18th Soils and Fertilizer Short Course

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KEY ISSUES IN LAND QUALITY
Are we losing fertilizer into our ground water and lakes?

W. P. Martin
Head, Department of Soil Science

The Minneapolis Star for Friday, March 8, 1968 headlined: Johnson asks 1.2 billion for conservation...a program to conserve America's natural resources, "not only for man's enjoyment, but for man's survival." In this program, the President put priority on the goal of pure water and air, ending despoiling of the land and preserving and creating beauty. He included strip mine reclamation, waste treatment plants, control of chemical contaminants of drinking waters, and solid waste disposal programs from garbage and farm wastes to automobile wrecks.

It is time that we take stock of our land resources and see to what extent this so-called self perpetuating environment is in fact threatened by pollution. Soil is an essential link in the food chain from plants and animals to man, and we must be concerned with its use as a waste disposal system; about the fixation, volatilization and movement of plant nutrients in soils and their significance in water contamination; and about the rapidly increasing acreages of land that are being taken out of production or from living and recreation areas to accommodate the billions of tons of waste that are coming from our burgeoning society.

Dr. Cecil Wadleigh, Chief of the Soil and Water Conservation Research Division, USDA, likes to cite a statement from Professor E. W. Hilgard, a distinguished soil chemist in the late 1800's, who gave a "hard-hitting" lecture before the Mississippi Agricultural and Mechanical Fair Association at Jackson, November 14, 1872. Professor Hilgard was gravely concerned over poor practices which were ruining the land and silting the streams: "If we do not use the heritage more rationally, well might the Chickasaws and the Choctaws question the moral right of the act by which their beautiful parklike hunting grounds were turned over to another race, on the plea that they did not put them to the uses for which the Creator intended them." It was another 60 years before the dynamic leadership of Dr. Hugh Bennett and the first Chief of the Soil Conservation Service, and Contemporaries, finally got through to the people and the conservation of soil and water came under organized attack so as to decrease air pollution from the tremendous dust storms of the great plains in the thirties and stream contamination from accelerated runoff and soil erosion.

There is an "information gap" and one of the key objectives of this conference is to inform our citizenry of the facts about environmental quality as they are known, point up deficiencies, hopefully moderate extremism and overgeneralization and engender support for the accelerated research effort that is needed to accommodate multiple use management decisions. In the time that remains, I should like to outline categorically a number of the contaminants of our soils and thus of our waters and their significance in the context of a clean and safe environment. I have relied substantially on a report entitled: "Wastes in Relation to Agriculture and Forestry" written by Dr. Cecil Wadleigh, Director, Soil and Water Conservation Research Division, ARS and just published as MSC Publ. 1065, U.S.D.A., Washington, D. C. March 1968. And also on Symposium No.85 of the AAAS, Titled "Agriculture and the Quality of Our Environment," N. C. Brady, Editor (476 p. 1967, AAAS, Washington, D. C.) I had the privilege of chairing the section on "Soil Pollution."

Sediment: Soil as a contaminant may be in the form of sediment washed into lakes and streams by land runoff. Erosion is the dominant problem on 39% of the cropland in the Lake States area or some 16 million acres, according to the recently completed Conservation Needs Survey.* It is a secondary problem on some 14 million acres. Half the sediment comes from agricultural lands and the total sediment load in the United States is some 4 billion tons a year. Urban and industrial sites and highways during construction also erode and make substantial contributions to local streams. Most of the erosion sediment is deposited enroute only about one-fourth getting into lakes and stream courses. Research has shown that land cover and treatment is the chief deterrent to sediment delivery and much empirical data have been accumulated on susceptibility of soils to erosion. Use has been made of soils with markedly different characteristics, different slopes, different kinds of cover and this has been used to produce a mathematical model called the "universal erosion equation" which aids in the prediction of soil losses so that soils can be managed to keep the annual soil loss below 3-4 tons/acre. Much work is needed on soil structure and aggregate stability, on water infiltration vs runoff particularly during soil freezing and thawing in this regional area and an integrated system of management that will reduce runoff and yet provide needed surface drainage with minimum erosion. Soil surveys should be accelerated for basic information on soil type and associations are essential to management decision making.

Plant Nutrients: Soil erosion produces sediment that contains nutrient elements that not only represent significant losses for crop production but it is the nutrient enrichment of surface waters that produces the algal bloom and growth of aquatic plants that is becoming a prime source of concern in the contamination of water supplies. Lake eutrophication, off-taste, foul odor, fish kills (because of oxygen depletion from decaying plants) and "unsafe" waters for recreational uses are frequently read about in today's newspapers and major conflict in use of land resources is becoming evident. Nitrogen and phosphorus are the two elements principally involved and it should be emphasized that they do not come largely from runoff and erosion from agricultural land though contribution is obviously made and such sources do impair the usefulness of farm ponds or shallow land-locked lakes for example.

Phosphorus applied to agricultural lands as fertilizer is promptly reverted to "unavailable forms" and 10-20% only becomes available for plant nutrition. Even where erosion occurs and fertilized soil becomes sediment in a water supply and total phosphorus may be as high as 1,000 pounds /1,000 tons of sediment, only about 10% is available for the growth of water plants, the rest remaining in an unavailable state. Phosphorus can not move through the soil in the soluble state and water in drains from fertilized fields in few instances will be found to yield as much as 1 ppm of phosphate. Total phosphorus has too often been

* Soil & Water Conservation Needs--A National Inventory (misc.Publ.917, U.S.D.A., Washington, D.C., 1965)

used as a criterion of "availability" and this is very much in error. Crop production to meet our rapidly increasing food demands is important, and use of fertilizers at an accelerating rate is necessary. We used 32 million tons of commercial fertilizers in the United States on our fields and gardens in 1966 and 2-1/4 million tons of this in our three lake states. Though appearing to be large, it is modest in contrast to the Netherlands or Japan where they have used almost ten times as much on each acre for many years. The dilution factor should also be considered, a 500 pound application of superphosphate, for example, being added to 2 million pounds of soil in the top six inches of an acre of farmland. The facts do not substantiate major concern at this time, though we must be concerned about the future. Sediment, in fact, because of high phosphorus-fixing abilities, can and does decrease and deactivate much of the soluble and available phosphorus in lakes and streams.

If the phosphorus doesn't come largely from farmlands, where does it come from? Careful examination of the evidence suggests that most of the phosphorus comes from sewage whether raw or treated, and largely from the use of household detergents, which on an average amount to about 2 pounds of phosphorus per person per year and from barnyards and feed lots. The recent Wisconsin report on "Excessive Water Fertilization" to the Natural Resources Committee for State Agencies (January 31, 1967), substantiates this generalization. Septic tanks are a prime source of contamination and particularly when clustered around recreation lakes. And from the soils standpoint, because soils are readily dispersed by the phosphate based detergents in the drain tile areas, thus reducing soil permeability, soil and water pollution and outbreaks of infectious diseases have resulted.

Increase in the use of boron-based detergents as a substitute for phosphorus should be discouraged for boron is a toxic element if used in substantial amounts with obviously serious consequences.

Nitrogen: Excess nitrate in drinking water above 45 ppm or 10 ppm N can be harmful to children and toxic to livestock not because of the nitrate as such but because it is reduced to nitrite which interferes with the respiratory system. Nitrates in water supplies though mostly found in modest amounts may come from sewage or septic tank effluent, from feed lots or barnyards, from field fertilization in areas of intensive use and with permeable soils or from the mineralization of soil organic nitrogen compounds. Nitrates are soluble in the soil solution and will move through the soil. In the soil system, organic forms of nitrogen are oxidized by soil microorganisms and the nitrogen released as the ammonium ion which is tightly held by the clay and organic matter soil colloids. These ions are easily removed by nitrifying bacteria which oxidize the ammonia to nitrate which is not "fixed" and which will move through the soil as noted. However, some of the nitrogen is utilized by plants and much of it is reduced by denitrifying bacteria under anaerobic conditions to gaseous nitrogen which escapes to the atmosphere already containing about 80% nitrogen to complete the nitrogen cycle. We don't have nearly enough information on the relative contributions of nitrogen from the above sources. Dr. Smith* from Missouri

* G. E. Smith: Nitrate problems in water as related to soils, plants and water. (Special Rpt.No.55, University of Missouri, Columbia, 1966)

has concluded that nitrogen from livestock feeding operations is significant and in the Wisconsin Water Study above noted, domestic sewage and land runoff where manure has been spread on frozen soils were suggested as prime sources of contamination.

Fertilizer nitrogen will increase in importance as nitrogen use increases, and we are expected to double our expected usage in this country to approximately 8 million tons in the next few years. Small amounts of nitrate nitrogen regularly "escape" to underground supplies * in permeable soil areas mostly in late fall and spring when soil microorganisms are relatively inactive. It is important that we use only enough to satisfy cropping needs so that surplus amounts will not be available to reach groundwater areas. So far as normal farm fertilization is concerned, we are a long way from usages that would be considered excessive. We are, in fact, still depleting our organic nitrogen reserves.

