BETTER CROPS

with plant food

Spring 1986

Sulfur deficiency can limit wheat yields.
Above: Wheat in Arkansas research plot shows deficiency.
Below: Three weeks after treatment, response is apparent.

Also inside this issue: Seeking the Upper Limit of Corn Productivity
Maximizing Wheat Yields
and much more . . .

BETTER CROPS with plant food

Editors: Don Armstrong, Bill Agerton, and Santford Martin
Assistant Editor: Selma Bushman
Circulation Mgr.: Barbara Martin

Vol. LXX (70) Spring 1986

BETTER CROPS WITH PLANT FOOD (ISSN: 0006-0089, USPS: 396850) is published quarterly by Potash & Phosphate Institute. Subscription price $5.00 per year or $1.25 per issue. Second Class postage paid at Atlanta, GA. **Postmaster:** Send address changes to Potash & Phosphate Institute, 2801 Buford Hwy., N.E., Suite 401, Atlanta, GA 30329. Phone (404) 634-4274.

Contents

Our cover: Sulfur deficiency and response in treated wheat plots are shown in photos at Kibler, Arkansas, by Dr. Bobby R. Wells. Article on page 15.

200-Bushel Club

High-Yielding Corn—Georgia Style

By William I. Segars

This "Club" goes beyond high yields: The objective now is to reduce costs per unit of production for corn growers.

THE GEORGIA 200-BUSHEL CORN CLUB was established in 1968 by Dr. W.H. Gurley of the University of Georgia and Dr. S.E. Younts, who was then with the American Potash Institute. The entry requirement was quite simple—a farmer could qualify for membership by producing a documented corn yield of 200 bu/A. It was 1972 before the first verifiable yield of 200 bu/A was produced by Mr. L.W. Hutchinson of Appling County, Georgia. Since that time, over 500 growers have produced qualifying yields.

The 200-Bushel Corn Club, as conceived by Drs. Gurley and Younts, was designed to stimulate growers to try new and innovative production practices on small acreages. That concept has continued to the present. The success of the "Club" has been phenomenal, especially when one considers that 181 yields greater than 200 bu/A were recorded in 1985. The top yield of 283 bu/A was produced by Mr. Herbert Jacobs of Screven County, Georgia. The results of the Club since 1981 are summarized in **Table 1**. Since no monetary awards are provided, qualifying members are given trophies, plaques or certificates of membership.

Table 1. Average Yield of Top 10 200-Bushel Producers.

Year	Yield (bu/A)	Farmers Qualifying
1981	244.9	66
1982	245.4	101
1983	230.3	18
1984	231.6	37
1985	253.7	181

The significant benefit of the 200-Bushel Club has been that producers have openly shared their production inputs and techniques with Extension Service agronomists. Using this producer information, coupled with the University of Georgia College of Agriculture research studies, Extension agronomists developed guidelines for 200 bu/A corn production.

These guidelines have been shared with all persons (industry, private consultants, county agents and farmers) throughout the state. The adoption of these production guidelines has enabled numerous farmers to develop highly effective production programs.

Agronomists have long advocated that high yielding crops cannot be achieved unless a total package approach is used. Perhaps Dr. Werner Nelson said it best: "The art of high yield crop production requires the fine tuning of every production practice." Developing a complete production scheme and following sound management practices are the common ingredients that our 200-Bushel producers utilize. Each one continues to refine and improve each component to suit his individual farm situation.

A few of the key management practices utilized in Georgia are given below. These practices, with individual modifications, have proven to be essential to a high yielding production program.

- **Soil Selection.** Select the most productive soil on your farm. Fertile, well-drained, loamy soils are most productive; however, sandy soils are

(continued on next page)

Dr. Segars is Extension Agronomist-Soils and Fertilizer, University of Georgia, Athens, GA.

HIGH YIELDING corn production requires a total management program—nothing can be left to chance.

capable of producing good yields when properly managed.

