BETTER CROPS
with plant food

Winter 1983-84

The Morrow Plots, University of Illinois at Urbana-Champaign

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Our cover: For more than 100 years, research in soil and crop management has been conducted on the Morrow Plots. Our cover shows a recent view of the site. The photo which accompanies the article on page 12 of this issue shows the scene in the mid-1950's.

Maximum Yield Research – A University Viewpoint

By Dr. Berlie L. Schmidt

MAXIMUM YIELD RESEARCH centers on identifying and developing those production systems that include the best of all controllable factors needed to produce the highest possible yield for a specific soil and climate. It evaluates the interaction among production inputs, and improves systems of production over time as more knowledge is developed, to better fit practices into the system. Maximum yield research forces agronomists and all researchers to join together in this research and to consider the entire production package in a "systems approach", a long overdue concept in crop production research.

For many years, researchers could not exceed corn yields of 150 bu/A or soybean yields of 40 to 50 bu/A. Fertilizer response research was conducted at those levels, and soil test and fertilizer recommendation correlations were developed on the basis of those data.

The theoretical limits on yields (based on available solar radiation) in Ohio range around 580 bu/A for corn and 165 bu/A for soybeans. Maximum research yields are just over half that, and state and U.S. averages are about one-fifth those levels. Thus, we have a long way to go in selection of maximum yield systems.

Ohio maximum yield research follows the systems concept in integrating many factors: variety, plant population, soil fertility, planting date (or growing season length), and water availability (irrigation). Both corn and soybeans were involved initially, and more recently wheat.

We are often asked: Why conduct maximum yield research or production research of any kind, in times of "surplus" crop production? The answer is obvious to the knowledgeable and thinking person: – Economics!

Maximum yield research helps define maximum economic yields, the point at which the last bushel produced equals the cost of its inputs – or the point of highest net profit. This is especially critical for the producer in times of tight profit margins, and helps make the optimum use of our soil resources. It is also obvious that the so-called "surpluses" in crop production can be very temporary, as is being shown by the greatly decreased yields and lower total production of corn and soybeans resulting from the disastrous high temperatures and drought conditions throughout the Corn Belt in 1983. ■

Dr. Schmidt is Chairman, Department of Agronomy, The Ohio State University. This article is condensed from his speech at the national Maximum Yield Research Workshop at Columbus, Ohio, August 1983.

Maximum Yield Research Progress at Ridgetown College in Ontario

By C.K. Stevenson

IN 1983, Maximum Yield Research Trials at Ridgetown College recorded a top corn yield of 249 bu/A (15.6 T/ha) and a top soybean yield of 87 bu/A (5.8 T/ha). This follows 1982 yield marks of 251 bu/A for corn and 69 bu/A for soybeans in the study.

The research plots are located near Chatham, Ontario. The soil is a Clyde loam with high soil test for both phosphorus (P) and potassium (K).

Corn

The 1983 growing season for corn included many stresses, such as late planting due to heavy spring rains, high temperatures later in the season, and drought.

Figure 1 shows the relationship between yield and profit in the maximum yield experiment. The yield and profit data are average values over the 1982 and 1983 growing seasons. The lowest yield (204 bu/A) was recorded by the check treatment: medium fertility (274 lb N/A, 45 lb P_2O_5/A, and 155 lb K_2O/A), high plant population (26,140 ppa), no irrigation.

Moving up the yield curve to 239 bu/A, maximum economic yield occurred for this study. This treatment used very high plant populations (37,250 ppa), high fertility (274 lb N/A, 130 lb P_2O_5/A, and 162 lb K_2O/A) under non-irrigated conditions. At this point profits were maximized in response to the best utilization of inputs and management.

The maximum yield averaged over two years was 249 bu/A. This was produced with very high plant populations (37,250 ppa), high fertility, and irrigation. As yields were increased to a maximum, profits decreased below maximum economic yield levels. However, profits were still maintained at a level above those produced by the check treatment.

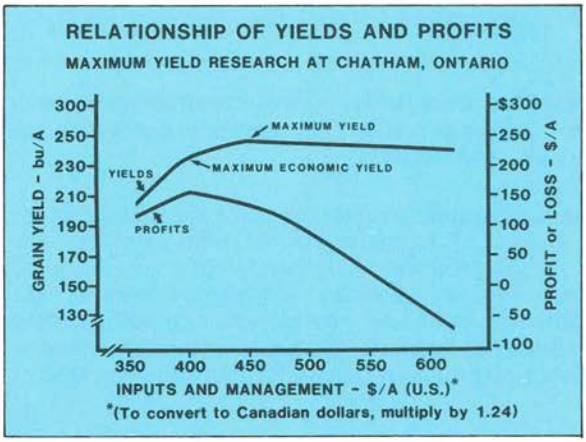

Figure 1

When combinations of very high plant populations, very high fertility (524 lb N/A, 258 lb P_2O_5/A, and 316 lb K_2O/A) and irrigation were used, yields decreased below the maximum. However, profits decreased dramatically due to unfavorable yield responses using these particular combinations of inputs and management.

Mr. Stevenson is a researcher with Ridgetown College of Agricultural Technology in Ontario, Canada.

The relationship between corn yields, inputs, management and profits shows that 89% of the cost to produce maximum economic yields is tied up in producing the lowest yield (check treatment).

The additional 11% increase in inputs and management to produce maximum economic yields increased profits by 48%.

The maximum yield was 4% greater than the maximum economic yield but inputs and management were 9% greater, so profits decreased.

Tables 1 and 2 show the difference between treatments during a good growing season (1982) and a stress year (1983) for corn grain and corn silage, respectively. Although irrigation showed no significant differences for corn grain yields, it gave significant increases in silage yields.

Soybeans

The top 1983 soybean yield of 87 bu/A was produced by Jacques 103 variety in 7 inch rows with a population of 175,000 plants per acre. The soil tested high in P and K; 25 lb of N/A was applied. ■

Table 1. Comparison of treatments in maximum yield corn research.

Years	Treatment	1	2	3	4
	Fertility*	Medium	High	High	Very High
	Plant Population**	High	Very High	Very High	Very High
	Irrigation	No	No	Yes	Yes
		-----Grain Yield-bu/A (15.5% moisture)-----			
1982 (good year)		210	243	249	251
1983 (stress year)		198	235	249	222
	Difference (bu/A)	12	8	0	29

* Average fertility application for 1982 and 1983 (lb/A).
Medium — 274 N, 45 P_2O_5, 155 K_2O
High — 274 N, 130 P_2O_5, 162 K_2O
Very High — 524 N, 258 P_2O_5, 316 K_2O, 95 Mg, 168 S, 13 Zn, 61 Mn, 6 Cu, 1 B

**Plant Population average for 1982 and 1983
High — 26,140 ppa
Very high — 37,250 ppa

Table 2. Comparison of treatments in maximum yield corn research.

