ground)
4. Light
5. Temperature (in soil and above ground)
6. Nutrient elements (16 of them!)
7. Soil reaction
8. Control of insects
9. Control of disease

When you consider the logistics of providing all nine factors to a corn crop in the proper amounts, forms, places and times, you can see that indeed, this is a complex operation! Our problem, however, is even more complex for two reasons: first, we do not have complete understanding of exactly what is needed with respect to each of the nine plant growth factors; and second, we do not have complete control of all these factors.

At this point, I'd like to pay my respects to those farmers who play this so successfully year after year. If you ever examined the statistical probabilities of a successful crop depending on so many factors with so many uncertainties, I am sure that the only rational decision would be to stop producing crops. Perhaps the next best alternative would be to sell fertilizer to those who decide to gamble and stay in!

The first step in producing top yields must be contemplative. Realistic, attainable goals must be set. Then, subsequent rational decisions can follow. Your goal need not be conservative: if others attain respectable yields, so can you. Accomplishing your goal is not an art. You don't do so consistently by luck. The regular reaching of yield goals is attained by applying a highly complex science of plant growth.

After you have decided upon your yield goal, then you can select your pathway by choosing a variety with yield potential and by considering the plant growth factors, one by one.

CORN MANAGEMENT RESEARCH

As a part of the research work carried on by the Agricultural Experiment Station, we at Waseca have been taking part in a corn management experiment since 1967. Similar work is also underway at Lamberton and Morris. In this work we are manipulating several plant growth factors simultaneously to attempt to clarify some of the interrelationships which are involved in producing top corn yields. The variables included in the study are planting date, rate of nitrogen application, plant population and hybrid maturity. P and K are each applied at a 100 pounds per acre rate annually, broadcast.

Data from Waseca is shown in the following tables. Complete data is not given for the sake of simplicity. Several early season hybrids are averaged together, as are the late or full season hybrids. An Experiment Station publication is now in process which will give much more complete information.

Waseca Average Yields for Years
1967 through 1969, 150 lbs. N/Ac.

		Date of Planting			
Plant Popl'n Per Acre	Relative Maturing Grouping	4/22 (68,69)	5/1-8 (67,68,69)	5/15-17 (67,68,69)	5/31-6/1 (68,69)
18,000	Early (80,85,95)	100	108	107	105
	Late (105,110,115)	149	147	139	128
24,000	Early (80,85)	114	116	117	100
	Lage (110,115)	174	168	162	144
30,000	Early (85)	127	137	127	124
	Late (115)	190	173	158	122

Waseca Average Yields for Years
1967 through 1969, 250 Lbs. N/Ac.

		Date of Planting		
Plant Popl'n Per Acre	Relative Maturity Grouping	4/22 (68,69)	5/8 (67)	5/15-17 (67,68,69)
18,000	Early (80,85,95)	102	128	108
	Late (105,110,115)	154	146	143
24,000	Early (80,85)	104	135	113
	Late (110,115)	180	183	170
30,000	Early (85)	129	173	141
	Late (115)	184	194	166

The data indicates that at Waseca on silt loam prairie soils where insects and weeds are controlled, where heavy rates of broadcast P and K are used, where early planting and moderate to heavy rates of N are used that we can expect consistently high yields of corn using full-season hybrids. This is not revolutionary. Look at the corn growing guides of the industry in late years, and statements like these will be found. What we do have here is solid evidence that these guidelines do work. We have consistently hit over 180 bushels per acre in replicated plots using this formula. I believe that we have shown that we can expect very respectable yields at 24,000 population and with only 150 pounds of N per acre if planting is done before May 1. This year our April 22 planting was snowed on, and temperatures went as low as 27 degrees as late as May 11, but the early planting consistently out-yielded the corn planted May 1.

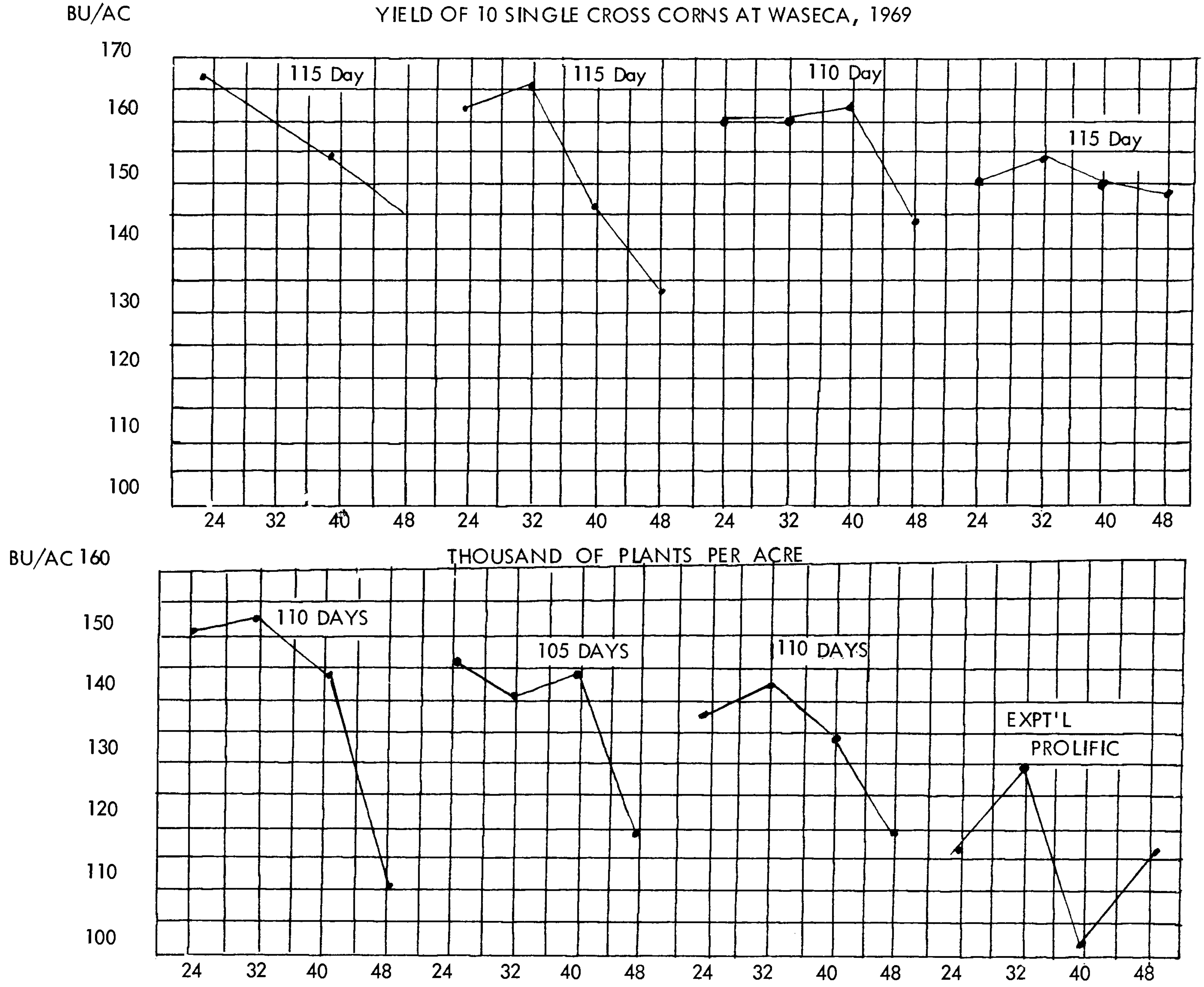
1969 CROP YEAR

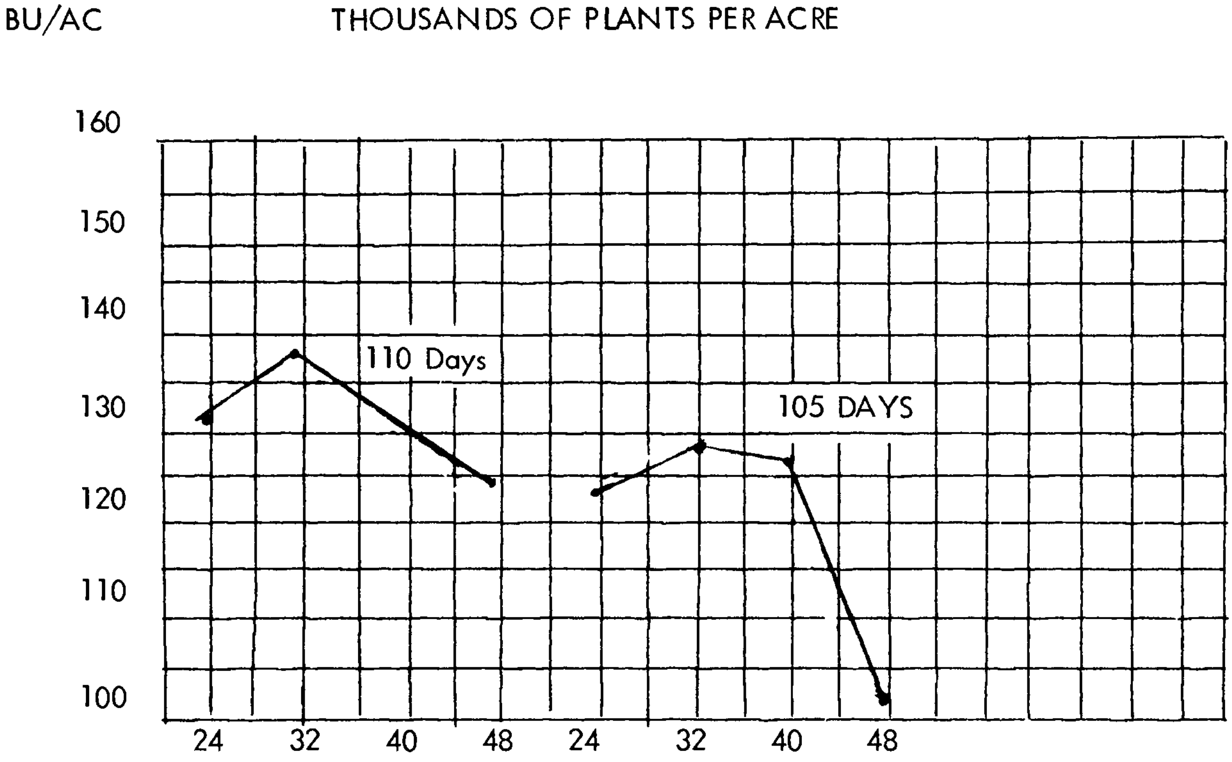
The crop year of 1969 started out with saturated soils, but in the central part of Minnesota especially the soil was bone dry by late August. In spite of this, good yields are coming through and especially so where the corn was planted early and with high populations. Nitrogen gave good response in 1968, especially where soils were well fertilized with P and K, where seed was not placed too deep and where weeds were controlled. These practices I believe were shown to give good results in spite of a season marked by extremes in soil moisture. I believe that high fertility and improved varieties have helped greatly in reducing the hazard of high populations under drouth conditions.