Dr. Wadleigh points out that we have lost from our agricultural soils in the United States during the past hundred years 1-3/4 trillion tons of organic nitrogen and that cultivated crops on some 294 million acres remove in excess of 9 million tons of nitrogen annually. Fertilizer use figures are small in comparison with these losses and it must also be remembered that natural processes associated with the nitrogen cycle are tremendously active. Lysimiter studies have consistently shown that nitrogen in the leacheate is very small where growing plants are present to intercept and rapidly absorb nitrates in the root zone.

Nitrogen in runoff waters is mostly associated with sediment load, and is part of the organic matter fraction of the soil. Average annual losses estimated for a 6 year period from natural-runoff erosion plots in western Minnesota varied from 31-183 pounds per acre. Plots were 72 ft. long on a 6% slope Barnes soil designed to maximize runoff and erosion under varied soil management operations.** An accelerated research program in this area is surely warranted for we badly need quantitative information for the Lake States area.

Conclusion In conclusion, May I suggest that the natural biosphere based on use of land and water resources has been altered significantly by man to assure food and fiber supply and to favor our living and recreational interests. But we have had to use management practices which accelerate the production of wastes or input amendments which increase the pollution hazard. Pollution of the soil-water complex occurs because we mostly have no other medium for our waste disposal systems. Soils in the form of sediment and associated nutrients may contribute to water pollution. Soils, however, are in turn contaminated by man though fortunately soils are somewhat self-rejuvenating by interaction of physical and biological components. Runoff from the land though serious in sedimentation has probably not been responsible for major buildup of phosphorus and nitrogen in surface waters with resultant eutrophication. Sewage and detergents are much more serious in this context.

* Stout and Burau found that 90-130 ppm of nitrate were present in waters percolating to underground supplies in certain permeable California soils (AAAS Symposium Publ.85, 1967)

** D.R. Timmons, et al: Runoff nutrient losses from Barnes soil in west-central Minnesota. (Minn. Science, Minn. Agr. Exp. Sta. publ., St. Paul, In Press, 1968)

Nitrates but not phosphorus will move through the soil into groundwater supplies to produce above normal levels in some locations and particularly in high density feedlot or faulty septic tank installation areas. Much more attention must be given to investigation studies on the many diverse problems arising from our need to increase farm efficiency and at the same time accommodate the multiplying wastes of our society. It is the scientist who must develop and refine the principles on which the conservation of our soils and waters, and the "wholesomeness of our environment" are based.

COMPUTERIZED FERTILIZER AND LIME RECOMMENDATIONS

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On September 13, 1968, the Soil Science Department of the University of Minnesota started making all fertilizer and lime recommendations with a computer. Although the computer program has proven to be quite successful, it must be realized that a complete updating of the Soil Testing Laboratory has also taken place. The computer alone could not provide better service, this could only be accomplished through cooperative efforts of both the Soil Testing Laboratory and the use of the computer. In order to better the soil testing service, it was necessary to hire full time chemists in the laboratory and also introduce some new soil tests. These new tests include zinc, sulfur, soluble salts and a buffer index, which is used for making lime recommendations. The computer and the Soil Testing Laboratory innovations now allow us to offer a 5 to 7 day service on all samples sent to the State Soil Testing Laboratory. The computer not only makes all of the fertilizer and lime recommendations, but also handles all of the accounting. At the beginning of every month, the computer automatically gives a full accounting of every transaction to include billing of firms which have charge accounts.

There are currently 72 crops which are completely computerized for fertilizer recommendations. In making the recommendations, many things are taken into consideration. These include the:

1. Crop to be grown.

2. Area of the state with reference to Growing Degree Days and rainfall.

3. Irrigation.

4. Previous cropping and fertilization.

5. Soil test - pH, Buffer index, O.M., P, K, and texture. The texture is very important here to determine if a starter response will occur. In many instances a starter response will be noted even when the soil tests high in P and K, for example.

6. Subsoil fertility with respect to P and K.

Since the computer takes many criteria into consideration, it is essential that the Farm Information Sheet be filled out completely and accurately. The more information that can be fed into the computer, the better will be the recommendations. For example: Many people fill in hay for crop to be grown. If the crop to be grown is alfalfa, put down alfalfa and not hay. In other words, be specific for the best possible recommendations.

Once the soil tests are run and the recommendations are made, the results are sent directly to the farmer or the fertilizer dealer that submitted the samples for the farmer. Two additional copies are also sent to the county extension office and one copy is retained in our laboratory file. Questions concerning the recommendations should be directed to the local county extension office.

TILLAGE TRENDS

(THEIR RELATIONSHIP TO CHANGING CONCEPTS OF SOIL MANAGEMENT)[1/]

W. E. Larson[2/]

Much of Minnesota and particularly the southern counties experienced a particularly wet fall in 1968. As a result little fall plowing has been done in many counties. In some cases the structure of the soil may be damaged because of compaction from heavy harvesting equipment. In this report I would like to discuss possible tillage and management problems that may be experienced next spring and perhaps suggest some ways to alleviate these problems. If the soils are wet this fall, they are likely to also be wet next spring because (1) any further precipitation must be removed by evaporation or deep percolation, (2) freezing will cause water to migrate toward the surface and the amount of migration will be enhanced in wet soils, and (3) the time of frost disappearance will be later in wet than dry soils.

Soil temperature is likely to be somewhat lower in the spring of 1969 than average because of the extremely wet soils and perhaps greater than normal mulch cover. If so, this will slow early growth of corn and soybeans. Usually the frost will remain in the ground somewhat longer on a very wet soil than on dryer soil. It requires about 5 times as much heat to warm a unit of water than it does a similar weight of dry soil. Heavy amounts of crop residues such as corn stalks or soybean residues will act as an insulating blanket and also slow the warming of soils. For this reason we would suggest farmers avoid tillage practices that leave heavy mulches of crop residues on the surface after planting. Our research in Minnesota and elsewhere suggests that a heavy mulch of crop residues such as would be obtained from a 100 bushel corn crop might reduce the soil temperature at the 4-inch depth by about 2°F and may reduce the corn growth early in the season by some 40 to 50%. In wet areas planting in furrows should be avoided since the soil in furrows is colder than on a smooth surface.

Because little fall plowing has been done in many areas and because plowing is likely to occur when the soils are wet next spring, cloddiness may be a big problem in 1969. It is always advisable to avoid plowing when the soils are excessively wet. Because the soil water content usually increases with soil depth, it may be desirable to plow more shallow next spring than usual. This allows tilling only the drier surface few inches. Plowing should be deep enough to cover residues, however. If plowing can only be done under wet conditions then the secondary tillage operations (disking and harrowing) needs to be timed carefully so that these operations are done when the water content of the soil is ideal. Assuming drying conditions are average to good, this usually means that a secondary disking or other tillage operations should be done within a few days after plowing. If the large clods formed by plowing are allowed to become very dry, they will be

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[1/] Contribution from the Soil and Water Conservation Research Division, Agricultural Research Service, USDA, St. Paul, Minnesota.

[2/] Research Soil Scientist, Soil and Water Conservation Research Division, ARS, USDA, St. Paul, Minnesota.

hard and extremely difficult to break up. Excessive cloddiness may make it difficult to properly place and cover the seed in the soil.

If the soils remain excessively wet next spring, it may mean that 1969 is not the year to experiment with minimum tillage systems that attempt to till and plant the seed in a very few operations unless these can be timed when the water content of the soil is near ideal. If strip tillage at planting time is done, it is necessary only to crush the clods in the seed row. The strip tillage and planting should be done at near optimum water contents. Because of cloddiness poor stands sometimes result from minimum tillage systems.

Fertilizer placement on wet cold soils is particularly important. Most plant nutrients are less easily taken up by a plant under cold conditions. For this reason adequate amounts of "pop up" or row fertilizers may be particularly desirable in the spring of 1969.

Problems associated with wet soils will be most severe on the finer textured soils that are poorly drained. They may not be serious on sandy soils.

THE EFFECTS OF SOIL SALTS AND IRON
(Problems they cause with soybeans & corn)

J. M. MacGregor

Where mean annual precipitation exceeds the amount of water evaporated & transpired from the soil, the excess moisture either runs off the soil surface (frequently causing soil erosion) or percolates downward, dissolving and removing the more soluble soil constituents. This results in an acid soil condition requiring frequent lime applications, & often a marked deficiency of many of the elements essential for plant growth. Since the entire eastern half of the United States has a precipitation - evaporation ratio greater than 1.0, the abundant use of lime and most fertilizer materials became essential here only a few years after cultivation commenced.

In the warm and drier western areas, essentially all precipitation penetrates only a short distance into the soil & then returns to the surface, either by root action or by capillary movement and then returns to the atmosphere leaving essentially all of the salts in the soil, since only small amounts are needed for plant growth. As shown in Figure 1, much of western United States except a small high rainfall area along the Pacific coast contain an excess of soil lime and other salts.