Years	Treatment	1	2	3	4
	Fertility*	Medium	High	High	Very High
	Plant Populations**	High	Very High	Very High	Very High
	Irrigation	No	No	Yes	Yes
		-----Silage Yields — Tons/A (Dry Matter)-----			
1982 (good year)		10.1	11.3	12.1	11.3
1983 (stress year)		10.5	11.7	13.0	12.2
	Difference	0.4	0.4	0.9	0.9

* Same as previous table

**Same as previous table

Editors note: Mr. Stevenson's two-year average yield of 241 bu/A for non-irrigated corn is believed to be the highest two-year average in North American research. The 1983 soybean yield of 87 bu/A is the highest known ever produced in Canadian research.

1983 Soybean Research

Yields Top 118 bu/A

CONTINUING a succession of research yield breakthroughs, Dr. Roy L. Flannery of New Jersey achieved 118.4 bu/A in irrigated soybean plots in 1983.

Perhaps even more important, Dr. Flannery's 4-year average soybean yield now stands at 103.5 bu/A in his top maximum yield research treatment. This includes soybean yields of 94 bu/A in 1980, 93 bu/A in 1981, and 109 bu/A in 1982.

The top 1983 yield was obtained with Asgrow A3127 variety which had received 175 lb/A of nitrogen (N), 225 lb/A of P_2O_5, and 300 lb/A of K_2O. These nutrients were applied as shown:

Amount N	P_2O_5	K_2O	Application Method
	lb/A		
25	75	150	Broadcast and disced in preplant
50	50	50	Fertigation, early bloom, June 6th
50	50	50	Fertigation, early pod fill, June 25th
50	50	50	Fertigation, pods half-filled, Aug. 17th

Two varieties, two plant populations, and two fertility levels were compared with and without irrigation. Soybeans were planted in 6-inch rows with precise distance between plants in the row to obtain the desired plant populations for the two varieties. The results are summarized in the following tables.

Table 1. Influence of fertilization, irrigation, and plant populations on soybean yields (Sprite Variety). New Jersey, 1983.

Nutrients Applied			Yield, bu/A, Sprite Variety[1]			
N	P_2O_5	K_2O	Nonirrigated		Irrigated	
lb/A			174,240 ppa	161,360 ppa	261,360 ppa	348,480 ppa
50	75	100[2]	58.8	65.6	-----	-----
50	75	100[3]	54.4	63.6	-----	-----
100	150	200[2]	56.8	66.7	-----	-----
100	150	200[3]	55.2	65.4	-----	-----
125	150	200[2]	----	----	92.7	96.1
125	150	200[3]	----	----	103.6	107.5
175	225	300[2]	----	----	104.8	108.7
175	225	300[3]	----	----	107.4	110.3

[1]Yields standardized to 13% moisture. Values reported are averages for 4 replications.

[2]No micronutrients applied.

[3]Micronutrients applied, lb/A: B, 1; Cu, 5; Mn, 25; and Zn, 5.

Table 2. Influence of fertilization, irrigation, and plant populations on soybean yields (Asgrow A3127 Variety). New Jersey, 1983.

Nutrients Applied			Yield, bu/A, Asgrow A3127 Variety[1/]			
N	P_2O_5	K_2O	Nonirrigated		Irrigated	
------------- lb/A -------------			130,680 ppa	174,240 ppa	174,240 ppa	261,360 ppa
50	75	100[2/]	71.3	58.9	-----	-----
50	75	100[3/]	76.2	60.1	-----	-----
100	150	200[2/]	62.2	56.6	-----	-----
100	150	200[3/]	74.3	60.8	-----	-----
125	150	200[2/]	----	----	105.8	109.7
125	150	200[3/]	----	----	110.2	113.8
175	225	300[2/]	----	----	108.9	113.1
175	225	300[3/]	----	----	114.8	118.4

[1/]Yields standardized to 13% moisture. Values reported are averages for 4 replications.

[2/]No micronutrients applied.

[3/]Micronutrients applied, lb/A: B, 1; Cu, 5; Mn, 25; and Zn, 5.

PPI and FAR Announce New Members of Boards

SIX NEW MEMBERS were appointed to the Board of Directors of the Potash & Phosphate Institute (PPI), and two were elected to the Board of Directors of the Foundation for Agronomic Research (FAR).

"We are pleased to welcome these leaders and appreciate their willingness to serve as Directors on the respective Boards," said Dr. R.E. Wagner, President of PPI and FAR. "They become part of a dedicated and sincere group, with a unique blend of high ideals."

The six joining the PPI Board of Directors are: **Mr. M.G. Boulanger,** Executive Vice President, Estech, Inc., Fairview Heights, Illinois; **Mr. R.H. Holzkaemper,** President, PCS Sales, Saskatoon, Saskatchewan; **Mr. P.S. Jack,** President, Potash Company of America, Denver, Colorado; **Mr. R.A. Pickren,** President, Freeport Chemical Company, Uncle Sam, Louisiana; **Mr. H.J. Ripperger,** Vice-President/Sales, Potash Company of America, New York, New York; and **Mr. J.A. Shirley,** Executive Vice President, Royster Company, Norfolk, Virginia.

Those joining the FAR Board of Directors are: **Mr. Dallas Cantwell,** President, Chemical Enterprises, Inc., Houston, Texas; and **Dr. Roger Mitchell,** Dean, College of Agriculture, University of Missouri.

Dr. Gino P. Giusti, President and Chief Executive Officer of Texasgulf, Inc., serves as Chairman of the Board of Directors for PPI and FAR. Mr. Douglas J. Bourne, Chairman and Chief Executive Officer of Duval Corporation, serves as Vice Chairman of the two Boards. ■

In Virginia

Triple-Digit Wheat Yields

By M.M. Alley and D.E. Brann

WHEAT IS BECOMING increasingly important in the humid region of the United States with up to 9 million acres being planted in the Southeast and eastern Corn Belt states. Average wheat yields in this region have remained rather static for the last twenty years ranging from 35 to 45 bu/A.

Recently released improved varieties appear to offer significant yield advantages, but management research to exploit increased yield potential has been lacking. A combined wheat research effort by university and industrial agronomists, plant pathologists, and entomologists was initiated in Virginia in 1981. Objectives of the research were to identify yield potentials, evaluate row widths and seeding rates, study nitrogen fertilization, and determine if a growth regulator to control lodging would assist high-yield wheat production.