CORN POPULATION RESEARCH

The corn management information indicates higher and higher yields as we increase population. Some data which Dr. Lueschen and I have gathered at Waseca indicates that with present full-season single-crosses we should not assume that the sky is the limit on population. We selected ten of the best full-season varieties we could find by discussion with University and seed company agronomists. Populations studied were 24-, 32-, 40-, and 48,000 plants per acre. The tables below indicate the 1969 yield results following fertilizer application totalling 800 pounds per acre N, 375 pounds per acre P_2O_5 and 750 pounds per acre K_2O applied in the past two seasons.

YIELD OF 10 SINGLE CROSS CORNS AT WASECA, 1969





Careful, understanding attention must be paid to management in order to grow top corn yields. We are dealing with a complex technology and some of the variables are not under our control. This means we must use our understanding to be in the best possible situation regardless of the conditions which come about during a growing season.

The results of the corn population study shown above indicate that it is possible to get population too high for existing corn varieties, and that extreme fertilization does not necessarily compensate. We need to understand where these turning points are in our pathway to top corn yields. Top corn yields can be produced consistently by meticulous attention to all the plant growth factors. When one factor is changed, we must consider the effect of this on the whole package of corn production practices.

PHOSPHORUS, POTASSIUM AND LIME RATES RELATED TO TISSUE CONTENT, SOIL TEST CHANGES AND PLANT YIELD

C. J. Overdahl

After several years of comparing yields, soil tests and tissue tests, we now have an opportunity to evaluate what these measurements mean.

There have been vast differences in how rapidly soils become depleted in basic nutrients. This has been one of the confusing things for fertilizer dealers, county agents and soils specialists. Alfalfa demonstration plots, for example, have been established where potassium responses were expected, but no yield differences were observed. After two years, the plots were often abandoned. Monitoring the nutrient levels in the plant tissue allows us to see whether there is a nutrient level decline as crops are removed or whether the soil has the capacity to continually supply adequate nutrients indefinitely.

Looking at potassium, for example, the Morris experiment station alfalfa yields averaged 3.7 tons per year for nine years, with an average of about 2.25 percent potassium in the tissue. This was an annual removal of 200 pounds of K_2O, or 1,800 pounds of K_2O removed during the nine years with no evidence of response from potassium. The soil test of the untreated plot averaged about 220 pounds of exchangeable K. Certainly plant removal in this case would not be a measure of potassium needs.

At Pierz, Minnesota in Morrison County, only moderate yield differences were measured from potassium application for the first year or two on a sandy loam soil. Potassium content in the soil rapidly declined, however, and severe potassium deficiency symptoms appeared after two crop years.

The silt loam soils at Morris, Minnesota apparently have a high potassium supplying power unaffected by withdrawal, while two years was all the time it took when no treatments were made to reduce potassium to critical levels on the sandy loams, see table 1.

Table 1. Alfalfa yields in tons per acre (15% moisture) at Pierz in Morrison County from varying seeding time potassium treatments (corrective). All plots had adequate P, S, B and lime.

Lbs. K_2O/acre Corrective 1963	1964	1965	1967
0	2.2 a	4.1 a	1.4 a
60	2.6 b	4.3 ab	1.4 a
120	2.7 b	4.7 c	1.5 a
180	2.6 b	4.6 bc	1.6 a
240	2.9 c	4.8 c	1.4 a

The 1966 crop was destroyed by winter kill. All values for each year that have differing letters are significantly different at the 5% level.

Table 2. Alfalfa yields in tons per acre from potassium topdressing (maintenance) superimposed in fall of 1964 over all treatments shown in table 1.

Lbs. K_2O/acre Topdressed annually	1964*	1965	1967	1968	1969
0	2.6 a	4.8 a	1.7 a	1.4 a	1.5 a
120	2.6 a	5.7 b	4.1 b	4.9 b	4.5 b
240	2.6 a	6.1 c	4.5 c	5.5 c	5.0 c

* Topdressing not made until fall of 1964.

Table 1 shows small but significant differences in 1964 due to differing potassium treatments. Note the unusually high alfalfa yield on the zero treatments in 1965. Rainfall was quite adequate that year, but the K soil test of the untreated plot was surprisingly low (50 pounds). Topdressing, however, increased yields to as high as 6.1 tons per acre. This top yield removed more than 300 pounds of K_2O from the soil and probably at least this much should be returned if such yields are to continue.

In 1967, there was no evidence of residual effect from the 1963 treatment. This was of great interest because the question had frequently been asked about how long the corrective treatments would last. There were no significant differences in yield, soil test or percent K in the tissue in 1967. The tissue K was reduced to less than 1 percent. The corrective potassium treatment effect was, therefore, used up before the third crop year. Soil tests had fallen to as low as 30 pounds of exchangeable K in the spring of 1967 across all original treatments.

Responses to annual topdressing of potassium were significant on all years. Yields in table 2 show the average effect of potassium treatments. Since original treatments were split three ways, these figures are the average topdressing effect over each of the 1963 corrective treatments.

Table 3. Soil tests corresponding to treatments in table 1, lbs/acre K.

Lbs. K_2O/acre 1963	1963	1964	1967*	1969
0	80	50 a	30 a	45 a
60	-	60 ab	40 a	45 a
120	-	53 a	40 a	55 ab
180	-	77 b	50 a	47 a
240	-	80 b	40 a	42 a

* Tissue tests in 1967, 1968 and 1969 ranged across the five K treatments from .8 to 1%. None were significantly different.

Table 4. Soil tests as exchangeable K and tissue tests as % K corresponding to table 2 treatments.

Lbs. K_2O/acre Topdressed annually	1967		1968	1969	
	Soil test lbs. K	Tissue* % K	Tissue* % K	Soil test lbs. K	Tissue* % K
0	42 a	.93 a	.91 a	47 a	.81 a
120	173 b	1.96 b	1.96 b	98 b	2.00 b
240	325 c	2.25 c	3.12 c	277 c	2.60 c

* For 1st cutting only. Soils were not tested in 1968.

Since there was no effect of the 1963 treatments remaining after 1967, we had the equivalent of 20 replications of each topdressing treatment. In 1968, half of the annual topdressings were omitted to study what happens when topdressing is discontinued and also to convert half of the 120 pound K_2O treatments to 60 pounds and half of the 240 pound treatments to 180 pounds, making five topdressing levels of 0, 60, 120, 180 and 240 pounds of K_2O.

Table 5. The effect of omitting last of 4 annual K topdressings on yield the following year. 1968 yields.

	Cutting	Annual treatments of K_2O, lbs/A				
		0	120		240	
Yields T/A	1	.67	2.02	1.70*	2.23	2.05*
	2	.62	2.01	1.68*	2.03	2.05*
	3	.12	.85	.60*	1.20	.99*
	Total	1.41 a	4.88 c	3.98* b	5.46 d	5.09* c
% K, tissue 1968	1	.93	1.96 b	1.48* a	3.12 c	2.21* b
	2	-	1.44 b	.90* a	2.24 c	1.74* b
	3	-	.89 a	.68* a	1.90 c	1.21* b

* Topdressing omitted for 1968 crop after 3 previous applications.

Where letters differ, results are significantly different at the 5% level. Yields are from 10 observations per treatment.

Table 5 shows a significant drop in yield when topdressing was omitted, even at the 240 pounds of K_2O. In table 5, it is also observed that the potassium in tissue declines considerably from first to third cuttings. In 1969, we applied additional topdressing after the first cutting to five of the ten replicates to observe what could be done to improve the low potassium content in the second and third cuttings. Table 6 shows that yields were enhanced by this additional topdressing and that yield, tissue and soil tests reflect the additional treatments.

Table 6. Effect on second cutting yield from supplemental potassium topdressing applied after the first cutting, in addition to the previous fall topdressing at the same rates. (1969)

	K_2O treatments in lbs. per acre								
	0	60	60+	120	120+	180	180+	240	240+
Yield T/A	.46	1.12	1.27	1.53	1.67	1.56	1.74	1.75	1.79
K soil test	47	50	76	70	126	108	192	202	352
% K tissue	.80	1.14	1.59	1.53	1.91	1.91	2.28	2.20	2.38

+ The plus indicates that these rates of fall topdressing were repeated in June after the first cutting.

The decline in potassium content in the tissue as shown in table 5 was, in most cases, stopped for the second cutting, but had declined considerably at the time of the third cutting, see table 7.

Table 7. The effect of supplemental topdressing after the first cutting on the % K in tissue by cuttings. (1969)

Cutting	K_2O treatments in lbs. per acre								
	0	60	60+	120	120+	180	180+	240	240+
1st	.81	1.44	-	1.85	-	2.00	-	2.60	-
2nd	.80	1.14	1.59	1.53	1.91	1.91	2.28	2.20	2.38
3rd	.50	.62	.78	.75	1.06	.98	1.39	1.58	1.59

Our experience with large potassium applications for potatoes and its effect on magnesium content is of interest.

Near Clear Lake in Sherburne County, a four year study on sandy loam soils where potato yield, K soil test, and both potassium and magnesium were compared, table 8 shows that as potassium treatments increased, yields increased, K in petioles increased and magnesium decreased correspondingly.

Table 8. Effect of potassium on potato yield, soil test K and % K and % Mg in petiole. Gray Farm, Sherburne County, Minnesota.