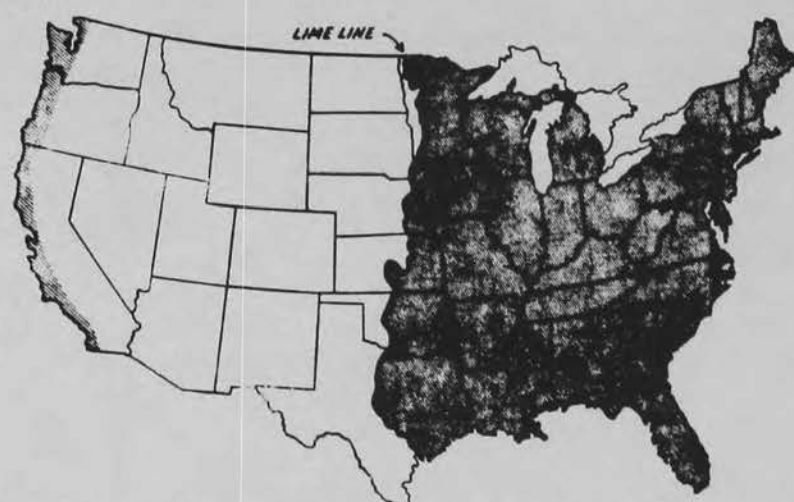

Figure 1.

It is obvious that agricultural soils adjacent to the lime line of Figure 1 will not be excessively leached & remain relatively fertile, but will vary considerably in lime and other salt content. Where soil drainage has been adequate, the more soluble salts will have been removed, while a major portion of those less soluble remain. With poor drainage, however, many of the more soluble salts moved relatively short distances and have accumulated around the rims of former ponding areas.

The "Handbook of Chemistry and Physics" lists a total of 3517 inorganic salts, but in most salty soils our main concern is with a relatively small number of these. Salts having low water solubilities remain largely inactive in soil, while those soluble concentrate in the soil solution and contribute substantially to salt toxicity. The lime carbonates are usually dominant but are only slightly soluble, and while detrimental to plant growth in some instances, they are usually not as damaging as are the sulfates or the chlorides. Solubilities of such salts in cold water is as follows:

Solubility of Salts in Cold Water

Salt	Solubility (grams salt/100 ml of cold water)
sodium chloride (table salt)	36
sodium sulfate	20
sodium carbonate	33
magnesium chloride	54
magnesium sulfate	26
magnesium carbonate	0.01
calcium chloride	60
calcium sulfate (gypsum)	0.21
calcium carbonate	0.001

Obviously, all three sodium salts and calcium and magnesium chloride readily dissolve in water. Magnesium sulfate is over 100 times more soluble than the calcium sulfate (gypsum) common to many of the drier area soils of western Minnesota.

Farmers and soil specialists have reported poor corn growth on "alkali rim" areas for many years, since this crop was most commonly grown. The recommended treatment for such areas was the application of ample potash and possibly some phosphate, or a heavy application of farm manure. Affected areas are often very irregular in shape and are seen most readily from the air. They can be readily observed where poor growth occurs on the rims of former ponding areas where salts have accumulated from surrounding higher elevations over many years. A contributing factor is the higher soil moisture levels depressing soil temperature and plant growth.

Different plant species and varieties show a wide range of tolerance to salty soil conditions, ranging from greasewood and saltgrass survival with excessive salts down through the relatively resistant small grains to the low tolerance of many soybean and flax varieties.

Numerous field experiments have shown the value of farm manure or of potash for improving corn growth such on such 'alkali rims' long before the farm operator had the partial solution of placing such areas in the soil bank. However, soybean acreage has rapdily expanded, and the yellow (chlorotic) condition of this salt sensitive crop has emphasized the salty areas.

Commencing in 1956, a greenhouse study by MacGregor and Ray showed lower soil temperature definitely decreased chelated iron uptake by flax. A more thorough 1967 study with Chippewa soybeans in the greenhouse reported by Timmons and Holt showed that a soil temperature increase of from 50° to 70°F increased iron uptake & dry matter production, with normal plant growth and coloration at the higher soil temperature. (Effect of soil temperature on Fe chlorosis of soybeans (Exploratory study) 1967 Location Annual Report SWCRD Morris, Minn.)

Field studies commencing in 1956 on both soybeans and flax were encouraging as shown in Table 1 and 2 and these were continued for some years.

Table 1. The Effect of Iron and Manganese Applications to Soil Growing Chlorotic Soybeans in 1956 (Average of 3 fields in northwestern Minnesota)

Treatment #	Soybean Yield in Bu/A
None	5.8
FTE 501	5.1
FTE 502	5.5
MMM Mn	5.2
MMM Fe	6.5
Min-Miz	6.7
Chelate 138	12.9
Chelate 330	14.3
Chelate Ra 157	15.7
Chelate Ra 159	16.1

All plots received 50-50-25 treatment per acre (Fe or Mn at 10#)

Table 2. The Effect of Iron and Manganese Applications to Soil Growing Chlorotic Flax in 1956 (Average Of 3 fields in northwestern Minnesota)

Treatment #	Flax Yield in Bu/A.
None	5.7
FTE 501	5.2
FTE 502	6.7
MMM Mn	5.4
MMM Fe	6.0
Min-Miz	6.9
Chelate 138	10.6**
Chelate 330	9.7**
Chelate RA 157	9.0*
Chelate RA 159	10.7**
Significant -5%	2.9 bu.
Highly significant - 1%	4.0 bu.

All plots received 50-50-25 treatment per acre (Fe or Mn at 10#)

Field trials were conducted near Springfield, Minnesota in 1961 using iron ammonium phosphate or magnesium ammonium phosphate but these compounds failed to increase either corn or soybean yield.

Coating soybean seeds with small amounts of micronutrients was then tried in 1963 but these treatments were also ineffective for increasing soybean yields as shown in Table 3.

Table 3.

The Effect of Iron Treatments on Seed or to Calcareous Soil on the 1963 Soybean Yield at Gaylord (Harpster clay loam-pH of 8.0)

No.	Iron Treatment	Lindarin	Chippewa
		(Bushels per acre)	
1	None	11.6	12.7
		Yield increase for iron treatment	
2	Kalo seed treatment	-2.6	1.9
3	Fe chelate 138@1#/A (0.06#Fe/A)	-4.4	-3.0
4	Fe " " @20#/A (1.2#Fe/A)	1.1	-3.0
5	Chelate 138@20#/A (no Fe)	-3.4	-----
6	" " Fe on vermiculite @2.5#/A or 0.06#Fe	-1.8	-----
7	Versenol Fe on vermiculite @1#/A or 0.06#Fe	3.6	-----
8	Grace 7-35-0 (Fe amm. phos) 78#Fe/A	-1.5	-0.4
9	ADM chelate 138Fe+$FeSO_4$ (21.2%Fe) @0.95#/A	-3.7	-0.2
10	ADM coated $FeSO_4$ (21.2%Fe) @ 0.954#/A)	1.9	1.4
	Significant (5%)	3.8 bu.	5.5 bu.

Spraying soybeans with ferrous sulfate or Nu-Iron on three chlorotic soybean fields also failed to improve soybean growth or yield on three chlorotic fields as shown in Table 4.

Table 4. The Effect of Spraying Chlorotic Soybeans in 1963 with Ferrous Sulfate or Nu-Iron on Soybean Yield

Location	Lake Lillian	Raymond	Montevideo	
Soybean Variety	Chippewa	Chippewa	Harmon	Average
Treatment	Yield in bushels per acre			
None	13.5	14.8	27.4	18.6
	Yield increase for iron spray			
$FeSO_4$ 1#/A June	2.3	0.6	1.8	1.6
$FeSO_4$ 1#/A June + July	2.5	1.7	-0.5	1.2
$FeSO_4$ 10#/A June	4.0	4.3	-3.0	1.6
$FeSO_4$ 10#/A June + July	5.3	4.8	-1.2	3.0
Nu-Iron (1/10 rec. rate) - June	5.1	-1.7	-1.7	0.6
Nu-Iron (1/10 rec. rate) - June + July	2.4	0.1	-1.5	0.3
Nu-Iron (rec. rate) - June	-3.0	1.8	-3.3	-1.5
Nu-Iron (rec. rate) - June + July	-1.0	6.0	-3.8	0.4
Significant (5%)	8.0 bu.	7.4 bu.	5.7 bu.	

However, the ineffectiveness of the soil additive approach to correcting severe soybean chlorosis was shown by the 1964 soybean yield obtained from a number of treatments on a problem soil in northwestern Lyon county. These are shown in Table 5.

Table 5. 1964 Yields of Chippewa Soybeans with Various Iron or Zinc Treatments to a Salty Clay Loam Soil in Northwestern Lyon County, Minnesota (Avg. of 6 replicates)

Treatment applied	Soybean Yield (bu/A)
Check	0.5
Chelate 138 Fe@1.67#/A (0.1#Fe)	1.5
Chelate 138 Fe@16.7#/A (1.0#Fe)	1.5
Chelate 138 Fe@167 #/A (10#Fe)	3.4
Rayplex Fe (powdered) at 20#/A	0.4
" " (granular) " "	1.4
" Zn (powdered) " "	0.8
" " (granular) " "	0.6
Sequestrene Zn chelate @1.0#/A (14.2% Zn)	1.1
" " " 10#/A (")	0.5

It is apparent that the use of even the most expensive (& certainly uneconomic) additives to relieve a salty soil condition and allow more normal growth of salt sensitive plants is not a practical solution. Extensive soil studies made during 1965-1967 in western Minnesota indicated the principal cause of abnormal growth and poor yields of soybeans, flax, corn, potatoes and other crops on alkali rim areas was associated with high contents of lime carbonates with varying amounts of soluble salts of calcium, magnesium, and even sodium in more extreme cases.