Experiments were located in the Coastal Plain region on Suffolk and State sandy loam soils (Typic Hapuldults) in 1981-1982 and 1982-1983, respectively. Plots were planted approximately one week prior to the average first frost date in 4 inch-wide rows with seeding rates of 24 (1981) and 18 (1982) seeds per foot of row. Other production practices included 125 lb P_2O_5/A, 250 lb K_2O/A, and micronutrients broadcast and disk-in. Also, 175 lb N/A was divided into a preplant incorporated (20 lb N/A) application and three spring applications. Nitrogen rates were less for the N management and growth regulator studies. Diseases, insects, and weeds were controlled as needed based on frequent scouting. Only the maximum yield experiments were irrigated. Irrigation was applied according to soil tensiometer readings and was begun after stem elongation.

Maximum Yield Experiments

Yields in excess of 100 bu/A have been produced with 5 currently available wheat varieties during the 2 years these experiments have been conducted **(Table 1).** The 'Saluda' and 'Coker 916' varieties produced top yields of 128 and 129 bu/A in 1983. Irrigation did not increase yields during either season, even though non-irrigated plants showed visible drought-stress symptoms for several days in 1982.

Yields **(Table 1)** tended to decrease with irrigation in 1983 due to earlier lodging. Production of high wheat yields without the need for irrigation means that intensive management can be adopted more extensively than if irrigation were a requirement. Also, properly managed wheat may become especially attractive on droughty soils.

Dr. Alley and Dr. Brann are with Virginia Polytechnic Institute and State University at Blacksburg, VA.

Table 1. Grain yields of selected wheat varieties as influenced by irrigation in 1982 and 1983.

Year	Variety	Irrigated	Non-irrigated	Variety means
1982	Tyler	118†	108	113
	McNair 1003	114	111	112
	Pioneer Brand S-76	105	97	101
	Treatment means	112	105	
1983	Tyler	112	118	115
	Coker 916	129	128	128
	Pioneer Brand 2550	115	120	118
	Saluda	123	128	126
	Treatment means	120	124	

† Yields are the average of four replications and are adjusted to 13.5% moisture.

Row Widths and Seeding Rates

Four-inch wide rows have consistently produced 10 to 12% higher yields than 8-inch wide rows with the same number of seed planted per unit area **(Table 2).** The yield advantage of narrow rows occurred with all seeding rates and with both early and late planting dates in other 1983 experiments (data not shown).

Seeding rates are expressed as seeds planted per foot of row because there are large variations in seed size. Our observations have shown as much as 60% variation in numbers of seed per pound, depending on variety and season, with 20% differences being common. Seeding rates ranging from 6 seeds/ft. of row (60 lb seed/acre in 1982 and 66 lb seed/acre in 1983) to 24 seeds/ft. of row did not affect yields in either season. Yields decreased and lodging increased when 36 seeds/ft. of row were planted in 4-inch wide rows in 1982.

Table 2. Grain yield of 'Tyler' wheat as a function of row width and seeding rate.

Row Width	Seeding Rate		Yields 1982	Yields 1983
inches	Seeds/ft. of row	$Seeds/ft^2$	bu/A	bu/A
4	6	18	106	117
4	12	36	108	117
4	18	54	101	120
4	24	72	104	117
4	36	108	95	113
8	12	18	94	108
8	24	36	97	105
8	36	54	91	104

Planting later than one week before average frost date may require higher seeding rates, particularly during cold winters. The influence of planting date on seeding rate and row width responses is currently being evaluated in several experiments.

Nitrogen Fertilization

Studies were initiated to evaluate split spring N application in contrast to standard recommendations that call for a single N topdressing as soon after February 1 as possible. Treatments included spring N applications totaling 80 or 120 lb N/A applied as a single February application (Zadoks[1] growth stage 23-27) or split at Zadoks stages 23-27, 45, and 58-59. Yields in 1982 and 1983 did not differ with increasing spring N from 80 to 120 lb/A applied as a single application during tillering (Zadoks 23-27). However, yields were increased 8 to 10% when the 120 lb N/acre was split into two applications. The initial application was in February (Zadoks 23-27) and the later application was at late boot (Zadoks 45). Splitting spring N also increased test weight and reduced lodging. More experiments are being conducted to evaluate spring N application timing and the effects of residual soil N on fertilizer management.

Lodging Control

Lodging may limit yields of many currently available wheat varieties when high

[1]Zadoks, J.C., T.T. Chang, and C.F. Konzak. 1974. A decimal code for growth stages of cereals. Weed Research 14:415-421. The chart following this article gives a brief comparison of the Zadoks and Feekes scales. For more detailed information, contact the Potash & Phosphate Institute.

N fertilizer rates are utilized to increase yields. Experiments were conducted with 'Tyler' and 'McNair 1003' wheat in 1981-1982 and with 'Tyler' and 'Coker 916' in 1982-1983 to evaluate the use of Cerone™(ethephon) for control of lodging. Cerone™ is an antilodging growth regulator produced by Union Carbide and currently has an experimental use permit in the United States. During the tillering period, 120 lb of N/A was applied (Zadoks 23-27) to promote vegetative growth. Cerone was applied during the boot stage (Zadoks 41-44) and essentially eliminated lodging in both seasons at rates of either 0.25 lb or 0.50 lb active ingredient (a.i.) per acre. Lodging in these trials occurred near maturity and therefore did not affect yields. Cerone application did not affect yields of 'Tyler' or 'McNair 1003' in 1982, nor 'Coker 916' in 1983; however, 'Tyler' yields were reduced in 1983 with the 0.5 lb a.i./acre treatment. Kernels per head were reduced by this application, but no environmental conditions associated with 1983 treatments can explain why a yield reduction was observed in 1983 but not in 1982. All yields were near to or greater than 100 bu/A.

Severe lodging can dramatically reduce yields in many instances and slows harvest in all cases. The probability of lodging increases with increasing N applications, and thus the use of an antilodging growth regulator should be considered with currently available varieties and intensive management.

Pest Control

Intensively-managed wheat must be scouted for diseases, insects, and weeds, and appropriate action taken when necessary. Dr. David Babineau, plant pathologist at Virginia Tech, has recorded yield responses to fungicides as yields of untreated plots near 100 bu/A, and/or when high levels of disease infection occur on the upper leaves in the spring. Dr. Robert McPherson, entomologist with Virginia Tech, has developed threshold values for insecticide use in wheat. He has observed up to a 15% yield increase by early spring insecticide application when aphid populations reached 17 per foot of row. Pest control needs and actions as shown by timely scouting are an essential component of maximum yield production.