Annual treatment N + P_2O_5 + K_2O	1966 CWT/A	1967* CWT/A	1968 CWT/A	1969 CWT/A
200 + 150 + 0	207	111	252	210
200 + 150 + 150	232	194	336	280
200 + 150 + 250	313	198	332	269
200 + 150 + 500	338	199	347	296
200 + 150 + 1000	341	203	329	296

	% K	% Mg	% K	% Mg	% K	% Mg	% K	% Mg
200 + 150 + 0	-	-	4.5	.49	4.9	.72	4.5	.67
200 + 150 + 150	8.3	.55	7.6	.22	7.5	.32	6.7	.28
200 + 150 + 250	10.0	.38	9.0	.15	7.8	.26	6.9	.22
200 + 150 + 500	11.8	.31	9.0	.13	7.6	.20	7.4	.17
200 + 150 + 1000	11.3	.37	9.0	.15	7.8	.17	7.7	.15

* Yield reduced by severe hail damage in 1967.
Petiole analysis in 1966 at Ohio, others at U. of Minn.
Variety - Norland

Yield increases from annual treatments as high as 500 pounds of K_2O appeared possible. From other experiments on magnesium, it appears that magnesium content has not diminished to deficiency levels. In a four year experiment in Hennepin County where initial K soil tests were 600+, no apparent response was obtained from potassium treatments the first two years, nor was there a treatment effect on % K or % Mg in the petioles. On the third year, soil K diminished to a 450 pound K test and a response was obtained from 150 pounds of K_2O in the row. On the fourth year (1969) soil test K was below 300 pounds and a response from even the 500 pound K_2O treatment was evident.

Table 9. Effect of potassium on potato yield, K soil test, % K and % Mg in petiole. Tessman Farm, Hennepin County, Minnesota

	1966		1967		1968		1969	
	CWT/A	Soil test lbs K	CWT/A	Soil test lbs K	CWT/A	Soil test lbs K	CWT/A	Soil test lbs K
200 + 150 + 0	332	600+	206	not tested	178	435	196	285
200 + 150 + 150	325	600+	225		280	-	215	430
200 + 150 + 500	277	600+	222		271	600+	266	600+
	% K	% Mg	% K	% Mg	% K	% Mg	% K	% Mg
200 + 150 + 0	11.6	.14	8.0	.22	6.8	.35	6.2	.22
200 + 150 + 150	12.7	.12	8.0	.20	7.6	.23	7.0	.12
200 + 150 + 500	12.8	.14	7.9	.20	7.9	.14	7.2	.10

Phosphorus relationship for soil test, tissue test and yield are equally interesting to that of potassium. On sandy soils with potatoes, we found responses from phosphorus to be about equal to that of potassium when soil tests were at the same relative level. Responses due to P were less on alfalfa, but were consistent if we had a medium soil test P. Seldom was more than an annual treatment of 30 pounds of P_2O_5 needed.

Lime trials with alfalfa often were surprising. In southwest Minnesota, where subsoil pH is generally high, lime responses were infrequent, even if surface soils tested as low as 5.5 pH. In other areas of the state where subsoil pH was acid, responses to lime were obtained, even when surface pH was 6.4.

Another point of interest - about the effect of added lime on soil pH was soil moisture. At Elk River on a loamy sand, the initial pH was 5.2. Where eight tons of lime were added, the pH rose to 6.2 on irrigated plots and only to 5.4 on the unirrigated plots. This may give us some insight as to why such high rates of lime are needed to raise pH on our sandy soils. Another probable reason why low rates of lime are so ineffective is the fineness of grinding. Often the percent of material passing a 60 mesh sieve is less than 30%, which results in a very slow reaction with the soil.

The following curves will serve as a summary of our trials in Morrison County. We have compared soil test P, K and pH from each individual plot with alfalfa yield to determine what soil level is needed before yields will not further increase. They are shown in figures 1, 2 and 3 with arrows pointing to the approximate optimum levels for these particular soils. These curves were computed by Gyles Randall, formerly research assistant in the Soil Science Department.

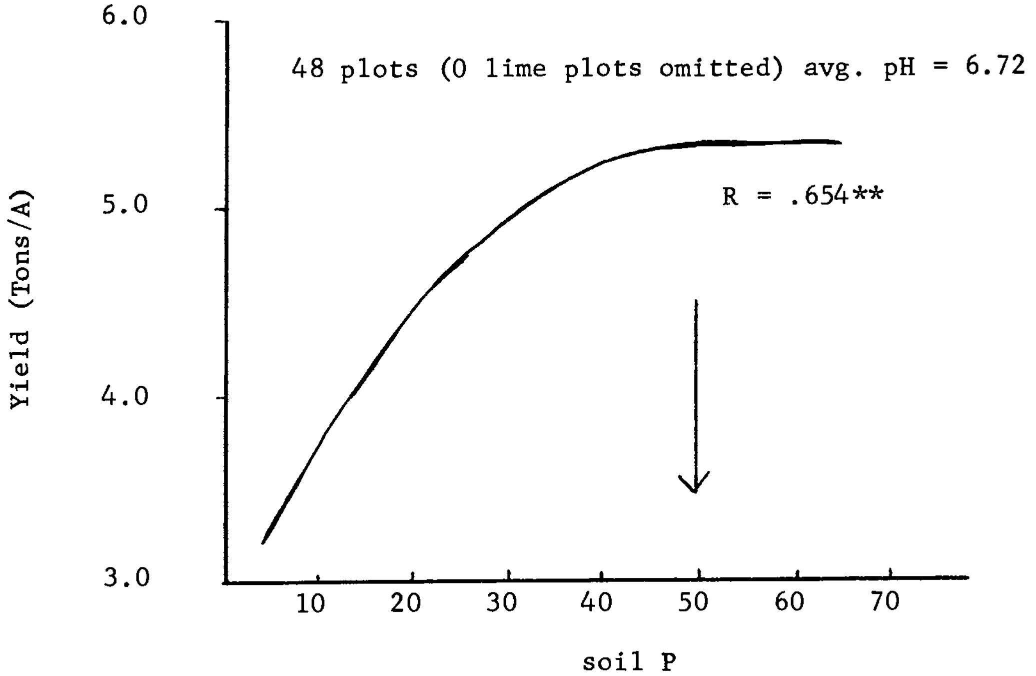


Figure 1. Relationship of soil test P and alfalfa yield, 1968, Pierz, Minn.

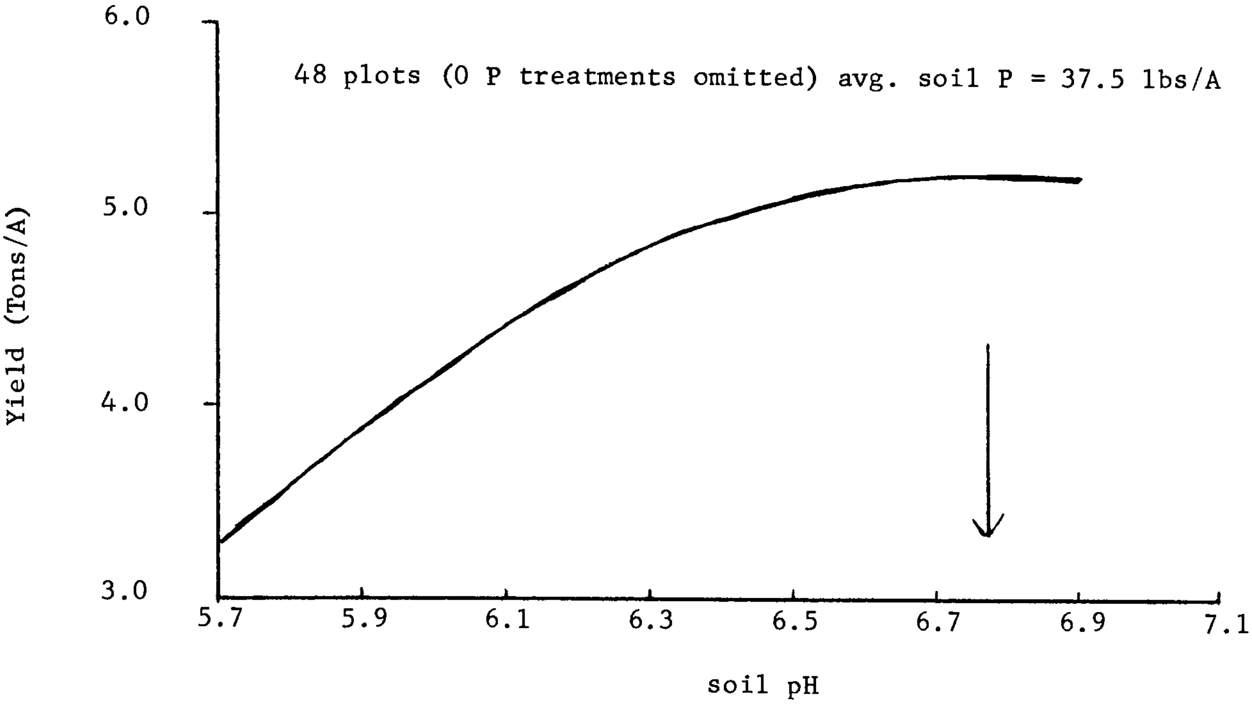


Figure 2. Relationship of soil pH and alfalfa yield, 1968, Pierz, Minn.