CONCLUSIONS

Since the soluble salts are most active and most troublesome in the soil solution, the obvious long term cure is to improve soil drainage to permit the removal of these salts by the leaching action of rainwater as rapidly as possible. The salts of lower solubilities such as the lime carbonates will naturally dissolve and be removed at an extremely slow rate, but these are also less damaging to plant growth. Improved drainage will promote drier and warmer soils, and this is an important additional step toward normalizing plant growth.

Applications of farm manure will benefit both soybean and corn growth in such soils since it supplies both plant food and organic matter which decreases salt concentration effect and increases soil aeration and temperature.

Since soybeans have as yet shown little direct effect of direct mineral fertilization, applications of potassium would serve to slightly increase salt effect on soybeans, but increase yields of corn and other crops on salt rim areas.

SOIL MANAGEMENT PRACTICES AND THEIR EFFECT ON CORN AND SOYBEAN ROOT DEVELOPMENT

W. W. Nelson
Superintendent and Associate Professor
Southwest Experiment Station, Lamberton

Throughout the history of crop production a great deal of time and effort has been spent looking and describing the growth of plant parts above ground. The importance of roots has always been recognized, however, to be able to study them in detail has presented a number of problems.

During the last two years a method has been devised to take roots out, wash them and still see them in their relative position in the soil.

In cooperation with the Agricultural Research Service, Morris, Minnesota, a series of corn plots with various tillage treatments were established. Temperatures, moisture content, growth differences, and root growth were observed. A striking visual effect of root growth due to tillage treatment was observed.

The extent and amount of root growth along with distribution is very suggestive of a great deal of work that may be done in the future.

John Reiser, Jr.
Farmer
Ashland, Illinois

I would like to first read a statement taken from a paper prepared by a New Zealand Field Research Officer in a presentation to his board of directors.

Quote - "today, more than ever before, New Zealand farming is at the cross-roads. Two of our major products have been badly hit financially and their future, as far as one can see, cannot be described as rosy. We are all aware of this depressing situation---the question we must all face up to "what can" and "what will" we do to extricate ourselves and the economy as a whole from the difficult position in which we find ourselves"--- unquote.

I do not know what two major products the gentleman was referring to but probably wheat and wool as they are both major products of New Zealand.

I mention this only for a selfish reason. You gentlemen deserve a bit of encouragement for sitting through this portion of the program. If I am unable to help in any other way, at least you will be consoled by the fact we are not alone in our economic struggle.

Countries are striving for better conditions, States are striving for the same, Communities are dedicated to higher education, business is faced with cut prices and volume sales, farmers are confronted with high overhead and low prices; not altogether because of overproduction but because we are producing enough to insure adequate supplies.

The problems confronting all of us are in relation to our business, but in general, are much alike. It takes the same remedy, used in a different way, to heal the sickness. Whether we are dealing in politics, salesmanship, education, religion, manufacturing or farming and no matter what the size of operation, one word determines the success of all.

I know of nothing more responsible for high yields of soybeans than this same word----------Management.

It's an old word--been around a long time--had a lot of use--both good and bad. It has been passed down from generation to generation but the quality of its results has depended, for the most part, on the individual.

I think most of us individuals consider ourselves to be good managers. The fact we are here today proves that, without a doubt.

We are back in school, searching other minds for knowledge that we can profitably use. I ask you---Isn't that good management? I ask you something else---Isn't there a vast library of information throughout the country on all elements pertaining to soybean production and isn't this information available for the asking? It is, but we have to manage it and put it to use where it does the most good. Somebody elses knowledge is not our knowledge until we make it work on our farm.

Our job of management starts with what we have to work with. The type of farm we have, the class of land, drainage, and in general just what the farm is best adapted to produce.

Suppose we have considered all the preliminaries and soybeans do fit into our rotation. We must not stop at just fitting them in the rotation. We have to put them in their proper perspective to fulfill our management obligation.

This means a good job of preparing a well fertilized, weed-free seed-bed, planting varieties that have proven high yielders for the conditions, inoculate and treat with a fungicide----good clean and high germinating----disease free seed.

These practices are not difficult to accomplish and neither is the next important step, which is planting depth, when we have prepared this smooth and firm seed-bed.

To get the most from our seed along, with stronger and healthier plants, we should stay within a depth range of one and a quarter to one and a half inches. We should prepare our seed-bed with this in mind since moisture must be present to insure quick emergence. Rough and dry seed-beds that prevent shallow planting open the gate to poor stands, weak plants, disease, weedsand lower yields. This slide is very convincing when you consider that last inch of depth costs us 45% of our stand.

Seed spacing or population cannot be made a steadfast rule due primarily to variety characteristics and fertility levels. At this point we must refer to our experiment station tests, our neighbors results and our past experience. The variable weather conditions from year to year and changing fertility levels of our fields makes this choice one that we just hope is right.

As a rule of thumb we can expect the most profitable seeding rate to vary according to the planting date. Early plantings as well as late plantings will ordinarily make better use of higher plant populations. The early planted beans grow slower due to cooler soil temperatures---making stronger plants that mature at shorter heights.

Late planted beans just don't have the growing season to reach excessive heights----but watch out for the ones going in the ground at the optimum planting dates. Soil temperatures are warm---we have planted shallow, in good moisture---the fertility is present to produce high yields. What can keep them from growing fast?

When a plant grows fast they are usually not as sturdy. The excessive early growth and foliage cause competition for light and more growth results in a favorable season. Branching will fail to exist under these conditions and the result is a loss of part of our yield to lodging.

Great progress is being made with a growth regulator that when sprayed on the plants during early bloom brings about shorter plants, with more erect leaves----allowing more light benefits. This in turn lessens lodging and in many cases produces more beans.

This material is not available for commercial use as yet so when lodging presents a problem we must resort to natures way and adjust the population to achieve stronger plants. How far we go depends upon the condition in which each individual works for his own ends.

The row-width we are using does have quite an influence on the optimum population per acre. Most generally a narrow row width, such as 20 inch, adjusted to the correct population for conditions, will equal or surpass other width rows.

Planting date, fertility levels and varieties in variable combinations make many confusing trials but a broad statement would be that narrow rows pay big dividends. This is especially true for late planted beans, for low fertility fields and in most cases for thin-line varieties.

Now we can get tripped up on that statement occasionally. When this happens and wider rows equal narrow rows in yield a closer check will probably explain the reason. Possibly the narrow rows were planted at too high population. Wide rows will stand thicker planting in the row before yield reduction occurs.

In other words I don't think 38 inch rows will equal 20 inch rows in yield if both are planted at the correct population for conditions. Stress from over-population on 20 inch rows can very easily result in many barren stalks and lodging with the end result being a yield reduction for the 20 inch rows rather than an increase for the 38's.

The difference in dollars would be the same but the potential for the 20's should serve as a challenge to your management for future years. It's a challenge to my management. Not that I beat 20 inch yields with wider rows but I just haven't been able to keep the 20's from lodging. I'm thoroughly convinced that as we move up the scale in fertility and other higher production practices we must in turn adjust and re-arrange our population to compensate for increased lodging. Thin stands are not the worry they used to be. They're just harder to come by.

Many of us in the past have planted thick stands to insure emergence in case of crusting. This practice does not accomplish its purpose. It is solely a guessing game where we are 50% wrong to start with. Should crusting conditions exist the other 50% of the time I would say half of the stand would be as planted. The end result shows a loss from over-population on 75% of the area to attain a small increase on 25%.

Narrow rows eliminate this risk involved in crusting by having the seed distributed over a larger area. The risk ratio on crusting for narrow-rows, planted for the optimum stand, is about opposite wide rows where extra seed is used to help emergence. With narrow rows we will have closer to 75% of the area producing normal yield and perhaps a slight decrease on the remaining 25%. It just doesn't pay to plant the extra seed to eliminate crusting. It usually costs us.

Nor does it pay to plant extra seed trying to keep down weeds and grass. In most cases the yield potential of the field is not reached where thick stands prevail even though weeds and grass do not exist. Although you may accomplish your purpose of eliminating the weeds, you still lose.

During the early days of soybeans and before herbicides this was a common and somewhat recommended practice, simply because it was the lesser of two evils. The better herbicides we have today will do a much better job of controlling weeds and grass than a few extra plants per acre. They will do it early in the season, when competition is greatest, and give us season long protection as well.

The following slides speak for theirself and represent weed and grass control with banded Amiben on my farm this year.

By all means lets use the herbicides to control the weeds and plant our seed at a population that will produce the most beans.

I have stressed the importance of population in relation to yield perhaps more than some of you think necessary. I have purposely done this because I feel your management is taxed to a higher degree in selecting the correct population than all the other practices put together.

General knowledge of soybean production has proven without a doubt that it takes good seed, an adapted variety, high fertility, absence of insects and disease and weed free fields to raise high yields on all of our farms.