Summary

Wheat yields in excess of 100 bu/A were obtained in five 1982 Virginia Tech experiments and in nine 1983 experiments. Triple-digit wheat yields are possible in Virginia with intensive management. Rapidly moving management research, improved varieties, and more precise equipment for planting, fertilizing, and spraying will enable Southeastern U.S. growers to harvest 100 bu/A wheat in the near future. ■

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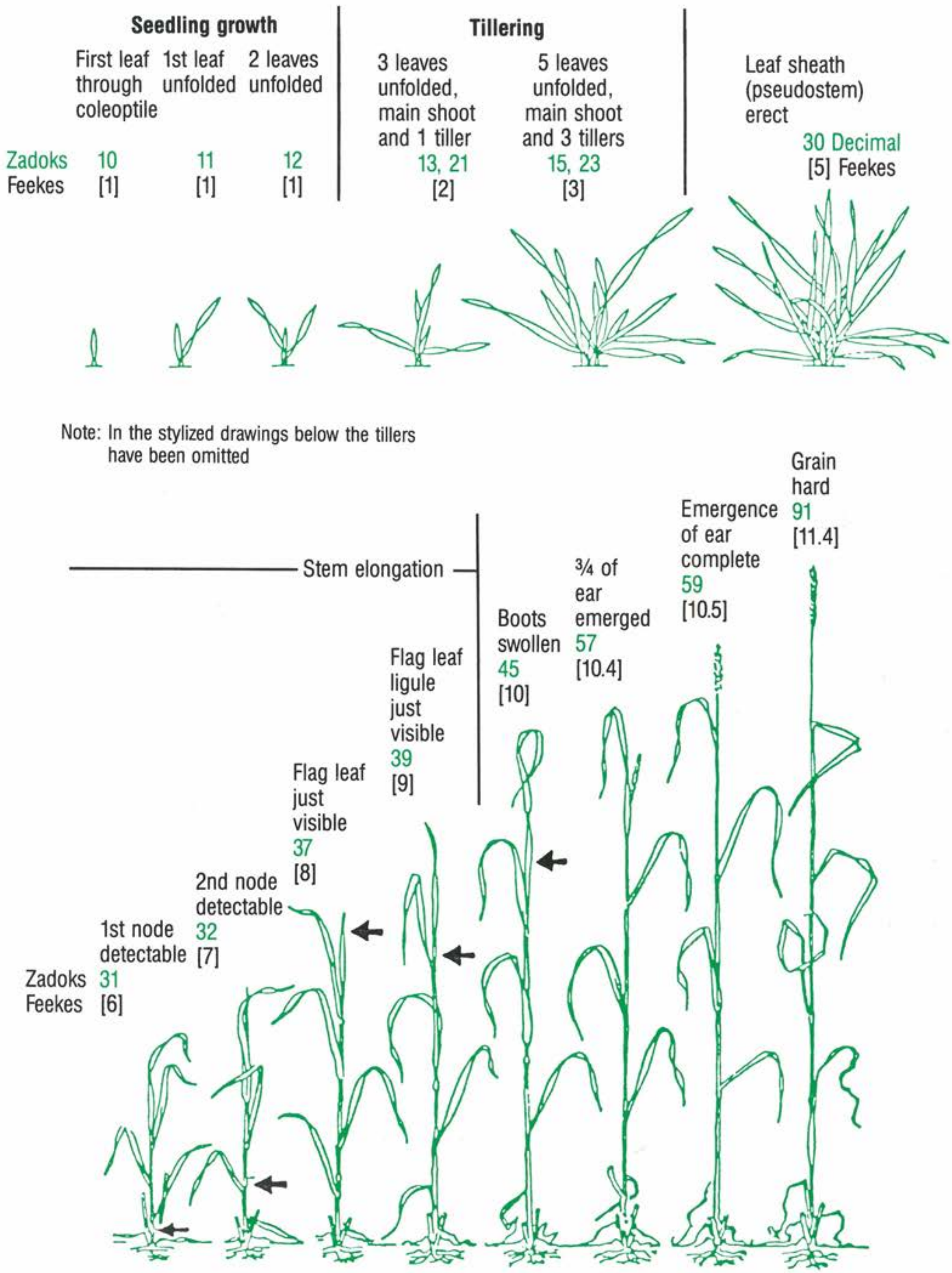
Note: The illustration on page 11 shows a comparison of scales for growth stages in cereal crops.

Growth Stages in Cereals
(Zadoks and Feekes Comparison)



The Morrow Plots — America's Oldest Experimental Field

By M.G. Oldham and R.T. Odell

THE MORROW PLOTS, located on the University of Illinois campus, are the oldest agronomic research plots in the United States and contain the oldest continuous corn plot in the world. Their historical importance was recognized in 1968 when they were designated a National Historical Landmark by the United States Department of Interior.

The Morrow Plots were laid out in 1876 by Professor Manley Miles with assistance from Professor George F. Morrow. The plots, as they were laid out, consisted of ten 1/2-acre plots and were used to study the effect of crop rotation on yield. Of the original ten plots, only parts of three remain today. In 1895 the observatory was built on plots 1 and 2, and in 1903 plots 6 through 10 were seeded to lawn grasses and are now occupied by Mumford Hall and other buildings on the agriculture campus. Prior to the 1904 growing season, the remaining three plots were reduced to their present size of 1/5-acre each and permanent borders were established. Also in 1904 the South half of each plot started receiving an application of manure, limestone and either rock or bone phosphate. The plots were further subdivided in 1955 and 1967 to study the effect of limestone, inorganic nitrogen, super phosphate and potassium. The rotation of the corn and oats that had been followed on plot 4 was also changed in 1967 to corn and soybeans. The subdivision of the plots over

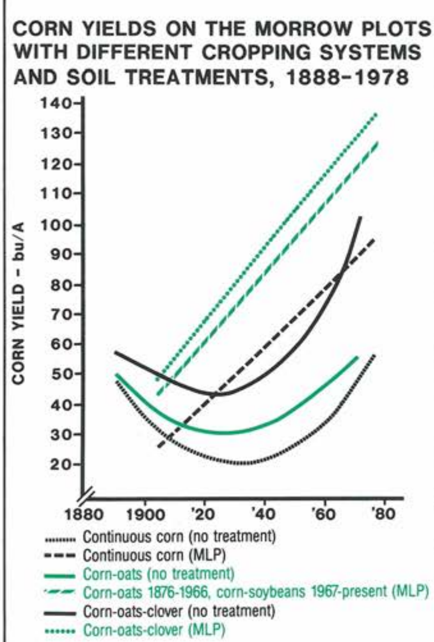


Figure 2

M.G. Oldham is an Agronomist and Dr. R.T. Odell is a Professor Emeritus, University of Illinois.