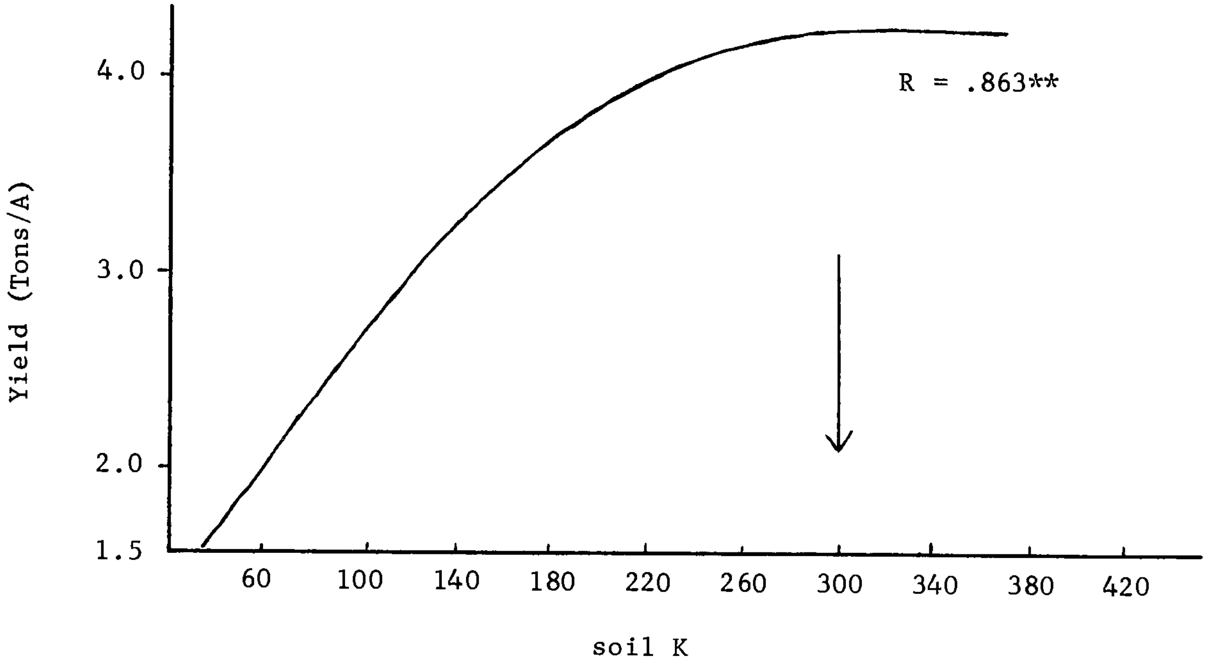


Figure 3. Relationship between soil K and alfalfa yield, 1967, Pierz, Minn.

"SALESMANPOWER" FOR THE AG-LIME INDUSTRY

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In the face of overwhelming evidence concerning the value of Aglime . . . . WHY DON'T FARMERS USE ENOUGH TO SATISFY THE BASIC NEEDS OF THEIR SOILS?

We have all heard this debated in grange halls, hotel rooms, offices and college classrooms. There seems to be as many answers as there are people involved. Frankly, there are too many fuzzy answers, most of which are whiskered with age. Is there anyone in the Aglime business that wouldn't admit that we do need a fresh start? We may fail, but let's have a "go" at it.

If you are disappointed with your present Aglime sales volume you probably have failed in two ways:

1. You have not created AWARENESS of your product.
2. You have failed to create a proper customer ATTITUDE for your product.

Awareness and Attitudes

Awareness is gained by proper advertising. In the act of advertising, your aim must be to create a healthy attitude for your product in the minds of your customers. The first step is to ANALYZE YOUR PRODUCT. You cannot possibly create AWARENESS and build a proper ATTITUDE for your product until you have carefully analyzed every facet that is characteristic of said product. During this analysis, one must ask himself, "what characteristics does my product have that will BENEFIT the consumer." Keep in mind that it is the BENEFITS that people buy, and keep buying as repeat customers.

After you have determined what outstanding characteristics your product may have, you should then attempt to turn these into BENEFITS for your customers. But first, buyers must be AWARE of these characteristics. Put another way -- you might think you have (and you may) the finest Aglime in your state, but if your potential buyers aren't AWARE of your product -- it doesn't really exist (in a commercial sense). Anyone in business today must let others know they are in business . . if they cherish any hopes for success. We have plenty of Aglime producers who expect the product to sell itself.

Developing Unique Marginal Difference

I suppose the best example I can think of to demonstrate Unique Marginal Difference (UMD) is the cigarette which is a "silly millimeter longer." A millimeter is all of .03937 of an inch; yet, a million dollar advertising program is being used on that silly millimeter to create an AWARENESS for that particular brand. To the "thinking man" that millimeter is not at all important. The millimeter reminds people of the brand, but they really continue to buy it because they like its flavor. The same is true (picking an example) of the color of limestone which comes in red, gray, blue and white. We, who are in the business, know that the color of limestone has no direct bearing on its acid neutralizing value. But don't ever discount the Unique Marginal Difference that color can make to a buyer. People in Boston buy only brown eggs and people here in Minneapolis buy only white eggs.

There is a very successful Aglime Company in Pennsylvania that sells "Soft White Lime." People remember this excellent quality Aglime because of its color, but they buy it because it benefits them.

Avoid the "Me Too" Approach

Developing a Unique Marginal Difference for your Aglime is important since your competitors may have Aglime which is at least similar to yours. Don't get trapped in the deadly game of saying, "our Aglime is just as good as yours." This approach doesn't sell cigarettes (that silly mm again) nor beer (the champagne of bottled beer) nor greeting cards (when you care to send the very best). When products are the same, or nearly so, their Unique Marginal Differences can tip sales in the direction of the most aggressive company.

Analyze carefully the characteristics of your Aglime or the stone from which it comes and then choose the UMD very carefully, and don't get trapped. Remember the oil company that based their UMD on "the 2,000 mile oil"? Who wants to buy an oil today that lasts only 2,000 miles? How about that tire firm that advertised an expensive 100,000 mile tire. Who wants to buy a replacement tire that will outwear a car twice over!

It Does Work

When you have found your UMD, let people know about it. Let me cite an example. The Adams Ag-Stone Company used as their UMD, "EFFECTIVE NEUTRALIZING VALUE." This was simply a valid method of using both fineness and base oxide content (both Mg and Ca) to come up with a single rating which could be used to compare one Aglime with another. Using this method the Adams Ag-Stone could compete with almost any other stone in its local marketing area. They used this UMD and called it ENV. This rating made people AWARE of the product, but continued sales were based on the BENEFITS people derived from using it. Incidentally, they charged a dollar more per ton for their Aglime -- AND -- outsold everyone else in their marketing area. I hope you are wondering if they spent much money on advertising. Yes, they did, but their allotted advertising dollars were not based on last years business. Instead, they allocated their advertising dollars as based on anticipated business for the next year. In other words, advertising cannot be a year old to be effective.

In ending, let me say that there is no agricultural input that can BENEFIT farmers more than Aglime. But isn't it abundantly true that -- IF FARMERS ARE NOT AWARE OF YOUR AGLIME IT DOESN'T REALLY EXIST, except in your own mind.

AGRICULTURAL RUNOFF AND LAKE POLLUTION

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There has been much speculation about what substances stimulate algal blooms in lakes and about where these substances come from, but there are very few facts. Procedures have been developed in recent years, however, so that daily growth rates of algae in lakes can be measured very accurately and the critical nutrients can be identified. There are still many problems, however, because different species of algae are present at different times of the year in any lake, and each species has unique nutrient requirements. Furthermore the concentrations of nutrients also fluctuate seasonally. Although there are many exceptions, the dominant algae during summer blooms are blue-green algae, many of which can "fix" their own nitrogen, just as legumes can on land. Thus phosphorus is probably the critical nutrient for the algae in summer blooms. We have demonstrated this in Lake Minnetonka, southwest of Minneapolis. Lake Minnetonka is really a group of lake basins. Most of the phosphorus in the largest basins comes from municipal sewage effluents, but many of the basins do not receive sewage. Much of the phosphorus in several basins with very dense algal populations must come from agricultural drainage.

Phosphorus is very immobile in soils, and usually only a few ounces are removed each year from an acre of farmland. How, then, can phosphorus in agricultural drainage cause problems in lakes? The answer is that quantities of phosphorus that are insignificant from the standpoint of agriculture are very significant in lakes. The phosphorus concentrations in lakes are very small, usually between 0.010 and 0.100 ppm, and it appears that algae cannot utilize more than 0.050 ppm phosphorus because light and temperature become limiting.

A typical lake with an area of 1000 acres and an average depth of 15 feet in central Minnesota will have a watershed of about 10,000 acres. Runoff typically removes at least 1 ounce of phosphorus from an acre of farmland each year, which means that 624 lbs may be carried into the lake annually from the land. This would yield a phosphorus concentration of 0.015 ppm in the lake. Feedlots and pastures are also usually located near streams that discharge into lakes, and they contribute additional phosphorus. The small quantities delivered to lakes from each of these sources are sufficient to support dense algal blooms, even without contributions from lake-side septic tanks or municipal sewage.

Small quantities of phosphorus in lakes have large effects. Shallow lakes typically contain several pounds of phosphorus per acre. Each pound of phosphorus is used by the algae to produce almost 9 lbs of new organic matter (dry weight) each day. Thus several pounds of phosphorus enable the algae to produce several tons of organic matter each year.

Many lakes were very fertile before Europeans settled in Minnesota. This should not be used as an argument to justify lake pollution. We have attempted to change the terrestrial environment to suit our purposes, and there is no reason why we should not attempt to manage and improve lakes as well. This can be accomplished only if agriculture assumes its share of the blame for lake and stream pollution. Water pollution is often dismissed as an unfortunate side-effect of economic progress, but a "side-effect" is an "effect", and the disadvantages of technology now threaten to outweigh the advantages. Pollution abatement in agriculture, as in other areas of technology, will increase production costs. Some of this cost must be absorbed by producers and passed on to consumers and some should be reimbursed by government subsidy, but sooner or later we must acknowledge that pollution is an integral, not peripheral, component of technology.

WHAT MAKES A SUCCESSFUL FARMER "TICK"?

Tom Doughty
Managing Editor
The Farmer

As I look back over the past two decades, the biggest change that has taken place, not only in farming but in most every other occupation, is change itself. And, basically, the farmer who has been willing to accept changes, and wisely adopt those by which he can profit, is the one who's still in business today.

Perhaps you remember being taught that the following five rules were virtues for success. If you weren't taught them, perhaps you remember your dad or granddad swearing by them:

Virtue No. 1: Stand pat with the old way; don't be swayed.

Virtue No. 2: Stay out of debt. If you go in debt, get out as soon as you can.

Virtue No. 3: Work hard all the time--it's the only way to get ahead.

Virtue No. 4: Be independent.

Virtue No. 5: Don't take chances.