Most of us are experts with these established practices and when we use them to the best of their advantage along with sufficient moisture dependable yields are obtained with any reasonable population.

These old stand-by rules, as important as they are, have terminal boundaries that limit their yield potential if not combined with the proper population.

The most suitable population cannot be reduced to pounds per acre and called law anymore than specific fertilizer recommendations can be made to include all farms. We wouldn't attempt to guess the rate of lime, phosphate and potash that our land needs and spend our money on that basis. We soil test first to determine the amount of fertilizer to apply for the sake of ecomomy.

Soil-testing has been made convenient for us and we know that a shortage of nutrients can limit our yield. Most of us have also decided that over-application is not a cure-all, therefore we rely on the soil test for the most optimum level of application to achieve maximum yields.

Why not do a little testing for population benefits? We all know of cases where seeding rates have varied considerable with little difference in yield. Why did this happen? Was it a case where the population was increased in the same row width? If so possibly lodging, lack of light, increased disease, barren stalks of poor filling prevented an increase or caused the decrease in yield.

Highest yields are obtained only one way and that is by harvesting the most weight of 13% moisture beans from an acre of land. At first thought we think of needing a good stand and this is true but what is a good stand? My definition of a good stand is enough plants to produce the maximum yield and that's all. Don't plant any extra to overcome crusting or to keep down weeds. Use the other management practices for these problems. When we overplant we are encouraging lower yields by reducing the efficiency of the plant. Narrowing the row-width allows more plants per acre without sacrificing the efficiency.

Variety, fertility, row-width, planting date and population must be in balance to reach the maximum productivity of each plant. This balance can only be reached on our farms. Research and Extension can give us leads but we must make the final adjustment under our farming conditions.

The testing we have done on our own farm has convinced me the old theory "that soybeans don't respond to fertilizer" is hogwash. They do respond to fertilizer and they will respond past the point of efficiency if our major factors are not in balance.

The past two years my over-all farm average has declined due primarily to increased growth and lodging. Reducing the population alone has not corrected the lodging as you will see in this slide showing the results of our seeding rates this year.

Perhaps I should move my planting date up----causing the plant a little hardship on the start----making it stonger and shorter with the idea that the excess fertility will be used to produce branches and beans rather than stalk and lodging.

Since we have built a high yield program around narrow rows possibly some of you question cultivation and you're right in doing so. Most of us still need cultivation to help control weeds. Even though broadcast herbicide alone will control some fields, banded herbicide accompanied by cultivation is still our cheapest way.

Let me assure you that it is just as easy to cultivate 20" rows as wider rows. It does take a smaller tire on the tractor and you cannot cultivate over as long a period of time but this second cultivation can and should be eliminated. Once is enough since the beans do close the rows much earlier.

Slides to be shown on cultivation, varieties, rainfall data, combining, disease, soybean profits as compared to corn and total vegetative control chemical use on fence-rows.

This chemical returns its cost in many ways and to me the most appreciated time is when I don't have several mile of weedy fence rows staring me in the face after I have the crop in and tended.

It gives me time for some extra trials and experiments which are still the most convincing evidence even though we usually have to do things the wrong way before we realize the right.

New products are also introduced each year with the sales pitch geared to increasing our yields and profit. Advertising claims some of them to be the greatest asset to the farmer since the plow. If this is so I want to use the product on all my acres as quick as possible, but not until it has proven itself on a smaller seale, on my farm and under my farming conditions.

This small acreage for testing some of these new products and practices such as varieties, row-widths and population can be our most profitable acreage on the farm since the results of these tests can later be used on our total acreage.

INNOVATIONS IN CORN RESEARCH

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Soil fertility research for corn production is presently undergoing considerable change. The reason for this is the change that is occurring in the fertility (P and K) status of soils. Although too many acres are still in the deficient range, other Midwest acres are probably more fertile today than ever before. This increase in soil fertility has come about primarily by the addition of commercial fertilizers. The favorable price of fertilizer will, no doubt, result in the fertility level being increased even further.

Much research in the past was often concerned with such factors as the best time and method (broadcast versus banded) for applying fertilizer. But, as the fertility level of soil increases, the importance of time and method of application diminishes. Thus, the researcher who formerly studied the above factors is being freed to research other factors in corn production.

The typical yield-response-to-fertilizer curve increases rather rapidly on very deficient soils with moderate rates of added fertilizer. However, as the rate of added fertilizer is increased further, the curve will flatten and may even turn down. Some states have recently reported yield decreases to very high rates of N, P, and K. These decreases may be the result of a nutrient imbalance at high rates of fertilizer; for example, high P has been shown to induce zinc deficiency and high K may induce a magnesium deficiency. While we must continue to be concerned with soils deficient in fertilizer nutrients, it would now be wise for the researcher to devote some attention to problems that may arise from "over" fertilization.

On maximum-yield research plots, rates of fertilizer are added so that no further yield increase occurs from the addition of more fertilizer. Under this situation, it is assumed that some growth factor other than fertility is limiting corn yield. The limiting growth factor may be due to genetic potential, water supply, light, carbon dioxide level of atmosphere, competition from weeds, or damage from insects and diseases. Although often deficient under normal situations, water may be removed as a limiting factor by irrigation. Weeds, diseases, and insects may be controlled on research plots and thus eliminated from further consideration as limiting growth factors. This leaves genetic potential, carbon dioxide, and light as possible limiting growth factors.

Studies have shown that with little air movement, the concentration of carbon dioxide near the corn leaf may become low enough to limit photosynthesis. However, in the Midwest air movement is rapid enough that carbon dioxide is not generally believed to be the limiting growth factor at present yield levels.

Research at Illinois by J. W. Pendleton has shown that light may be the limiting factor at high yield levels. Corn yields are reduced when shade is added. Conversely, yields have been increased with the addition of light.

Presently, it is not economically feasible for the grower to add artificial light to corn fields. However, the grower may better utilize natural light by giving heed to such factors as planting date, population, and row width.

Pendleton's recent research has reemphasized the role of the plant breeder in changing the efficiency of light use by the corn plant. Plants with upright leaves have been shown to increase light efficiency.

AMMONIUM POLYPHOSPHATES: PLANT GROWTH RESPONSES AND SOIL REACTIONS

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The introduction of polyphosphates into the fertilizer market has raised questions of possible differences in effects of ortho and polyphosphates on plant growth. Essentially, these two forms of phosphorus differ in the structure of the phosphate molecules, the polyphosphates being comprised of condensed orthophosphate units. Sequestering abilities attributed to polyphosphates have raised the question of increased availability of micronutrients when these elements are applied in combination with polyphosphate materials. To answer questions concerning effects of polyphosphates on micronutrient availability and availability of phosphorus applied as polyphosphate, work comparing polyphosphates and orthophosphates was begun in Kansas in 1964.

Polyphosphate as a Carrier of Micronutrients

Studies of the effects of polyphosphates on the availability of soil applied micronutrient metals began with field comparisons of ortho and polyphosphates in combination with inorganic and organic forms of the elements. The idea behind these investigations was to determine if combinations of polyphosphate and inorganic forms of iron and zinc were as efficient as combinations of orthophosphates and more expensive chelated forms of the elements for the nutrition of irrigated corn.

Plot sites selected for the initial phases of the work were situated on alluvial soils which had been levelled in preparation for furrow irrigation. Such sites are frequently deficient in phosphorus as well as iron and zinc in Kansas. Liquid ortho and polyphosphates were selected for the study in order to facilitate the incorporation of the iron and zinc carriers into the phosphatic fertilizer. The liquid ammonium polyphosphate contained approximately 50 per cent of its phosphorus in the ortho form and 50 per cent in the polyphosphate (pyrophosphate) form. Zinc and iron were supplied where required as zinc sulfate and sodium zinc EDTA.

Results of the 1964 investigations varied. Of the four sites selected only one responded to zinc. Banded application of orthophosphate without zinc at this location produced increasingly severe zinc deficiency in corn and resulted in depressed yields. When zinc was included with the banded phosphatic fertilizer, yields increased rapidly. Yield data indicate that combinations of ammonium polyphosphate and zinc sulfate were equal to applications of orthophosphate (monoammonium phosphate) and the more expensive chelated zinc (Table 1). Banded orthophosphate plus zinc sulfate produced yields of corn considerably below those of polyphosphate plus zinc sulfate or orthophosphate plus zinc chelate, particularly at the lower levels of zinc application. It is interesting to note that banded applications of zinc lowered the plant phosphorus content when both ortho and polyphosphate carriers were applied. Concomitantly, the zinc content of the plant leaf tissue rose with increasing applications of zinc.

Research conducted in 1965 indicated that polyphosphate materials are also capable of increasing the severity of zinc deficiencies when phosphorus is applied banded to zinc deficient soils. Liquid ammonium polyphosphate banded without supplemental zinc lowered irrigated corn yields about 20 bushels per acre on a site determined to be borderline in zinc according to soil tests. Few yield or plant composition differences were noted in this crop year between ortho and polyphosphate carriers applied in combination with inorganic and chelated forms of zinc. Results of the 1965 study, reported in Table 2, also indicate few differences in corn yields or plant composition between the two forms of zinc employed.