Figure 1. Layout of the Morrow Plots

Plot 3 Continuous Corn 1876-Pres.	3NA No Treatment	3NB LNPK since 1955	3NC No Treatment	3ND No Treatment
	3SA High LNPK since 1967 MLP 1904-1924	3SB LNPK since 1955 MLP 1904-1924	3SC MLP ML	3SD 1904 — 1924 1925 — Present
Plot 4 Corn-Oats 1876-1966 Corn-Soybeans 1967-Pres.	4NA No Treatment	4NB LNPK since 1955	4NC No Treatment	4ND
	4SA MLP 1904-1924 High LNPK Since 1967	4SB MLP 1904-1924 LNPK since 1955	4SC MLP ML	4SD 1904 — 1924 1925 — Present
Plot 5 Corn-Oats-Clover 1876-Pres.	5NA No Treatment	5NB LNPK since 1955	5NC No Treatment	5ND
	5SA MLP 1904-1924 High LNPK since 1967	5SB MLP 1904-1924 LNPK since 1955	5SC MLP ML	5SD 1904 — 1924 1925 — Present

MLP — Manure, Limestone & Rock or Bone Phosphate
LNPK — pH 6.0-7.0, 200 lb N/A on corn; P_1, 40-60; K, 300-400
High LNPK — pH 6.0-7.0, 300 lb N/A on corn; P_1, greater than 100; K, greater than 400

the years has allowed researchers to gain additional information from the plots, but a section of the original plot as established in 1876 has been retained.

The present plot layout along with the crop rotations and fertilizer treatments are shown in **Figure 1.**

Several observations are apparent from the long time yields of the Morrow Plots. For the period between 1888 and 1980, corn yields from the continuous corn plot were consistently lower and the corn-oats-clover plots' yields were higher, whether the soil received the manure, limestone, and phosphate application or was untreated **(Figure 2)**. On the untreated portion of the plots, corn yields declined from 1888 to the mid-1930's due to the graduate removal of plant nutrients by the growing crops. Since the mid-1930's most of the yield increases that have occurred on the untreated plots could be attributed to the use of hybrid corn that was started in 1937. **(continued on page 14)**

The application of the LNPK treatment on the respective sections of each plot, started in 1955, has had a dramatic impact on corn yields **(Figure 3)**. The continuous corn plot yields are also consistently below the yields of the other two plots.

The addition of the LNPK treatment resulted in average yield increases of approximately 70 bu/A of corn over the untreated check in each of the three rotations **(Table 1)**. The addition of the higher rates of LNPK that were started in 1967 has shown little if any yield advantage over the LNPK treatments that were established in 1955 and are considered adequate.

In 1982 the all-time record high yield was produced on the Morrow Plots. The sub-plot that has received the LNPK treatment since 1955 in the corn-oats-clover rotation produced 215.2 bu/A of corn. A LNPK sub-plot in the continuous corn rotation yielded 200.1 bu/A. This occurred in the 107th year of continuous corn for that plot.

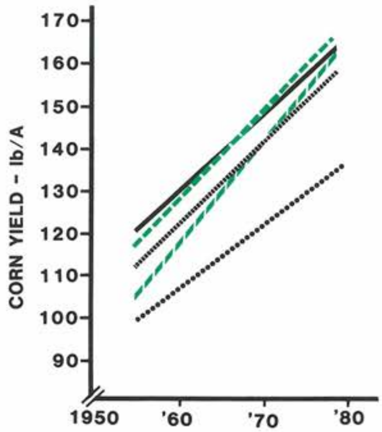


Figure 3

Table 1. Average Corn Yields from 1957 to Present.

Soil Treatment	Continuous Corn	Crop Rotation Corn-Oats 1876-1967 Corn-Soybeans 1967-Pres.	Corn-Oats-Clover
No Treatment	46.8 bu/A	62.5 bu/A	82.6 bu/A
LNPK Since 1955 Untreated Before	117.1	135.4	150.2
MLP 1904-1924 LNPK 1967-Pres.	130.5	146.6	152.6
MLP 1904-1924 High LNPK 1967-Pres.	130.2	152.7	153.6

In addition to crop yields many other measurements have been made on the soil and the crops grown on the Morrow Plots. These observations include changes in percent organic matter, percent nitrogen in the grain, soil test changes, organic carbon and nitrogen, and other physical properties. **Much of this work along with individual plot yields for all crops are summarized in Bulletin number 775 which is available from the College of Agriculture, University of Illinois.** ■

Win Some, Lose Some?

By Dr. L. Fred Welch

I RECENTLY HEARD a speaker discuss the importance of adequate fertility for high crop yields. When asked about a bad crop year when a lower fertility level may have been the more profitable rate that particular year, the speaker replied "Win Some, Lose Some." The preceding expression is appropriate to cite for certain matters. It may be misleading when used to refer to annual crop response (profit) to fertilizer, if the hearer assumes that one loss cancels one win.

If you are trying to determine the conference football champions, the won-loss record is the accepted judgment criteria. Unless trying to resolve a tie between two teams with the same won-loss records, a win counts as a win and a loss counts as a loss whether by 1 point or 50 points.

In many aspects of life, the degree of the win or loss is also important. It is possible to have fewer wins than losses but still gain if one "wins big" when they win and "loses little" when they lose.

What does one lose when immobile nutrients like phosphorus and potassium are added to the soil, but the value of the crop yield increase for that year is less than the cost of fertilizer? Is the investment lost, or is the potential profitable return on fertilizer merely delayed? Whether there are multiple opportunities or only a single chance for an investment to be profitable would surely influence one's decision as to whether or not to make the initial investment.

Growers already think in terms of long- and short-term investments. Combines are not expected to pay for themselves during the first harvest. Neither is land, nor equipment storage. Seed corn and some other costs truly have only one season to show a profit, but not immobile nutrients.

Growers have generally not been conditioned to think of fertilizer as a long-term or capital investment. Indeed, not all fertilizer should be thought of as a long-term investment. If the rate of fertilizer is only equal to or less than that removed in the harvested portion of the immediate crop, the fertilizer should be considered a short-term investment and the cost assigned to the one crop. But, the situation is different when the rate of fertilizer is greater than the amount removed in the immediate crop. If this residual fertilizer has potential for increasing yields of future crops, then some of the initial investment should be assigned to future years.

There may be different reasons why added fertilizer exceeds that removed in harvested crops. There may be a large rate of added fertilizer to intentionally build up the fertility level of the soil. The fertilizer rate may be modest but yields so low that there is still some carryover of fertilizer. The low yields and profits may be due to dry weather or various other reasons besides limiting levels of nutrients.

Crop response to soil fertility level follows a diminishing returns curve. If one is overly cautious about "winning them all" from the standpoint of a profitable return each year from the last increment of fertilizer, then that grower is likely to still be on the steep part of the response curve. Such a position may prevent the grower from "winning big" during good years. "Failure to gain" when growth conditions are favorable for high profits may actually be worse than "winning big" in good years and "losing little" in bad years. The cost of "playing it safe" may be more costly than "losing an occasional one." ■

Dr. Welch is Soil Fertility Specialist, University of Illinois at Urbana-Champaign.