While these five virtues may have been rules for success in farming back in Dad or Granddad's time, I submit that they are the rules for failure in farming today, if closely adhered to.

Applying these virtues, what successful farmer of today can: 1, Go for any length of time without changing his operation through new ideas? 2, Afford to stay out of debt? 3, Work so continuously hard physically that he doesn't have time to think about improving his operation and, in the long run, gain more profit? 4, Be so independent that he fails to communicate with others--to gain new insight for improving his own farming operation, his farming community and the whole of agriculture? 5, Not afford to take a chance on a new idea or innovation--before it has become so commonplace that the big profits have long been skimmed off by the first adopters?

SOIL FACTORS AND PLANT ROOT GROWTH

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Our knowledge of plant response to environment can be improved as we learn more about root response to soil factors, such as, moisture, temperature and compaction. Consequently, we may better learn how to manage tillage, residue placement, and fertilization.

As a corn root proliferates laterally and downward into new soil volumes, it encounters a different soil environment of temperature and water content. This arrangement of proliferating root and soil environment is especially evident when straw mulch residues are placed as strips on the surface, or when different tillage treatments (including tractor traffic) are performed in the row compared to the interrow. Both straw mulches and tillage are known to influence the soil water and temperature even at depths as great as 30 inches. On a Nicollet soil at Lamberton, corn root growth has been significantly affected by row or interrow placement of straw mulch and by different tillage in the row compared to the interrow. In two seasons of measurement, the same tillage and straw mulch treatments showed different corn root proliferations. However, these different effects of similar treatments can be explained by differences of soil water and temperature between seasons.

Root growth is also affected by soil compaction and related properties. Alfalfa roots branched differently in response to an experimental compaction performed 10 years ago on a Nicollet soil. Alfalfa roots observed on a Nicollet soil showed much different growth than on a fragipan soil in Northern Minnesota. There was also a large difference of mature corn roots as affected by different soils. Moreover, nonsymmetric corn root proliferation could be traced to compaction made by tractor traffic.

CAN WE AVOID DROUTH ON SANDY SOILS WITH ASPHALT BARRIERS?

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Hot asphalt has been sprayed in a sheet underneath the soil surface to try to improve the water holding ability of sandy soils. Machines for the purpose can place the barrier up to 2 foot deep in the soil in an 8 foot strip in one pass. Overlapping of the passes makes a nearly continuous sheet.

The asphalt does not form a water tight seal. It slows water movement and allows free water to pass through so as to avoid "drown out". At the same time it becomes nearly impermeable when excess water drains so that more is held for storage than without a barrier to be used between rains or irrigation. After prolonged drouth plants wilt and growth stops as if the barrier weren't there.

Barriers are efficient in conserving water from intermittent rains. By prolonging the period water can be stored, they reduce the frequency of irrigation and hence the number of irrigations needed. Field crops grown without irrigation will produce more than without the barrier in average years. The increase can be appreciable but depends on the crop and rainfall distribution..

Barriers are expected to remain effective for several years. Some estimate that 15 years can be expected. There is reason to believe they may last much longer. Cost per acre for application is estimated to be around $300 per acre.

FERTILIZER RESULTS IN LOW RAINFALL AREAS

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Fertilizer response in western Minnesota is greatly influenced by available moisture. How optimistic should one be when applying fertilizer to crops such as corn and soybeans? Full season crops use about 20 inches of moisture in evapotranspiration. The average precipitation at Morris is 23 inches with about 16 inches occurring during the period of April 1 through August 31. If we always received average precipitation, there would be no problem. However, we must look at the extremes. Annual precipitation has ranged from a low of 15.31 inches in 1933 to a high of 33.48 inches in 1965. In the last 15 years the growing season rainfall has ranged from 10.32 inches in 1961 to 22.62 in 1962. So, we would expect fertilizer response to vary with season.

Weather alone can influence corn yields drastically as shown by Holt and Timmons (1) in western Minnesota and eastern South Dakota. In four years of work they found that where fertility was adequate (100 pounds N, 80 pounds P_2O_5, and 40 pounds K_2O/acre), yields ranged from 1 to 133 bushels per acre where stands were from 7,920 to 23,720 plants per acre. In their analysis 91 percent of the variation in yields could be accounted for using weather variables. These variables were the available soil moisture at the one-foot plant stage, precipitation the first three weeks in July (Period P1), and the precipitation during the last week in July and the first two weeks in August (Period P2). They found that low rainfall during Period P2 resulted in lower yields than the same amount of rainfall during Period P1. These last two measurements include the tasseling and silking stages for most of our hybrids. Thompson (2) assessing the effect of weather and technology on corn yields in the corn belt from 1930 through 1967 found that July rainfall was the most important weather influencing yields. In his analysis August rainfall had very little effect on yields. Many other researchers in the drier areas have found precipitation and temperature two weeks before to two weeks after this stage to be very critical.

If these periods are critical, can we correlate the variation in fertilizer response with the precipitation during these periods? For the first period at Morris precipitation during the last 15 years has ranged from 0.64 to 5.89 inches. During the second period it has ranged from 0.52 to 5.80 inches.

I would like to take six years (Table 1) as examples and show how weather affects fertilizer response.

Table 1. Precipitation at Morris, Minnesota, for two selected three-week periods for 1956, 1960, 1963, 1966, 1968, and 1969.

YEAR	PERIOD P1 (July 5-July 25)	PERIOD P2 (July 26-August 15)
1956	2.54	3.06
1960	1.03	1.04
1963	.96	5.35
1966	.62	4.17
1968	.44	1.82
1969	1.70	1.86

Yields of continuous corn (Table 2) in three years on a Nitrogen-Phosphorus-Potassium rotation experiment at Morris with widely varying moisture situations showed a consistent yield increase due to nitrogen application. Phosphate and potash did not affect yields significantly. On soybeans in the same experiment there was no response to fertilizer.

Table 2. Treatment effects on a Nitrogen-Phosphorus-Potassium rotation experiment at Morris, Minnesota.

	CONTINUOUS CORN (Bu/A)			SOYBEANS (Bu/A)		
YEAR	144# N/A	140# P_2O_5/A	40# K_2O/A	20# N/A	40# P_2O_5/A	40# K_2O/A
1956	+16*	+2	+5	+3.5	+1.3	0
1960	+19**	-4	+3	-0.7	+0.4	-3.8
1963	+21*	-4	-3	+0.2	-0.8	-1.3

Note: Treatments marked (*) were significant at the 5% level; those marked (**) were significant at the 1% level. All others were nonsignificant.

A longtime nitrogen fertilization study at Morris (Table 3) shows wide variations in yield due to moisture patterns. In 1960 low rainfall limited corn yields to the 50-55 bushel per acre range with no fertilizer response. In 1963 with low moisture in period P1 and over five inches in period P2 there was a 20-bushel per acre increase due to the first 40-pound increment of nitrogen. In 1966 with about the same pattern as 1963, 80 pounds of nitrogen gave the highest yield. In 1968 with very low moisture in period P1 and less than 2 inches in period P2, 80 pounds of nitrogen again gave the highest yield. The 240-pound per acre rate did not lower yields significantly in any of the four years, but on the other hand 40 and 80 pounds seemed to be adequate.

Table 3. Corn yields on a nitrogen fertilization study at Morris, Minnesota.

	POUNDS OF NITROGEN/ACRE			
YEAR	0	40	80	240
	(yields in bu/acre)			
1960	53	55	54	52
1963	68	88	82	86
1966	48	59	80	73
1968	66	72	81	78

Results on a phosphorus fertilization trial on continuous corn at Morris (Table 4) on a soil testing in the 20-25 pound per acre range shows very little response to phosphate. In 1966 with low rainfall in period P1 and high rainfall in period P2 yields were close to 100 bushels per acre, but there was no increase due to phosphate application. In 1968 with lower rainfall in both periods, the yields were lower, but again there was no fertilizer response.

Table 4. Corn yields on a phosphorus fertilization experiment at Morris, Minnesota.

	POUNDS OF P_2O_5 PER ACRE				
YEAR	26	51	77	102	102*
	(yields in bu/acre)				
1966	99	96	93	99	103
1968	66	68	72	68	71

* This treatment had an annual application of 10 pounds of zinc as zinc sulfate.

Recent work at Morris in a corn management experiment shows a difference in response to nitrogen due to both maturity rating of the hybrid used and population (Table 5). The long season hybrids respond to at least 150 pounds of nitrogen, but yields are lowered by the 250-pound rate. For the mid-season hybrids 50 pounds appeared adequate in 1967 and 1969 at 16,000 plants per acre, but at 22,000 plants per acre in 1967 there was a slight decrease and in 1969 a slight increase as nitrogen was increased. In both years 50 pounds of nitrogen was adequate on the short season hybrids and higher rates tended to lower yields.

Table 5. Corn yields on a corn management experiment at Morris, Minnesota.

		NITROGEN RATES IN POUNDS PER ACRE					
HYBRID	POP.	1967 - Planted May 9			1969 - Planted April 24		
MATURITY	1,000's	50	150	250	50	150	250
		(Yields in bu/acre)					
Long	16	101	123	113	84	92	78
Medium	16	117	115	114	78	73	80
Short	16	110	98	90	78	75	73
Medium	22	109	94	99	76	83	87
Short	22	116	116	112	76	84	75
Short	30	110	98	89	78	79	82

What can we conclude from these experiments?

1. Nitrogen rates for average yields of corn in west central Minnesota appear to be at about 80 pounds per acre. The present recommendation by the University of Minnesota Soil Testing Laboratory for continuous corn on a soil testing high in organic matter is 70 pounds if the yield goal is 70-100 bushels per acre and 120 pounds if the goal is 101-129 bushels per acre.

2. At phosphorus soil test levels over 20 we cannot expect to obtain large yield increases on any of our crops. On corn the present recommendation for soils testing in this range in western Minnesota where subsoil test levels are low is 30 pounds of P_2O_5 per year. For soybeans no phosphorus is recommended and on small grain the P_2O_5 application should be 20 to 30 pounds per year.

Literature Cited

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2. Thompson, L. M., 1969. Weather and technology in the production of corn in the U. S. cornbelt. Agron. J. 61:453-456.