EFFECT OF P-CARRIER ON YIELD AND LEAF COMPOSITION OF IRRIGATED CORN

Table 1. Shawnee County, Kansas - 1964

Treatment Lbs./A. P_2O_5	Zn	P Carrier	Zn Carrier	Yield Bushels/A.	Leaf Content[3/] P %	Zn ppm
0	0	--	--	115.3	0.16	21.0
34	0	MAP[1/]	--	68.1	0.27	13.5
34	0.3	MAP	Chelate	84.3	0.22	17.8
34	0.6	MAP	Chelate	94.6	0.20	14.9
34	3.0	MAP	Chelate	121.2	0.12	20.0
34	0.3	MAP	$ZnSO_4$	48.2	0.32	20.2
34	0.6	MAP	$ZnSO_4$	65.0	0.28	13.6
34	3.0	MAP	$ZnSO_4$	119.7	0.14	17.5
34	0.3	APP[2/]	$ZnSO_4$	80.2	0.24	22.5
34	0.6	APP	$ZnSO_4$	88.4	0.23	13.6
34	3.0	APP	$ZnSO_4$	120.2	0.16	18.8
$L.S.D._{.05}$				18.0	0.05	5.8

1/ MAP - Monoammonium phosphate

2/ APP - Ammonium polyphosphate

3/ Sampled at 52 days

EFFECTS OF P-CARRIER ON YIELD AND LEAF COMPOSITION OF IRRIGATED CORN

Table 2. Shawnee County, Kansas - 1965

Treatment Lbs./A. P_2O_5	Zn	P Carrier	Zn Carrier	Yield Bushels/A.	Leaf Content[3/] P %	Zn ppm
0	0.0	--	--	109.0	0.20	9.4
0	2.0	--	$ZnSO_4$	110.3	0.16	11.6
34	0.0	APP[1/]	--	93.4	0.34	8.4
34	0.5	APP	$ZnSO_4$	116.0	0.24	9.8
34	1.0	APP	$ZnSO_4$	124.4	0.26	8.9
34	0.5	APP	Chelate	123.0	0.22	8.8
34	1.0	APP	Chelate	120.0	0.22	8.5
34	0.5	MAP[2/]	$ZnSO_4$	114.8	0.24	8.5
34	1.0	MAP	$ZnSO_4$	118.1	0.21	8.6
34	0.5	MAP	Chelate	123.4	0.22	9.1
34	1.0	MAP	Chelate	120.5	0.18	9.4
$L.S.D._{.10}$				17.0	0.04	2.2

1/ APP - Ammonium polyphosphate

2/ MAP - Monoammonium phosphate

3/ Sampled at 60 days

COMPARISONS OF MONOAMMONIUM PHOSPHATE AND AMMONIUM POLYPHOSPHATE AS SOURCES OF PHOSPHORUS FOR IRRIGATED CORN

Table 3. Shawnee County, Kansas - 1966

P_2O_5 Treatment Lbs./A.	P Carrier	Method of P Application	Yield Bushels/A.
0	--	--	141
40	APP[1/]	Broadcast	161
80	APP	"	149
120	APP	"	150
40	MAP[2/]	Broadcast	152
80	MAP	"	145
120	MAP	"	149
40	APP	Banded	144
80	APP	"	164
120	APP	"	172
40	MAP	Banded	147
80	MAP	"	153
120	MAP	"	164
$L.S.D._{.10}$			13

1/ APP - Ammonium polyphosphate

2/ MAP - Monoammonium phosphate

EFFECTS OF ORTHOPHOSPHATE AND POLYPHOSPHATE ON THE YIELD AND COMPOSITION OF IRRIGATED CORN

Table 4. Pottawatomie County, Kansas - 1967

Treatment P Lbs./A.	Treatment Zn Lbs./A.	P Carrier	Method of P Application	Yield Bushels/A.	Leaf Content[3/] P %	Leaf Content[3/] Zn ppm
0	0	--	--	101	0.139	12.1
0	10	--	--	102	0.164	24.2
80	0	MAP[1/]	Broadcast	127	0.280	11.8
80	10	(Orthophosphate)	"	152	0.208	24.1
80	0	"	Band	111	0.602	11.0
80	10	"	"	163	0.344	19.0
80	0	APP[2/]	Broadcast	112	0.236	10.2
80	10	(Polyphosphate)	"	149	0.209	24.7
80	0	"	Band	73	0.729	9.8
80	10	"	"	162	0.412	16.5
$L.S.D._{.05}$				28.5		

1/ MAP - Monoammonium phosphate (11-48-0)

2/ APP - Ammonium polyphosphate (15-60-0)

3/ Sampled at 51 days

Comparisons of polyphosphate and orthophosphate in 1966 included rates of phosphorus and methods of phosphorus application for irrigated corn. Nitrogen, potassium and zinc were held constant. Ammonium polyphosphate supplied as solid 15-60-0 and monoammonium phosphate (11-48-0) were the two phosphatic materials employed. These carriers were broadcast and banded at rates of 40, 80 and 120 pounds of P_2O_5 per acre. Results of the investigation (Table 3) indicated some superiority of banded ammonium polyphosphate over banded monoammonium phosphate. Banded applications of both P carriers were superior to broadcast applications in that particular crop year.

Plant tissue analyses revealed no difference in plant composition which could be attributed to the form of phosphorus applied. Visual differences between treatments were few.

The fact that banded applications of both ammonium orthophosphate and ammonium polyphosphate had intensified zinc deficiency symptoms in corn grown on zinc deficient soils prompted an investigation of the effects of phosphorus carrier on phosphorus-induced zinc deficiency. Such an investigation was established in 1967 on an alluvial soil in the Kansas river valley. The particular site chosen for this work had a history of zinc deficiency during the two previous crop years since levelling for furrow irrigation. Soil analyses from the experimental area revealed very low levels of available phosphorus and zinc.

Two orthophosphates, triple superphosphate and monoammonium phosphate, were chosen for the study along with solid ammonium polyphosphate, 15-60-0, obtained from TVA. These materials were applied at a rate of 80 pounds of P_2O_5 per acre broadcast and banded. Zinc was included as a variable being applied broadcast pre-plant as zinc sulfate at the rate of 10 pounds of metal per acre. Nitrogen was held constant at 300 pounds per acre, potassium was constant at 100 pounds of K_2O per acre.

As soon as the plants emerged, definite treatment differences were noted. Plants which had received banded applications of ammonium polyphosphate without zinc were chlorotic and definitely slower growing. As the plants developed, severe zinc deficiency symptoms were in evidence, leaves exhibited interveinal chlorosis, internode length was depressed, stems were thin and leaves were curled inward. Concomitantly, plants which had received banded applications of the two orthophosphates without supplemental zinc were also exhibiting zinc deficiency much more severely than were the check plots but these plants were definitely superior to those which had received banded polyphosphate without zinc.

Broadcast applications of the various phosphorus carriers without zinc did not produce such severe zinc deficiency symptoms as did the banded applications regardless of the phosphorus carrier involved. On the other hand, plant growth was essentially equal when supplemental zinc was supplied regardless of the P carrier used. Generally, banded applications of phosphorus with zinc produced somewhat better growth during the early part of the season due to wet soil conditions which prevailed in May and early June.

Plants which had received banded ammonium polyphosphate without zinc remained in poor condition throughout the growing season. Some recovery was noted late in the summer.

COMPARISONS OF ORTHOPHOSPHATE AND POLYPHOSPHATE
AS SOURCES OF PHOSPHORUS FOR IRRIGATED CORN

Table 5. Pottawatomie County, Kansas - 1967

P_2O_5 Treatment Lbs./A.	P Carrier	Method of P Application	Yield Bushels/A.
0	--	--	170
40	MAP[1/] (11-48-0)	Broadcast	172
80	"	"	169
120	"	"	183
40	"	Band	170
80	"	"	184
120	"	"	188
40	Solid APP[2/] (15-60-0)	Broadcast	166
80	"	"	178
120	"	"	200
40	"	Band	181
80	"	"	177
120	"	"	196
40	Liquid APP (10-34-0)	Knifed	180
80	"	"	178
120	"	"	182
40	"	Band	188
80	"	"	155
120	"	"	187
$L.S.D._{.20}$			12

1/ MAP - Monoammonium phosphate

2/ APP - Ammonium polyphosphate

COMPARISONS OF ORTHOPHOSPHATE AND POLYPHOSPHATE
AS SOURCES OF PHOSPHORUS FOR IRRIGATED CORN

Table 6. Shawnee County, Kansas - 1967

P_2O_5 Treatment Lbs./A.	P Carrier	Method of P Application	Yields Bushels/A.
0	--	--	155
40	APP[1/]	Broadcast	179
80	"	"	174
120	"	"	169
40	MAP[2/]	"	176
80	"	"	187
120	"	"	165
40	APP	Band	161
80	"	"	165
120	"	"	173
40	MAP	"	184
80	"	"	180
120	"	"	181
40	APP	½ B'cast, ½ Band	183
80	"	"	181
120	"	"	192
40	MAP	"	172
80	"	"	170
120	"	"	187
$L.S.D._{.10}$			21

1/ Ammonium polyphosphate (15-60-0)

2/ Monoammonium phosphate (11-48-0)

Grain yields substantiated field observations. Plots which had received banded polyphosphate without zinc yielded approximately 30 bushels less per acre than did the no treatment checks and 40-50 bushels less than plots receiving banded applications of orthophosphate without zinc. When zinc was supplied with the ammonium polyphosphate, yields were increased some 90 bushels per acre (Table 4). Banded applications of the three forms of phosphorus produced equal yields when zinc was supplied.