Phosphorus ... The Forgotten Nutrient When Applying Nitrogen on Grass

By Duaine L. Dodds

FERTILIZATION of tame grass hay and pastureland can more than double forage yields in North Dakota. Fertilizing grass has been tried on many North Dakota farms and ranches but with limited success. Field demonstration and yield checks conducted by North Dakota State University specialists and County Extension Agents since 1970 show that the level of phosphorus (P) in the soil significantly influences grass response to nitrogen (N) fertilizer. See **Figure 1**.

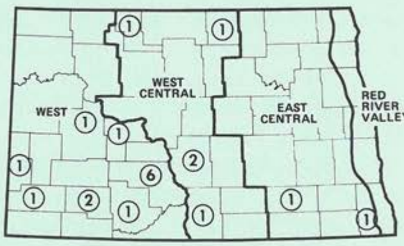


Figure 1. Number and location of tame grass fertilization demonstrations in North Dakota. Geographic areas differ in grass fertilization recommendations.

A summary of yield data from 20 grass fertilizer demonstrations is shown in **Table 1**. These data are an average of 39 test years at 11 locations on low phosphorus testing soils and 31 test years at 9 locations on medium to very high phosphorus testing soils.

Data from low P testing soils show that the forage yield from the applications of 60 lb/A N (60 N) was about equal to the yield obtained from the application of 30 lb/A N plus P (30 N + 20 P_2O_5): 3,492 lb/A vs 3,327 lb/A of 15% moisture forage, respectively. The application of P with 60 lb of N (60 N + 20 P_2O_5) increased the forage yield 964 lb/A more than the 60 N treatment without phosphorus. In comparison, statewide average yield data for the 60 N and 60 N + P_2O_5 treatments on medium to very high phosphorus testing soils were nearly equal or were marginal in relation to the cost of phosphorus.

The application of phosphorus on low P testing soils in combination with N (30, 60 and 90 N) increased forage dry matter

Table 1. Nitrogen and phosphorus increased grass yields in North Dakota studies.

Treatments lb/A	Forage yield — lb/A (15% Moisture): Low Soil P	Forage yield — lb/A (15% Moisture): Med. to Very High Soil P
Check	1,862	2,687
P_2O_5[1]	2,291	2,867
30 N + P_2O_5	3,327	4,075
60 N	3,492	4,796
60 N + P_2O_5	4,456	4,965
90 N + P_2O_5	4,738	5,551

[1] 20 lb P_2O_5 recommended on low P testing soils.

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yield for each additional increment of N applied, but at a decreasing rate of forage production: 1,465, 1,129 and 282 lb, respectively.

The 60 N treatment on low P soils produced about 27 lb of forage per pound of N applied compared to 43 lb for the 60 N plus P_2O_5 treatment. The 60 N treatment on medium to very high testing soils produced about 35 lb of forage per pound of N.

Low available soil P supply is a major cause of disappointing yields on N fertilized grass. Demonstration plot yield data from various geographic areas and average statewide yield responses to grass fertilization show similar response trends. Data from low P testing soils in three geographic areas **(Table 2)** emphasize the need to consider the soil P level when fertilizing grass.

The first 30 lb increment of N increased forage yields more than the 2nd and 3rd increments when soil P was adequate. However, in West Central and East Central North Dakota, the second 30 lb increment of N increased yields nearly as much as the first. For western North Dakota, 30 lb of N annually plus P when required by soil test, provides good forage yield increases. In West Central and East Central areas, 60 lb of N annually plus P when required, provides substantial increases in forage yield under normal or better weather conditions.

Table 2. Tame grass hay yield increases to N and P were similar in most geographic areas of North Dakota.

Treatments	Forage Yield — lb/A (15% Moisture)		
lb/A	West	West Central	East Central
Check	2,119	1,878	1,588
P_2O_5[1]	2,822	1,743	2,307
30 N + P_2O_5	3,756	2,705	3,521
60 N	3,464	2,775	4,234
60 N + P_2O_5	4,301	3,699	5,370
90 N + P_2O_5	4,838	4,288	5,094

[1]20 lb P_2O_5 recommended on low phosphorus testing soils.

Economics

Cost return analyses of forage yield indicate higher potential profit from applying N and P. Yield data indicate little, if any, increased forage yield from phosphorus applied alone. Both nutrients must be applied to obtain full benefit of the investment. With nitrogen valued at 22 cents/lb and P_2O_5 at 23 cents/lb, the break-even yield increases (with hay valued at \$40, \$45 and \$50/ton) ranged from 324 to 965 lb/A. A charge of \$1.50/A was included for fertilizer application costs. Yield data indicate that yield increases from N and P were far in excess of the break-even levels.

On the average, fertilization returned \$3 for every \$1 invested in fertilizer. More attention to adequate nutrition for forage crops can result in improved returns to farmers and ranchers. ■

Table 3. Break-even hay yield increases from N and P.

Hay Price and Fertilizer Rates	Hay Yield (15% Moisture)
\$40/ton	
30 lb/A N	405
60 lb/A N	735
30 lb/A N + 20 lb/A P_2O_5	635
60 lb/A N + 20 lb/A P_2O_5	965
\$45/ton	
30 lb/A N	360
60 lb/A N	653
30 lb/A N + 20 lb/A P_2O_5	564
60 lb/A N + 20 lb/A P_2O_5	858
\$50/ton	
30 lb/A N	324
60 lb/A N	588
30 lb/A N + 20 lb/A P_2O_5	508
60 lb/A N + 20 lb/A P_2O_5	772

Bermudagrass Hay Depletes Soil Potassium

By C.H. Burmester and Fred Adams

IN 1980, a field that had been in Coastal bermudagrass hay for 13 years was returned to row cropping on the Tennessee Valley Substation, a part of the Alabama Agricultural Experiment Station. This offered a unique opportunity to study the potassium (K) fertilizer requirements of a row crop following long-term hay removal, a practice that sometimes results in unexpected K deficiencies in the row crop.

While in bermudagrass, the field had been fertilized according to soil test each year. After being turned, the Emory silt loam soil was found by the Mehlich 1 extraction method to be "Medium" in both K and phosphorus (P). On this soil series some crops, such as corn, do not always show a yield response to P or K fertilizer when the soil tests "Medium." Nevertheless, P fertilizer was applied to the area to increase soil test P to a "High" level. Wheat and corn were then grown in rotation on the area, using varying rates and times of application of K fertilizer. Initial soil tests were: pH, 6.4; P, 22 lb/A (Med. 90); and K 88 lb/A (Med. 70).