ZINC NEEDS AFTER HIGH PHOSPHOROUS BUILDUP IN SOILS

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High levels of soil phosphorous, either naturally or by phosphorous fertilization, have been associated with zinc deficiencies of certain crop plants. There are reports in the literature from 1948 which discuss the depressive action of phosphorous on zinc uptake by plants.

More recent research has produced additional evidence of phosphorous induced zinc deficiency. Burleson et al (2) reported the yield of corn was reduced 29% where 60 lbs. of P_2O_5 was applied to the soil and 41% from 120 lbs. In Nebraska Langin et al (4) reported the reduction in corn yield from starter fertilizer was due to phosphorous interfering with plant uptake of zinc. Other researchers have described the soil conditions which appear to intensify the phosphorous-zinc interaction.

Zinc availability in soils is inversely related to soil pH, since as soil pH increases the availability of zinc decreases. It was established by Camp (3) that the critical level for zinc availability is pH 5.5 to 6.5. Peech (5) reported that practically all of the soil zinc is fixed in an unavailable form at pH 9.0. Stukenholtz et al (6) found severe zinc deficiency in corn when phosphorous was added to a calcareous soil with a soil pH 7.8. In an acid soil with pH 6.0 he found no adverse affects on total zinc uptake.

Low soil temperature in the spring intensifies the zinc deficiency symptoms of corn grown on high phosphorous soils. As the soil temperature increases the deficiency symptoms lessen and the corn might make normal growth. Burelson et al (2) reported that restricted root development in cold, wet soils was the cause for low uptake of zinc. Zinc is present in the soil in both organic and inorganic forms. The organic portion of soil zinc is likely present as part of the protein in plant tissue. Bauer and Lindsay (1) suggested that very little change in the mineralization of organic zinc might be expected at low soil temperature.

On land leveled for irrigation in Nebraska, Ward et al (7) found soil compaction and high soil moisture retarded the uptake of zinc by corn. Row applications of phosphorous induced zinc deficiency on these soils. They also found that on soils with potassium saturation there was less depressive action by the applied phosphorous. Stukenholtz et al (6) also reported that an increased level of native or applied potassium reduced the adverse affects of phosphorous on zinc.

The depressive action of phosphorous on zinc uptake by plants is thought to be physiological in nature at the root surfaces or within the root cells. Stukenholtz et al (6) showed that it was not chemical inactivation of zinc by phosphorous in the soil.

In 1966 an experiment was initiated in Swift County Minnesota under the leadership of Dr. Mac Gregor to study the effects of high rates of phosphorous on the zinc uptake of continuous corn. The soil tests of this field are shown in Table I.

Table I

Phosphorous-Zinc Interaction Study, Benson, Minnesota
Soil Tests 1967

Annual PD
Treatment

P_2O_5 lbs/A	pH	P-lbs/A	Zn-ppM
40	8.4	5	1.3
80	8.4	4	2.0
160	8.4	11	1.3
320	8.3	18	1.2
640	8.3	90	1.1
320+Zn*	8.3	19	3.2
640+Zn*	8.3	37	4.3

*Zinc as $ZnSO_4$ plowed down 10 lbs/Z 1966, 1967
(Ave 4 Rep)
Hammerly clay loam

This soil has several of the characteristics which are known to be conducive to adverse phosphorous-zinc interactions. These are very high soil pH, marginal available zinc, and generally cold and wet in the spring. The organic matter was high and the potassium medium. The native available phosphorous was low and high rates of fertilizer phosphorous were used to induce a zinc deficiency of corn. A corrective application of 100 lbs per acre of potash was applied in 1967. Annual treatments of 100 lbs nitrogen and 40 lbs potash were broadcast over the experiment.

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*Zinc as $ZnSO_4$ plowed down to 10 lbs/A 1966, 1967
(Ave 4 Rep)

Table II

Phosphorous-Zinc Interaction, Benson, Minnesota
Corn Yield Bu/A at 15.5%

Annual PD
Treatment

P_2O_5 lbs/A	1966	1967	1968	1969	Ave
40	98	69	87	97	88
80	97	66	95	104	90
160	96	61	100	94	88
320	97	50	81	90	79
640	83	34	72	82	68
320+Zn*	114	75	93	111	98
640+Zn*	108	75	101	117	100

*Zinc as $ZnSO_4$ plowed down 10 lbs/A 1966, 1967
(Ave 4 Rep)

The corn grain yields for four years are shown in Table II. In 1966 increasing rates of phosphate had no effect on corn yield except at the rate of 640 lbs. As indicated earlier the native soil phosphorous level was low and these results were expected. In 1967 the spring was cold and dry and the summer cold and wet. A mid-September frost before the corn was mature decreased the yields. Increased rates of phosphate resulted in reduced yields of corn. The application of fertilizer zinc with treatments of 320 and 640 lbs. of phosphate reduced the depressive effects of the phosphorous.

The year 1968 was near normal after a cold, wet spring. There was a reduction in corn yield from the 640 lbs. phosphate rate which again was corrected where zinc had been applied. This year, 1969, was cold and wet through June and near normal during July, August, and September. The maturity of the corn was much delayed being in the silking stage the week before Labor Day. The late fall allowed the corn to mature and the differences in growth which were observed earlier were not reflected in the final yield. The depressive effects of high rates of phosphate on this soil are again shown by the reduced corn yields.

Tissue analyses of corn leaves taken at silking time provide an opportunity to study the effects of high fertilizer phosphate rates on the nutrition of the plants. The zinc and phosphorous content of the corn leaves for the various treatments are shown in Tables III and IV.

Table III

The Effect of Zinc and Phosphorous on the Zinc Content of the Sixth Corn Leaf at Silking

Annual PD
Treatment ppm leaf Zinc

P_2O_5 lbs/A	1966	1967	1968	1969
40	10.0	10.2	13.3	17.1
80	10.2	12.5	16.1	18.4
160	8.4	10.5	13.1	15.0
320	7.5	9.0	12.7	11.4
640	7.3	8.2	9.3	13.4
320+Zn*	12.4	13.2	15.4	28.4
640+Zn*	11.0	12.0	17.3	27.1

*Zinc as $ZnSO_4$ plowed down 10 lbs/A 1966, 1967
(Ave 4 Rep)

Table IV

The Effect of Zinc and Phosphorous on the Phosphorous Content of the Sixth Corn Leaf at Silking

Annual PD
Treatment % leaf phosphorous

P_2O_5 lbs/A	1966	1967	1968
40	0.351	0.317	0.410
80	0.313	0.312	0.338
160	0.359	0.323	0.462
320	0.400	0.436	0.510
640	0.486	0.570	0.630
320+Zn*	0.325	0.308	0.351
640+Zn*	0.304	0.310	0.458

*Zinc as $ZnSO_4$ plowed down 10 lbs/A 1966, 1967
(Ave 4 Rep)

There was a significant depression in the zinc content of the corn leaves with increasing rates of phosphate in 1966 and 1967. The difference did not prove to be significant in 1968 and statistical significance has not been determined for 1969 data. However, the zinc content was depressed with increased rates of phosphate and the application of zinc fertilizer resulted in a large increase in the uptake of zinc.

The zinc values for the 1969 crop are considerably higher than in previous years. Soil samples taken in the fall of 1969 were also higher in available soil zinc with an average of 2.4 ppm zinc on the treatments where zinc fertilizer was not applied. We are unable to explain this at the present time. This experiment is tilled and planted by the farm owner and there is a possibility that some mechanical mixing of the soil from various treatments might have occured to cause the increase in the zinc levels.

Increasing the rates of fertilizer phosphate resulted in corresponding increases in the phosphorous content of the corn leaves. Where both phosphate and zinc fertilizer were applied the P cont ent was reduced and zinc content was increased. The application of fertilizer zinc to the high rates of phosphate resulted in a better balance of these two nutrients within the plants and this was reflected in the corn yields.

The ratio of phosphorous to zinc within the plant tissue appears to be an important factor in the normal growth of crops. Research has shown that potato yields were severely depressed when the P/Zn ratio was over 400. Watanabe et al (8) found corn yields to be affected when the P/Zn ratio was over 300. However, Stukenholtz et al (6) found no correlation between P/Zn ratio and corn yields.

Table V

P/Zn Ratio in Corn Sixth Leaf at Silking

Annual PD
Treatment

P_2O_5 lbs/A	1966	1967	1968
40	351	310	308
80	307	250	210
160	427	308	360
320	533	484	405
640	665	695	677
320+Zn*	262	233	228
640+Zn*	276	241	265

*Zinc as $ZnSO_4$ plowed down 10 lbs/A 1966, 1967
(Ave 4 Rep)

The P/Zn ratios for three years are shown in Table V. The ratios are increased with increasing rates of phosphate. At the rate of 640 lbs. the P/Zn ratios were the highest and also the lowest corn yields were found. The highest yields were obtained where the P/Zn ration was less than 300.

Table VI

Phosphorous Fertilization of Continuous Corn
West Central Experiment Station, Morris, Minnesota

Average Cron yield 1965-1968
Annual Row

P_2O_5 lbs/A	Yield bu/av
0	85
35	82
70	80
100	78
100+zn	83

100 lbs/A P_2O_5 Broadcast Annually
Forman clay loam
pH 6.6 p19 K 353

Phosphorous induced zinc deficiency of corn will not occur on all soils as is shown in Table VI. This soil has good internal drainage and is not normally cold and wet. The soil tests show it to be neutral in reaction, medium phosphorous, and high potassium. As discussed earlier these are not the factors which contribute to the adverse P/Zn interaction. There is a slight reduction in corn yield from the highest rate of 200 lbs. However, tissue analyses of corn from this field do not show a depressive effect of phosphorous on the zinc uptake.

Conclusions

1. Phosphorous induced zinc deficiency of corn does occur on certain soils in Minnesota. These soils have high pH, high phosphorous levels, are borderline in available soil zinc, and are cold and wet in the spring.

2. The application of zinc fertilizer will overcome the yield reductions caused by high phosphorous. An application of 10 lbs per acre zinc as an inorganic material, broadcast or as starter, will correct the problem for three or four years. An annual application of 0.5 lb zinc per acre as zinc chelate in starter fertilizer can also be used.