Analyses of tissue collected during the summer indicated that plants which had received banded polyphosphate without zinc and which had exhibited extreme symptoms of zinc deficiency throughout the growing season contained extremely large amounts of phosphorus and very small amounts of zinc. Such conditions are typical of phosphorus induced zinc deficiency. Tissue analyses did not, however, supply answers as to just why the plants receiving banded polyphosphate without zinc contained more phosphorus than did plants receiving banded orthophosphate. Such a situation suggests some ability of the plants to recognize differences in species of phosphate molecule.

Further field comparisons of monoammonium phosphate, and ammonium polyphosphate, both solid and liquid, were conducted in 1967 at two locations. When zinc was supplied in adequate amounts, there were few measurable differences in the yield of irrigated corn which could be attributed to the form of phosphorus applied (Tables 5-6). Tissue analyses conducted on samples collected from these locations indicated few differences in plant composition arising from type of phosphatic fertilizer applied.

In light of the 1967 results studies were initiated in 1968 comparing ammonium ortho and ammonium polyphosphates on two irrigated sites in the Kansas river valley. One site was definitely calcareous in nature with soil pH of 8.1. The second site with a neutral pH was the same one employed in 1967. Unlike 1967, plant growth responses in these two investigations did not reveal differences in growth related to the type of phosphorus compound applied regardless of the zinc content of the soil. Throughout the growing season ammonium polyphosphates and ammonium orthophosphates produced essentially the same plant growth on both zinc sufficient and zinc deficient plots.

Tissue samples collected during the 1968 season have shown a slightly higher phosphorus content when plants received ammonium polyphosphates particularly on the calcareous soil. Concomitant with the higher phosphorus levels in the plants receiving polyphosphate was a lowered zinc content. This seeming contradiction between 1967 results and 1968 observations may be partially resolved by considering the weather patterns in the two years. The spring of 1967 was wet and cold and approximately 16 inches of rain fell during the month of June at the plot sites. In 1968, however, soil temperatures were considerably higher with a warmer May and June and considerably less rainfall in June. Apparently the detrimental response to polyphosphates in 1967 was related to the uptake of both phosphorus and zinc. These deficiencies in 1968 were much less pronounced than in 1967, a condition which was apparently related to the warmer soil temperatures and lower rainfall in 1968.

Laboratory investigation into the possibility of plant uptake of intact polyphosphate molecules were conducted using corn as the test plant. In these studies, the corn plants were grown in solution culture after being germinated in vermiculite. The plants in this particular study were allowed to remain in the phosphorus deficient nutrient solution for five days at which time polyphosphate (pyrophosphate) was added. Individual plants were decapitated at intervals and the stem exudate analyzed for polyphosphate via paper chromatographic methods. No polyphosphate was detected in the exudate regardless of the concentration of phosphorus in the nutrient solution or the time at which the samples were collected. Subsequent analyses of corn plant roots in such cultures did not reveal the presence of polyphosphate despite the presence of polyphosphate in the nutrient solution.

In summary, research in Kansas as in other states has indicated that orthophosphate and polyphosphate are essentially equal in their abilities to supply phosphorus to plants. Under certain soil and climatic conditions, not yet defined, polyphosphates may show some superiority to orthophosphates applied in similar manner and quantities. On the other hand, banded applications of polyphosphates have produced severe phosphorus induced zinc deficiencies in corn when applied to soil low in available zinc. Apparently, this effect is to some extent a function of soil conditions with increased severity of zinc deficiency induced by greater concentrations of phosphorus within the plants receiving polyphosphate. Practical application of this latter information suggests that banded applications of polyphosphate for corn should be conducted in the presence of adequate amounts of zinc, particularly when the soil tends to be cool and moist during early stages of plant growth.

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Minnesota Department of Agriculture

FERTILIZER LABELING AND SAFE HANDLING

Minnesota Fertilizer Law requires each container be labeled with a complete guaranteed analysis statement whether it be a bag, box, barrel, bulk bin, tank, or any other container. The information required is clearly spelled out in the statutes. In addition, regulations have been adopted covering labeling of soil conditioners, trace elements, and anhydrous ammonia which require additonal labeling to clearly identify the product and to further insure safe and correct handling. Some difficulties have been encountered in achieving the ideal in labeling and handling.

* The use of a universal or plain bag requires a stamping or printing operation to get proper grade and analysis guarantees on each container.

* This information is sometimes stamped on in such a manner that the information is not legible, or appears in the wrong position relative to pre-printed information on the bag. In some instances the containers just DO NOT get printed at all.

* Bulk containers are used for different grades of materials at various times of the season and it seems rather easy for the plant manager or the operator to unload a new shipment of grade 18-46-0 into an empty bin which formerly had been used to store grade 0-46-0 and still carries a label guaranteed for 0-46-0. Part-time inexperienced help in such an operation can easily make an error in formulating a grade or custom blend by putting the wrong material in a batch he is mixing.

* Tanks containing liquids are interchanged as well as bulk bins of dry materials. In this situation, it is often found that the storage tank has a large sign or emblem denoting a brand and grade.
  No change in label is made when a different brand and grade is put in the storage except in some instances where a chalk or crayon marking was made in addition to the original label. This double labeling can prove to be confusing and leads to errors in handling.

* Handling of Anhydrous Ammonia has presented problems in addition to guaranteed analysis labeling due to the nature of this product. Regulations require marking of storage systems, nurse tanks and applicators with "Caution Ammonia" signs.

* Anhydrous Ammonia systems and nurse tanks with no caution ammonia signs are in violation of the regulations.

* Anhydrous Ammonia regulations require that the name, address and telephone number of the nearest representative or agent be given. This information is lacking on a large percentage of sites checked.

* Main container shut-off valves shall be kept closed and locked when the installation is unattended. Often this is not being done and in numerous cases, no provision was made for such lock-up.

* Poor housekeeping and construction has made access to the main shut-off valves a rather perilous venture.

* Each fixed facility shall have on hand, an easily accessible shower or at least 50 gallons of clean water in an open top container. Tanks are missing, found empty, and inadequate.

* Water tanks are sometimes used for storage of material other than the clean water which is required.

* Nurse tanks must be labeled with "Caution Ammonia" signs in letters at least four inches high on both sides and the rear. They shall also be equipped with a storage of at least five gallons of readily available clean water.

* All trailers shall be securely attached to the vehicle drawing them by drawbars supplemented with suitable safety chains. Some trailers are equipped with such chains but these are found wrapped around the tongue and thus contribute nothing toward safety.

* Trailers shall be constructed so as to follow in the path of the towing vehicle without weaving and whipping. Some units do not trail properly and worn tires are often noted, which could easily cause trouble on the highway.

* Uniformity of quality usually is found in a well organized and labeled facility

* An orderly, well-kept, well-operated storage, manufacturing and distribution system presents few regulatory problems and is a real credit to the industry.

CHEMICAL WEED CONTROL

Gerald Miller, Extension Agronomist

Herbicides are paying substantial dividends to the Minnesota farmer! He cannot afford to be without this modern production tool that reduces the risks in crop production. This was especially apparent in 1968 when heavy rains prevented timely cultivation in many fields.

The value of chemicals for weed control in corn is illustrated by data in Table 1 from county weed control demonstrations.

Table 1. Corn yields* from county weed control demonstrations.

	Corn yields, bu/A				
	1965	1966	1967	1968	Ave.
Chemical + cultivation	103	120	99	127	112
Chemical only	96	101	95	121	103
Cultivation only	93	97	85	99	94
No weed control	59	57	62	92	68

* Average of 13 locations in 1965, 15 in 1966, 7 in 1967, 6 in 1968; two replications at each location.

These results show a consistently high return for the use of herbicides. The average yield from all the chemical treatments in the trials without cultivation was 11 bushels higher than from plots that were just cultivated. Cultivation in addition to use of chemicals resulted in yields 18 bushels higher than for cultivation alone and 9 bushels higher than chemicals alone. This is the average effect of all the chemicals in the trials. With cultivation, the best chemical treatment in the demonstration averaged 25 bushels per acre more than cultivation alone; the lowest yielding chemical treatment with cultivation averaged 11 bushels per acre more than cultivation alone.

The yield data illustrate, too, that cultivation is still needed to get top yields. Herbicide performance has improved considerably in the last 5 years but a timely cultivation usually increases yields. Some of the newer chemical treatments are averaging good control over 80 percent of the time in Minnesota trials. Chemicals that were widely used a few years ago were rated good only about one-half the time. Several developments have brought about this improved performance. Such things as new chemicals, mixtures, additives, crop oil and better application methods and equipment, have each played a part in improved performance.