The K fertilizer requirements of successive corn crops were studied for 2 years (1981 and 1982) in a four-replication experiment. Each year, wheat was planted for winter grazing; it was followed by no-till corn planted into wheat stubble in late March or early April. Potassium treatments for the 1981 corn crop were applied either to wheat in the fall (1980) or to corn at planting (1981). In 1982, K was applied only to corn, either at planting or as a sidedressing.

Wheat showed no K-deficiency symptoms, and wheat yields were unaffected by K fertilizer rates. However, symptoms of K deficiency were very striking on corn. In both 1981 and 1982, K-deficiency symptoms appeared on corn plants, where no K fertilizer was added, about 2 weeks after they emerged. Corn growth slowed markedly, the leaves were a light-green color, and leaf margins became necrotic. The development of these severe K-deficiency symptoms at such an early age was quite surprising.

Since soil-test K of the surface soil did not predict the severe K deficiency, deeper soil samples (12 to 24 in.) were taken. They revealed that the normally "High"-K subsoil was actually "Low" in available K. Apparently, the deep-rooted bermudagrass plants removed large amounts of K from the subsoil during hay production, and it was not replaced by normal fertilizer rates during that period.

In 1981 and 1982, an application of 40 lb/A of K_20 fertilizer did not completely correct K deficiency, but an 80 lb rate did (see **Table 1**). This is double the recom-

Table 1. Effect of potash (K_2O) fertilizer rates on corn yields following 13 years of Coastal bermudagrass hay production.

K_2O Rate	Time of Application	Corn Yield
lb/A	1981	bu/A
0	----	68
40	To wheat in fall	83
80	To wheat in fall	96
80	To corn at planting	100
160	To corn at planting	102
	1982	
0	----	34
40	To corn at planting	102
80	To corn at planting	120
80	To corn at sidedressing	47
160	To corn at planting	119

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mended K_20 rate of 40 lb/A for corn on this soil series when the soil-test K is "Medium" in the surface soil. In 1981, fall and spring applications of potash were equally effective in preventing deficiencies and in producing high yields. In 1982, however, 90 lb/A of sidedressed K_20, applied soon after deficiency symptoms appeared, did not correct the deficiency. This result was unexpected, and the reason for almost no response to sidedressed fertilizer is not known. It can be speculated, however, that the fertilizer was not moved downward into the root zone soon enough to be effective, possibly because the middles had become compacted by grazing cattle during the fall and winter.

Potassium fertilizer requirements of crops following extended hay production is a special situation and requires special attention. This experiment showed the importance of subsoil K in the corn plant's nutrition and demonstrates how long-term hay removal can deplete subsoil K to the detriment of succeeding crops.

Because hay crops remove large quantities of K, often from subsoil horizons, certain crops that follow the hay crop can be expected to require higher-than-normal K fertilizer rates. ■

Alfalfa Yield of 24 tons/A in Arizona Research

RESEARCHERS at the University of Arizona Yuma Mesa Experiment Station recorded alfalfa yields of over 24 and 21 tons per acre with two varieties in a 1981-82 experiment. Results of the study were reported at the recent California Alfalfa Symposium.

A yield of 24.1 tons/A was recorded with Mesa-Sirsa variety. This is the total of 10 cuttings, based on 12% moisture content. Lew variety yielded 21.5 tons/A with the same management.

The experiment was designed to evaluate water and nitrogen (N) conservation using sprinkler irrigation on the sandy soils of the Yuma Mesa. The top yields of the two varieties were both achieved with 151 inches of water and 508 lb/A of N.

The two cultivars were seeded at a rate of 20 lb/A in March 1981. Treble super phosphate was broadcast prior to planting the alfalfa at a rate of 458 lb of P_2O_5/A.

Data for the study show an increase in yield with each increment of water. At the highest rates of irrigation there is an increase in yield with increased N for the Mesa-Sirsa variety. **Table 1** shows a summary of the yields.

Table 1. Alfalfa Yields; Lew and Mesa-Sirsa Varieties (Arizona, 1981-82).

Inches	Nitrogen	Total Yield-Tons/A	
Water	lb/A	Mesa-Sirsa	Lew
56	346	6.7	5.7
73	183	5.0	4.9
73	508	7.7	7.4
112	114	14.2	15.1
112	346	16.8	15.9
112	578	18.0	17.6
151	183	19.4	18.1
151	508	24.1	21.5
168	346	18.3	19.4

Soil pH = 7.9; available P test = medium. Each acre-foot of irrigation water contained 278 lb calcium, 16 lb K, 76 lb magnesium, and 266 lb sulfate sulfur (SO_4-S).

Chinese Research Shows Soybeans Respond to Potassium on Deficient Soils

By Guo Quing-Yuan

SOYBEANS are produced on more than 17 million acres (100 million mus*) in China. Because of intensive farming, removal of residue, and insufficient fertilizer application, more potassium (K) is removed from the soil than is returned. Potassium deficiency is an important factor limiting soybean yields, especially in the Yangtze Valley and regions south of the valley. Average yield for soybeans is about 22.4 bu/A (200 jin/mu*) in the area.

Recently, field experiments and pot culture tests have shown that K gave a yield response of 18%. In K deficient soils, deficiency symptoms appear closely correlated with the level of available potassium in the soil. Potassium application increases the accumulation of dry matter, as well as nitrogen (N), phosphorus (P) and K content of the crop. Symbiotic N fixation and oil content are also increased. Research results indicate that the satisfactory range in a soybean plant is 1.7 to 4.0% K during the seedling stage. Satisfactory range of functional leaves is 1.2 to 3.1% during the blooming stage.

Research Methods

Most of the field experiments reported here were conducted on Maganni paddy soil in a region with a climate transitional from warm temperate to subtropical. The fields were cropped for three harvests per year. Available K content of the soil was low — 70 to 120 ppm K or less.

Two different plans were used for field experiments. One plan consisted of 5 different treatments: K, P, NP, NPK, and unfertilized check. Rates were N = 65 lb/A (10 jin/mu); K_2O = 65 lb/A; P_2O_5 = 33 lb/A.

Another plan used these levels of nutrients: N = 0, 65, and 130 lb/A; K_2O = 0, 65, and 130 lb/A; and P_2O_5 = 0, 33, and 65 lb/A.

The same soil, containing 0.146% N, 6 ppm available P, and 79 ppm available K was used for pot experiments. Pot experiments of 4 treatments (N, NP, NPK and unfertilized check) were conducted in 1978-1982. Pot experiments of 6 treatments of different levels of K were conducted in 1979, 1980 and 1982. These treatments received equal amounts of N and P.

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*A mu is a unit of land area, approximately one-sixth of an acre.
A jin is a unit of weight, approximately 1.1 lb.

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Total N, available P and available K were determined by Kjeldahl, Olson's, and flame photometric methods, respectively.