3. Soil tests for pH, phosphorous, potassium, and zinc along with visual observations of the growing crop will aid in determining the need for using fertilizer zinc.

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Larry Hunt
Vice President
State Bank of Madison
Madison, Minnesota

I. Agricultural Trends

- A. Larger Farms
- B. Larger Capital
- C. Larger Amounts of Credit
- D. Better Management

II. Past Financing

- A. Farm Credit
    - 1. Conventional Loans
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    - 2. Inventory & Accounts Receivable
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III. Future Financing

- A. Actions necessary by industry
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- C. Proposal of participation
    - 1. Advantages to dealer
    - 2. Advantages to lender
    - 3. Advantage to farmer

IV. Summary

FINANCING OF AGRICULTURAL SUPPLIES

Larry Hunt
Vice President, State Bank of Madison
Madison, Minnesota

Suggested agreement between dealer and supplier.

A number of our customers in your area desire loans for the purchase of fertilizer used in their farming operations. These customers purchase fertilizer from______________________________ of_________________________. We feel that your bank would be interested in participating in making such loans and we would like to propose a method by which this might be accomplished. The Fertilizer Company would authorize $________________ as the maximum loan commitment you are authorized to make pursuant to this agreement, said limit to remain constant each year unless changed by our mutual agreement in writing.

Loans made pursuant hereto will not be for a period longer than the normal crop cycle. The customer will purchase fertilizer from said dealer and upon each delivery of fertilizer the dealer will invoice said customer and secure the signature of the customers on a note bearing_________% interest and due when the crop being produced is normally marketed. Said note will include all the provisions required by regulation of the Truth in Lending Law. The dealer will present the note and copy of invoice to the bank for payment. You will pay the dealer the amount of the invoice for the fertilizer.

You will submit month-end reports to the Fertilizer Company showing the amount of loans outstanding to each customer pursuant hereto. A reserve fund will be maintained by the company with you. We will call this reserve fund "_____________________________ Fertilizer Company Reserve Fund".

______________________Fertilizer Company Reserve Fund will be maintained in an amount equal to 10% (ten per cent) of the total amount of the loans outstanding to all customers. Once each month you will compute the total amount so outstanding and,

A. If the amount in the Reserve Fund at that time is less than 10% (ten per cent) of this total amount, you will so advise the company and the company will make a payment to you in the amount by which the company Reserve Fund is deficient, for deposit in the Reserve Fund: but

B. If the amount in the Reserve Fund at that time exceeds 10% (ten per cent) of this total amount, you will so advise the Fertilizer Company and will refund to the Fertilizer Company the amount of the excess.

Thus there will be a Fertilizer Company Reserve Fund for the loans to all of these customers, provided by the Fertilizer Company. This fund may serve as security to you for repayment of these loans, in addition to the collateral you wish to take to secure the loans.

In the event of a default in repayment by a customer, you will take all reasonable means of recovering collections and all legal remedies available to you including resort to the collateral security held by you, in an effort to collect the indebtedness owing to you. If, after exhausting such collection efforts, a deficit remains, the Reserve Fund will become available for application against the deficit within the limits and in the manner as follows:

> It is intended that Fertilizer Company make up to you such deficits as may occur to an amount equal to 90% of the total amount outstanding on each loan from the Reserve Fund. In the event the Reserve Fund is not adequate to cover the deficit within the 90% limit, then an additional payment by the Company will be required. If the Reserve Fund is used totally or in part to make up a deficit, then the Company will immediately make a deposit to restore said Reserve Fund to an amount equal to 10% of the total amount of the loans outstanding. Thus the bank shall stand a maximum of 10% of each loss sustained.

After a deficit is known and application from the Reserve Fund has been made, the Fertilizer Company will cooperate in attempting further recovery from the customer and any sums so recovered will be divided between the Fertilizer Company and the Bank pro-rata with the amount of loss each sustained on that customer.

All payments to and the collections by you from a customer (unless agreed otherwise) shall be applied to the customer's indebtedness to Bank arising from loans made pursuant hereto until such indebtedness has been fully paid and then to any other indebtedness the customer may have to you arising after your acceptance of such customer for financing hereunder.

If we reach an agreement on the foregoing terms, the same shall remain in effect until terminated by either the Bank or Fertilizer Company giving 30 days written notice of termination to the other. Any such termination, however, shall not affect rights and obligations accrued up to the time of termination.

The forgoing will constitute a binding agreement between us if accepted by you. If you find the same acceptable, please indicate your acceptance and agreement thereto by causing the two copies of this agreement to be signed in the space provided and return the first copy to us.

Sincerely,

______________ Fertilizer Company

President

Accepted and Agreed to

This ___________ day of________________, 19____,

____

By _____________________________,______________
(Signature) (Title)

INSECT CONTROL RECOMMENDATION ON FIELD CROPS FOR 1970

Phillip K. Harein, Extension Entomologist,
David Noetzel, Assistant Extension Entomologist,
and L. K. Cutkomp, Professor, Entomology

DO NOT USE AFTER 1970

Insect	Crop	Insecticide	Rate/acre	Limitations
Aphids	Small grain	malathion	1 lb.	7 days
			0.6 lb.ULV+ by air	7 days
		methyl parathion	4 oz.	No time limitations
		parathion	4 oz.	15 days
	Corn	malathion	1 lb.	5 days
		methyl parathion	4 oz.	12 days
		parathion	4 oz.	12 days
		phorate(Thimet)	1 lb.	Granular applied to whorl immediately before tasseling; do not apply if used as soil application.
Armyworms	Small grain	carbaryl(Sevin)	1 lb.	Do not apply after heads are visible.
		toxaphene	2 lb.	Do not feed treated forage. No restrictions on grain.

+ULV = ultra-low volume.

DO NOT USE AFTER 1970

Insect	Crop	Insecticide	Rate/acre	Limitations
Armyworms	Corn	carbaryl (Sevin)	1 lb.	No time limitation
		toxaphene	2 lb.	Do not feed stalks, leaves, and husks.
Bean Leaf beetle	Soybeans	carbaryl (Sevin)	1 lb.	No time limitations
		toxaphene	1 1/2 lb.	21 days before feeding treated plants.
Beet webworm	Sugar beets...	carbaryl (Sevin)	2 lb.	14 days (tops)
		endosulfan (Thiodan)	1 lb.	Do not feed tops
		toxaphene	3 lb.	60 days; do not feed tops.
		trichlorfon (Dylox)	1 1/2 lb.	14 days
				28 days (tops)
Corn earworm	Sweet corn	diazinon	1 1/2 lb.	2 days for forage
		carbaryl (Sevin)	1 1/2 lb.	No time limitation
Corn rootworm larvae	Corn	Bux	3/4 lb.	Rate given for 40-inch rows with band application. Bux, diazinon, and phorate, are only materials registered and recommended at cultivation time.
		carbofuran (Furadan)	3/4 lb.	
		diazinon	1 lb.	
		phorate (Thimet)	1 lb.	
		Dasanit	3/4 lb.	
		Dyfonate	3/4 lb.	
		Landrin	3/4 lb.	
		Mocap	3/4 lb.	
Corn rootworm adults	Corn	carbaryl (Sevin)	1 lb.	
		malathion	1 lb. or 0.6 lb. ULV+ by air	5 days
Cutworms	Corn	aldrin	2 lb.	Preplant broadcast disked in.
		heptachlor	2 lb.	
		chlordane	4 lb.	

ULV+ = Ultra-low volume

DO NOT USE AFTER 1970

Insect	Crop	Insecticide	Rate/acre	Limitations
Cutworms (Cont'd.)	Corn	carbaryl (Sevin)	2 lb.	12" banded spray in 15 gals. per acre.
		diazinon	2 lb.	Band treatment at planting time.
		toxaphene	2 lb.	Preplant broadcast disked in. Limitations same as for armyworm.
		trichlorfon (Dylox)	1 1/2 lbs.	Postemergence with 40 days waiting period.
	Small grain	toxaphene	2 lb.	Do not use straw.
	Soybeans	carbaryl (Sevin)	1 lb.	No time limitations.
		toxaphene	1 1/2 lb.	Do not feed vines to dairy animals or animals being finished for slaughter.
	Sugar beets	carbaryl (Sevin)	1 lb.	14 days (tops)
		trichlorfon	1 1/2 lb.	
European corn borer	Corn	carbaryl (Sevin)	1 1/2 lb.	
		diazinon	1 lb. granular	Do not feed to dairy animals; 90 days before slaughter.
		toxaphene	2 lb. granular	Grain only.
		EPN	1/2 lb. as spray	14 days.
			1/4 lb. granular	14 days
		Bacillus thuringiensis (as labeled)		No limitations
Grasshoppers	Alfalfa, clover, hay, and forage.	carbaryl (Sevin)	1 lb.	5 days
		diazinon	1/2 lb.	7 days
		malathion	1 1/2 lb.	No time limitation
			or 0.6 lb. ULV+ by air	5 days (do not apply when in bloom)

ULV+ = Ultra-low volume

DO NOT USE AFTER 1970

Insect	Crop	Insecticide	Rate/acre	Limitations
Grasshoppers (Cont'd.)				
	Corn	carbaryl (Sevin)	1 lb.	
		diazinon	1/2 lb.	
		malathion	1 lb.	5 days
		toxaphene	1 1/2 lb.	Grain only
	Small grain	carbaryl(Sevin)	1 lb.	Not after heads are visible.
		malathion	1 lb.	7 days
			or 0.6 lb. ULV+ by air.	7 days
		toxaphene	1 1/2 lb.	Grain only
	Soybeans	carbaryl(Sevin)	1 lb.	No time limitations
		malathion	0.6 lb. ULV+ by air.	7 days
		toxaphene	1 1/2 lb.	[Do not feed treated forage [to dairy animals or animals [being finished for slaughter.
	Grass (pasture, hay).	carbaryl(Sevin)	1 lb.	No time limitations
		diazinon	1/2 lb.	Do not graze on treated forage, wait 21 days before cutting for hay.
		malathion	1 1/2 lb. or 0.6 lb. ULV+ by air.	
		naled(Dibrom)	1/2-3/4 lb.	4 days for hay
Leafhoppers	Alfalfa	carbaryl(Sevin)	1 lb.	No time limitation
		diazinon	1/2 lb.	7 days for hay; 4 days for grazing
		methoxychlor	1 1/2 lb.	7 days