However, herbicides still have some limitations that must be understood to get best performance. Results will be influenced by soil characteristics, weather, kinds of weeds, rate, and time of application. Crop tolerance is limited for some herbicides, so crop injury may occur, especially with misuse or improper application. Several cases of injury result every year in Minnesota from using the wrong chemical, using chemicals that are for preemergence only as postemergence treatments, uneven applications, etc. A rather common practice, harrowing immediately after planting is often involved in crop injury cases because the chemical is dragged into the planter press wheel mark and concentrated in the row. Drift of herbicides causes considerably crop injury and is an increasing problem.

By recognizing the potential and the limitations of herbicides, you can improve performance even further. We're past the shot-gun approach to weed control. Pull a tight bead on the problem. Then hit it directly with the best answer. Analyze the situation carefully. What kinds of weeds are in the field? What is the texture of the soil? What percent organic matter is in the soil? What crop will be grown this year? What crop will be grown next year? Get the answers to these questions. Then pick a herbicide, mixture of herbicides or combination of cropping practices, tillage, and herbicide treatments that will do the best job.

Several new chemicals are being added to the herbicide arsenal this year. Butylate (Sutan) has given good annual grass control and some nutsedge control, but the chemical usually does not control broadleafs or other perennial weeds. Butylate should be applied before planting and incorporated by disking. A mixture of atrazine (AAtrex) and butylate applied preplanting and disked in has effectively controlled both grasses and broadleafs. Or, butylate could be followed with a postemergence 2,4-D application for broadleaf control.

CP50144 (Lasso) is a new preemergence herbicide chemically related to propachlor (Ramrod). Corn and soybeans have shown good tolerance to CP50144. The chemical has given good control of annual grasses and fair to good control of redroot pigweed, lambsquarters, and common ragweed. Control of other broadleafs has been erratic. U.S.D.A. label approval has not yet been obtained, but clearance is expected soon.

C6989 (Preforan) is a recently developed preemergence herbicide that has shown promise in limited trials for control of annual grasses and broadleafs in soybeans. Soybeans have good tolerance to the chemical. C6989 is now cleared only for soybeans grown for seed.

Chloroxuron (Tenoran) can be used as an early postemergence spray for controlling certain annual broad-leaved weeds in soybeans. Broad-leaved weeds have become an increasing serious problem in soybeans since several of the herbicides used control grasses better than broadleafs. Chloroxuron is most effective against lambsquarters, mustard, and redroot pigweed. Other broadleafs are only partially controlled and grasses are usually not controlled. Early postemergence sprays applied when soybeans have the first trifoliolate leaf and weeds are less than 2 inches tall have been more effective than later applications. Earlier applications, when soybeans are in the unifoliolate leaf stage, have injured soybeans. The spray must contact weeds to be effective. Some soybean leaf burn and delayed growth usually occurs following chloroxuron treatment. A few days delay in soybean maturity has sometimes resulted. Proper timing and application are critical factors effecting the performance of this new chemical.

Several herbicide mixtures are now cleared for use and can be mixed by the user or bought as pre-packaged mixtures. Some of these mixtures show promise for overcoming limitations of single chemicals. Certain mixtures control more kinds of weeds, give more consistent performance with different soils and weather conditions, lessen soil residue problems, increase persistence enough to give full-season weed control and reduce crop injury. Only those mixtures that have been registered for use by the U. S. Department of Agriculture and tested under local conditions should be used. Other mixtures could give poor results or result in illegal chemical residues in the crop.

For additional information on chemicals, see Cultural and Chemical Weed Control in Field Crops 1969, Extension Folder 212, Agricultural Extension Service, University of Minnesota, St. Paul, Minnesota 55101.

CONTROLLING ROOT WORMS, CORN BORERS AND GREEN CLOVER WORMS

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Corn Rootworms

There was little significant change in the Minnesota corn rootworm situation from 1967. Some areas showed increases while others showed decreases from 1967. Generally northern corn rootworms were up and westerns were down except for the counties along the western edge of Minnesota.

Some states to the southwest (Nebraska, South Dakota, and Iowa) reported considerable resistance to diazinon. As a result they are removing diazinon at least partially from their recommendations. We do not feel that we have any serious problem with diazinon resistance in Minnesota yet and will continue to recommend diazinon for 1969.

The following table gives the 1969 recommendations for corn rootworm larvae.

Insecticide	Dosage	Limitations
Bux-Ten (status uncertain)	3/4 lb.	Rate given for 40 inch rows. Band application at planting or cultivation, except by Bux-Ten should be used at planting time only.
diazinon	1 lb.	
phorate (Thimet)	3/4 lb.	
Dasanit	3/4 lb.	
Dyfonate	3/4 lb.	

European Corn Borer

The first brood of corn borers was down for most of the state compared to 1967. However, many of these produced a second brood giving a considerable increase (about double the 1967 fall count) in the southern part of Minnesota where most of the corn is grown. Other parts of the state generally showed lower fall counts.

Normally this would not cause much concern as corn borers have not been a serious problem during recent years. The harvest situation this fall could conceivably pose a threat from corn borers in 1969. Corn-picking is way behind schedule due to wet fields and very few cornfields are apt to be plowed before spring. It is known that stalk shredding, clean plowing (especially if it is done in the fall) and leaving the cobs in the field with a picker-sheller or a combine reduces the survival of corn borers. Just how extensive acreages of spring plowed or even spring picked cornfields will affect survival is not certain. It could possibly result in an increased emergence. It might be well to watch closely for corn borers in 1969.

The following table presents the 1969 recommendations for European corn borer control.

Insecticide	Dosage	Limitations
carbaryl (Sevin)	1-1/2 lb.	
DDT (status uncertain)	1-1/2 lb.	Do not feed forage
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 1/4 lb. granular	14 days 14 days
Bacillus thuringiensis (as labeled)		No limitations

Stalk shredding, clean plowing and early plowing may be especially important in the spring.

Green Cloverworms

Soybeans have, at least in Minnesota, been relatively free of serious insect pests. This year we received our first serious state-wide threat to this crop. The culprit which caused the big stir was the green cloverworm. This insect is by no means new to Minnesota, however, it is the first time in recent years that a large scale outbreak has occurred. This is quite likely due partly to the greatly increased acreage of soybeans raised today.

The green cloverworm is closely related to cutworms but feeds on the upper leaves, primarily of legumes. It has always been present in small numbers in clover, alfalfa and soybean fields. At times small numbers apparently are able to overwinter in the soil under Minnesota conditions but the more usual means of reinfestation seems to be by the flight of adult moths from more southern states. This probably was the source of the 1969 invasion.

Two of the biggest questions on the minds of soybean growers are "what about next year" and will this insect become a perennial pest?" We don't have all the answers but we might do a little speculating. From past experience it is known that the nature of this insect is to fluctuate widely in numbers. It will usually be present in small numbers and occasionally explode into a major outbreak. This seldom lasts for more than one year as the pest is easily brought under control by various natural forces, especially a certain fungus disease. It may well be that this past year's invasion was one of these periodic outbreaks and it may have run its course and not reappear for many years. No doubt the abundance of soybeans allowed this insect to build up to higher levels than before which resulted in a large overflow of excess adults into Minnesota from Iowa and Illinois. Favorable weather conditions and strong south winds at the proper time may also have aided the development and spread of the larvae and the adults. If things continue as they have in the past we probably won't have much of a problem with them next year. They will very likely continue to have periodic outbreaks, possibly more frequently and more serious than in the past.

There are at least two factors which might return the problem next year or change it into a perennial threat. One of these is the huge numbers of adults which were present this fall. Even if most of them are killed over winter there may still be more live ones present next spring than there has been for a long time. Even if there isn't there may still be larger numbers present just below our border in Iowa where their chance of survival is better. The other factor is the huge soybean acreage which might be able to maintain a high population every year despite strong natural factors opposing them. A mild winter with heavy snow cover is likely to increase the danger while a cold open winter may destroy most of the overwintering pupae or adults. It is also possible that the wet soil conditions this fall may prove disasterous to the overwintering population.

Generally we feel that there isn't much danger of an outbreak occurring again next year but we would advise soybean growers to watch closely just in case.

While there was a lot of concern and a lot of spraying in 1968, very little serious damage was done. Most of the pods were nearly filled out when the worms built up to their highest populations. Many of the fields were ready to start turning color within a couple of weeks so spraying was seldom justified. Fears that the worms were cutting off pods were unfounded. There is no evidence that the cloverworms do any such damage. Most of the fallen pods were the result of natural pod droppage or in the case of larger pods, insects such as grasshoppers. In many fields bean leaf beetles apparently were responsible for more leaf damage than the cloverworms.

The main insecticide used in spraying was toxaphene; poor results usually followed. In tests at Lamberton toxaphene used at 1.5 lbs. per acre gave only 65% control. Carbaryl (Sevin) at 1.5 lbs. per acre and malathion at 1 lb. per acre gave good control. If control should be needed in 1969 we would recommend using carbaryl or malathion but not toxaphene. We have not yet received all our data so we are not ready to recommend at what population level it would be economical to initiate chemical controls.