Results

Except for plant height, K treated soybean plots showed better early growth than untreated plots. K improved the size of the first compound leaf, dry weight per plant, number of nodes per plant, number of blooming nodes per plant, and functional leaf size in the early blooming stage.

Effects of K fertilizer were even more marked during the podding stage.

During early flowering and late pod stage, K fertilizer tripled the number of nodules, increased dry weight of nodules three times, and improved nitrogenase activity compared with untreated plants.

Potassium content of plants increased with K fertilizer treatment. Research shows that K content of functional leaves at early podding stage is correlated with grain yield. **Table 1** shows the critical levels of K content in soybean plants.

Table 1. The critical levels of K in soybean plants (%).

Stages	Material	Deficient	Inadequate	Optimum	Excess
Seedling	Shoot	Less than 0.8	0.8-1.7	1.7-4.0	More than 4.0
Blooming	Functional leaf	Less than 0.6	0.6-1.2	1.2-3.0	More than 3.0

China

Although K application increases soybean oil content, research shows no relevant difference in protein content related to K treatment.

Yield Increases

Results of 63 field experiments show that K application increased soybean yields per crop by 3.3 bu/A (29.6 jin/mu) or 17.8% over the control plots without K fertilizer. Yields averaged 22.8 bu/A without K and 26.1 bu/A with K.

On Maganni paddy soils, the average yield increase due to potassium application was 18.7% when the K was applied at seedling stage. ■

For more information on ordering, turn to page 23.

Four New Members Named to Institute's Advisory Council

FOUR NEW MEMBERS have been appointed to the Advisory Council of the Potash & Phosphate Institute (PPI). The individuals succeed other agricultural leaders whose three-year terms were completed at the end of 1983.

The new members are: **Dr. Carl D. Fanning, Dr. J.A. Robertson, Dr. Edward C.A. Runge,** and **Dr. Emmett E. Schulte.**

Dr. Carl D. Fanning is Extension Soils Specialist, North Dakota State University, Fargo. Dr. Fanning brings a wealth of diversified experience, having worked in research, as a retail fertilizer dealer, and as a fieldman with the TVA (NFDC) Test and Demonstration Branch. He has been a leader in the Great Plains Soil Fertility Workshop held in Denver and helped establish the Manitoba-North Dakota Zero-Till Farmers Association.

Dr. J.A. Robertson is Professor of Soil Science, University of Alberta, Canada. Dr. Robertson's main role in recent years has been in teaching undergraduate courses. His research activities have had a strong emphasis toward soil fertility. Projects under Dr. Robertson's supervision have been directed at improvement of predictions of fertilizer requirements based on soil tests. He is a past President of the Canadian Society of Soil Science.

Dr. Edward C.A. Runge is Head, Department of Soil and Crop Sciences, Texas A&M University. Dr. Runge has specialized in Soil Genesis and Classification, Soil Chemical Relationships, and Soil Water-Climate-Crop Yield Modeling. His research has contributed to a better understanding of the dynamic nature of soil development processes and to the interdependence of soil moisture-rainfall-temperature on corn and soybean yields. Dr. Runge is President-Elect of the Soil Science Society of America.

Dr. Emmett E. Schulte is Extension Soil Scientist, University of Wisconsin. Dr. Schulte has responsibilities in Soils Extension, Research and Teaching. Presently, he serves as Director of the Soil and Plant Analysis Laboratory at the University. He has authored or co-authored numerous publications related to liming, fertilizer, and tillage practices.

"Since its beginning in 1976, the Advisory Council has been a two-way channel for communication and discussion of ideas and programs," noted Dr. R.E. Wagner, President of PPI and the Foundation for Agronomic Research (FAR). "We are happy that these outstanding professionals will continue the tradition of cooperation. The timely, straightforward and objective input they provide is beneficial to all."

Dr. Wally J. Moline, Director of the Arkansas Cooperative Extension Service, will serve as Chairman of the Council for 1984. Mr. Marty Thornton, Vice President and Senior Farm Manager, Peoples Bank of Bloomington, Illinois, will serve as Vice Chairman of the 12-member Council.

The Potash & Phosphate Institute is a nonprofit organization with research and education programs focused on sound agricultural uses of potash and phosphate. The concepts of maximum yield research and maximum economic yields for farmers are important thrusts of the PPI program. ■

PPI Folders Offer Agronomic Information to Help in 1984

THE NEED for factual, timely, and useful agronomic information never ceases. As the agricultural scene takes on a new outlook for 1984, growers will be positioning themselves to take full advantage of economic opportunities.

Following are current folders available from the Potash & Phosphate Institute (PPI).

	Quantity	Amount
• **"WHY . . . Fertilizer Fits Your 1984 Profit Plans"** features a discussion of outlook and management strategies with Dr. John Marten.	______	$______
• **"Fertilizer – A High-Yield Investment"** relates the economic returns that accrue with short-term and long-term yield increases from increased fertility and productivity.	______	$______
• **"P & K Cut N Costs"** tells why phosphate and potash are so important for obtaining maximum efficiency of nitrogen in crop production.	______	$______
• **"Maximum Economic Yield Systems: How They Work for WATER USE Efficiency"** presents timely information on improving crop yields and quality by efficient use of available water.	______	$______
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Tomorrow's Leaders

IN THE NEXT DECADE who will do the agricultural research, the extension work, the teaching, the selling, and the administering? Dr. Terry Kinney, administrator of USDA's Agricultural Research Service, forecasts an annual need for 59,780 new graduates in agriculture between now and 1985. Projections predict 51,976 graduates.

And the Resident Instruction Committee of Organization and Policy, National Association of State Universities and Land Grant Colleges, states: "American agriculture is seriously threatened by deepening shortages of highly qualified scientists – "

At the same time, Dr. Robert Miller, head of the soil science department, North Carolina State University, expresses concern about the quality and quantity of the undergraduate students in all agricultural disciplines. He suggests that high quality students are encouraged to enroll in so-called glamour professions – medicine, law, computer science, business.

If our agricultural colleges don't provide tomorrow's ag leadership, where will it come from? It may come as a surprise to some, but other disciplines are ready and eager to jump into the gap. This includes majors in such fields as chemistry, physics, botany, biology, etc. They are smart, competent and well trained in their fields and have their eyes on agriculture's jobs and funds.

You see, in reality, technical and applied agriculture is a fascinating, difficult but, most of all, an enjoyable field. It offers a diversity and variety, plus a chance to contribute to humanity, that few areas offer.

Think about it. Would you rather be a dentist, or a urologist, or an accountant – or would you rather be an agriculturalist with the great outdoors as your office and the future as your challenge?

Agriculture needs the best, and deserves the best, and should be satisfied with only the best – for tomorrow's leaders.

– Dr. J. Fielding Reed

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