ULV+ = Ulta-low volume

DO NOT USE AFTER 1970

Insect	Crop	Insecticide	Rate/acre	Limitations
Pea aphid	Alfalfa, clover	demeton(Systox)	4 oz.	21 days
		diazinon	1/2 lb.	7 days for hay; 4 days for grazing on alfalfa; 7 days for grazing on clover.
		malathion	1 lb. 0.6 lb. or ULV+ by air	No time limitations
		parathion or methyl parathion	4 oz.	15 days. Apply by air only.
Plant bugs	Alfalfa, clover	Endosulfan(Thiodan)	1 lb.	Clover seed crop only.
		toxaphene	2 lb.	Seed crop only
Seed corn maggot Corn seed beetle	Corn	aldrin dieldrin heptachlor or lindane	1 oz/bu	Seed treatment Corn rootworm application effective for these insects
Sunflower moth	Sunflowers	endosulfan(Thiodan)	1 lb.	Not more than 3 applications
Sweet clover weevil	Sweet clover (plowdown)	toxaphene	2-3 lb.	Do not graze or cut for feed.
Thrips	Barley	parathion or methyl parathion	6 oz.	15 days
Wireworms	Corn, beans Small grain	aldrin dieldrin heptachlor, or lindane	1 oz. per bushel	Seed treatment
Wireworms and White Grubs	Corn	aldrin or heptachlor	1-2 lbs.	Soil treatment, row or broadcast.
		chlordane	2-4 lb.	

ULV+ = Ultra-low volume

CHEMICAL WEED CONTROL

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Chemicals and cultivation continue as the winning combination for clean corn and soybeans. For 1970, there are some new chemicals and mixtures. But you'll need specific information on performance of these new chemicals to select the most effective one for a particular situation. And proper application continues to be the critical difference between complete success and utter failure in many cases.

Corn and soybean yields from herbicide experiments conducted at the Lamberton, Morris, and Waseca farms of the University of Minnesota Experiment Stations are summarized in Tables 1 and 2. The yields for the "chemical and cultivation" treatment are averages for all the cleared chemicals used in the trials. All plots were cultivated twice.

Table 1. Corn yields as affected by different weed control methods at three Minnesota locations.

	Corn Yield, bu/A				
	1966	1967	1968	1969	Average
Cultivation	91	86	82	96	89
Chemical and cultivation	104	118	108	121	113
Cultivation and hand weeding	96	132	107	126	115

Table 2. Soybean yields as affected by different weed control methods at three Minnesota locations.

	Soybean Yield, bu/A				
	1966	1967	*	1969	Average
Cultivation	26	21		22	23
Chemical and cultivation	34	27		27	29
Cultivation and hand weeding	31	29		33	31

* 1968 yields not useable because of adverse weather and soil conditions.

These yield trials show an average return of 24 bu/A of corn or 6 bu/A of soybeans for the use of chemicals with cultivation compared to cultivation only. Yields from 31 corn weed control trials conducted by County Extension agents during the past four years gave the following results:

Treatment	Corn yield, bu/A
No weed control	64
Cultivation only	90
Chemical only	104
Chemical and cultivation	117

These results show a 27 bu/A return for chemicals with cultivation over cultivation only and 13 bu/A increase over chemical only.

Tables 3 and 4 indicate the relative effectiveness of herbicides now suggested for use in corn and soybeans.

Table 3. Control of Major Weed Species with Herbicides for Corn

Good - G

Fair - F

Poor - P

None - N

	Preplanting	Preplanting Preemergence	Preemergence	Preemergence	Preemergence	Postemergence	Postemergence	Postemergence
	Butylate (Sutan)	Atrazine (AAtrex)	Alachlor (Lasso)	Propachlor (Ramrod)	Linuron (Lorox)	2,4-D	Dicamba (Banvel)	Atrazine (AAtrex) and Oil
Corn Tolerance	G	G	G	G	F	G	G	G
Grasses								
Giant foxtail	G	F	G	G	F	N	N	F
Green foxtail	G	G	G	G	F	N	N	G
Yellow foxtail	G	G	G	G	F	N	N	G
Barnyardgrass	G	F	G	F	F	N	N	F
Crabgrass	G	P	G	G	G	N	N	P
Panicum	G	P	G	F	G	N	N	P
Nutsedge	G	P	G	F	P	N	N	F
Quackgrass	N	G	N	N	N	N	N	G
Broadleafs								
Cocklebur	P	F	N	P	P	G	G	G
Lambsquarters	P	G	F	P	G	G	G	G
Mustard	P	G	P	P	G	G	F	G
Pigweed	F	G	G	F	G	G	G	G
Ragweed	P	G	P	P	G	G	G	G
Smartweed	P	G	P	P	F	P	G	G
Velvetleaf	F	F	P	P	F	G	G	F
Wild sunflower	P	P	P	P	P	F	G	G
Canada thistle	N	P	N	N	N	F	G	F

Table 4. Control of Major Weed Species with Herbicides for Soybeans

Good - G
Fair - F
Poor - P
None - N
Inadequate Inf.

	Preemergence					Pre-planting	Post-emergence	
	Amiben	Alachlor (Lasso)	Linuron (Lorox)	Amiben + Norea (Noraben)	Chlorpropham (Chloro-IPC)	Trifluralin (Treflan)	Chloroxuron (Tenoran)	2,4-DB
Soybean Tolerance	G	G	F	F	G	F	F	P
Grasses								
Giant foxtail	G	G	F	G	P	G	P	N
Green foxtail	G	G	F	G	P	G	P	N
Yellow foxtail	G	G	F	G	P	G	P	N
Barnyardgrass	G	G	F	G	P	G	P	N
Crabgrass	G	G	G	G	P	G	P	N
Nutsedge	P	G	P	P	N	P	N	N
Broadleafs								
Cocklebur	P	P	P	P	P	P	P	F
Lambsquarters	G	F	G	G	P	G	F	P
Mustard	F	P	G	F	F	P	G	P
Pigweed	G	G	G	G	P	G	F	P
Ragweed	G	P	G	G	P	N	P	P
Smartweed	F	P	F	F	G	P	P	P
Velvetleaf	F	P	F	F	P	P	P	P
Wild sunflower	P	P	P	P	P	N	–	P

Several of the herbicides listed in the above tables may be used in mixtures. But it should be remembered that herbicide mixtures require U.S. Department of Agriculture clearance. Clearance is now required for either packaged formulations or tank mixing. Before clearances for mixtures are granted data must be submitted to show that the mixture can be used effectively and safely without resulting in illegal residues in or on food or feed, that the ingredients are physically and chemically compatible, and if formulated together that the formulation will remain stable. Several new mixtures may be announced by planting time if clearances are obtained.

Mixing herbicides and liquid fertilizers appears to be an increasingly popular practice. The saving of time and reducing the number of trips over a field are obvious. But at least three questions are paramount to success:

1. Can the herbicide and fertilizer both be applied at the right time and properly placed in the soil?
2. Are the herbicide and fertilizer physically compatible so they mix uniformly and do not clog the sprayer?
3. Is the equipment adequate to make the completely uniform application required for herbicides?

Several herbicides now carry instructions for mixing with fertilizers. These instructions should be followed carefully. Additives and agitation may be required to keep some herbicides and fertilizers mixed. If not properly mixed, some herbicides may separate, resulting in nonuniform application and severe crop injury in parts of the field.

Some mixtures may form a sludge, crystallize, or curdle when mixed. Physical compatibility can be easily checked before mixing the products in the sprayer. Some labels and product information sheets give instructions for mixing small amounts of the products to check physical compatibility. The idea is to mix a small amount of the herbicide, fertilizer and additives in the approximate proportions used in the sprayer. If specific instructions are not available, the following guide may be used. If using 25 gallons of spray per acre, physical compatibility can be checked by putting 3 quarts of fertilizer liquid in a gallon container and adding 1/2 ounce of wettable powder for each 1 pound of wettable powder to be used per acre. If the herbicide is a liquid concentrate with 4 pounds active ingredient per gallon and the sprayer applies 25 gallons per acre, mix 2 teaspoons of the concentrate in 1 quart of fertilizer solution. If an adjuvant is used, add 1 teaspoon per quart of fertilizer liquid. Mix the fertilizer and herbicide and adjuvant thoroughly. Then wait about 10 minutes to see of the chemicals stay mixed without forming a sludge, curdling, or separating and forming a film on the surface.

Fall application of atrazine (AAtrex) for corn and trifluralin (Treflan) for soybeans is a recent innovation of some interest in Minnesota. Results of University of Minnesota research (Tables 5 and 6) indicate that fall applications are feasible. But higher rates may be required for fall applications than for spring applications. Weed control was not as good from fall applications as spring applications, but with timely cultivations the results may be satisfactory. If applied in the fall, a full rate of the chemical for the soil type should be applied. The chemical should be incorporated by disking at least once right after application. Applications should generally not be made until after October 15.

The main advantages for fall applications are reducing the time demand at planting and the possibility of combining herbicide and fertilizer application. There are also some disadvantages. Herbicide applications should not be attempted on rough, cloddy soil or fields subject to flooding. The land is also left smooth after application which leaves the area subject to erosion during the winter and spring. If planting is delayed in the spring, effectiveness of the herbicide may be reduced. Fall application is feasible only for long-lived herbicides that can be incorporated into the soil.

Table 5. Influence of time of application of atrazine on corn yields and weed control in Minnesota.

	lb/A	Corn Yield * bu/A	Weed Yield * lb./A
Fall, incorporated	1.5	73	1877
	3.0	82	730
Spring, preemergence	1.5	84	1249
	3.0	96	559

*Average 2 years, 3 locations

Table 6. Influence of time of application of trifluralin on soybean yields and weed control in Minnesota.

	lb/A	Soybean Yield* bu/A	Weed Yield* lb /A
Fall	1/2	17	2401
	1	22	1781
Early spring	1/2	19	2078
	1	22	1079
At planting	1/2	22	1391
	1	22	929

* Average 2 years, 3 locations