- **Use High Yielding Hybrids.** Many corn hybrids have 200-bushel yield potential. Plant at least two high-yielding hybrids with good standability and disease resistance. Early to medium maturity hybrids are best suited for irrigated production.
- **Plant Population.** Plant sufficient seed to obtain a final plant population of 26,000 to 28,000 plants per acre. Plant slow enough to obtain uniform seed drop. Uniformity of stand is critical.
- **Protect Stands.** Use a recommended insecticide-nematicide at labeled rates to control soil borne insects and light to moderate nematode infestations. Do not plant on soils with high nematode infestations.
- **Fertilize Properly.** A good fertility program that supplies the right amount of needed nutrients at the right time is essential for top yields. The N target rate for 200 bushel corn is 250 lb/A. Rates of P_2O_5 and K_2O will be determined by soil test levels. About 30% of the nitrogen (N) and 100% of the phosphate and potash needs may be applied at or before planting. The remaining N can be applied sidedress and/or through injector pumps.
- **Starter Fertilizer.** Early-planted corn is frequently exposed to cool soil temperatures which may reduce phosphate uptake. Improved early-season growth can be obtained by banding a starter fertilizer (high P analysis) two inches to the side and two inches below the seed at planting. Ammonium polyphosphate, monoammonium phosphate and diammonium phosphate are suitable materials.
- **Secondary and Micronutrients.** Apply a minimum of 25 lb/A elemental magnesium (Mg) if soil test results indicate low Mg levels. Apply 3 lb/A elemental zinc (Zn) if soil test results indicate low levels. Apply 30 to 40 lb/A sulfur (S). A total of 2 lb/A boron (B) is suggested on irrigated corn. Soil test results will determine whether manganese (Mn) is needed.
- **Plant Analysis.** Corn requires definite levels of essential plant nutrients. Plant nutrient status of the corn can be monitored throughout the growing season by using a plant analysis. If nutrient levels fall below sufficiency levels, corrective measures can be taken.
- **Moisture Management.** Monitor available soil moisture throughout the season. Schedule irrigation to make sure available soil moisture never exceeds 50% depletion in the major rooting zone. Do not plant more acres than can be adequately

irrigated during peak moisture use periods.

- **Harvest Early.** Harvest the grain at high moisture (25-30%) for maximum economic yields. Adjust the combine for maximum harvesting efficiency. Dry promptly and correctly before storing.
- **Keep Records.** Keep an accurate record of all production inputs, weather patterns and special problems that arise during the growing season. These records will be helpful when evaluating crop performance.

Numerous questions have been received regarding the fertilizer use of 200-Bushel producers. The average N P K usage is given in **Table 2.**

Table 2. Average Nutrients Used by 200-Bushel Corn Producers.

Year	N	P_2O_5	K_2O	Farmers Qualifying
	---------- lb/A ----------			
1981	301	122	190	66
1982	289	104	166	101
1983	283	101	165	18
1984	264	97	158	37
1985	250	85	143	181

Nutrient use has declined dramatically since 1981. This decline is the result of continual refinements by producers. Since growers monitor plants with plant analysis, they have been able to develop fertilizer rates that maintain sufficient levels of plant nutrients. As a result of monitoring nutrient levels they have been able to achieve improved efficiency in nutrient utilization. In short, they are attempting to refine their programs as they continue in the quest for Maximum Economic Yields (MEY).

The Top Ten 200-Bushel Growers produced yields more than double the state average in 1985. The average yield on 310,000 acres of irrigated corn in Georgia was 125.3 bu/A. Production costs, excluding land for an irrigated producer with a 150 bu/A yield goal are approximately $450/A.

Production costs for the Top Ten 200-Bushel producers are estimated to be $525/A. Thus, the bottom line on cost per bushel, the key to profits, is:

Variable and Fixed Costs (No Land Charge)
State average yield 125 bu/A @ $450/A = $3.60/bu
Top 10 200 Bushel 254 bu/A @ $525/A = $2.07/bu

Our objective in Extension education corn production programs in Georgia: Continue to reduce costs per unit of production. ■

South Carolina

Palmetto Corn Club Announces Top Yields

Many growers topped 200 bu/A in 1985, with a new state record of 244.94 bu/A.

SEVENTEEN GROWERS in the Palmetto (South Carolina) Corn Club and Contest achieved yields over 200 bu/A in 1985. The top yield in the contest was a new state record of 244.94 bu/A harvested by the Durant Brothers of Clarendon County, according to Dr. J.P. Zublena, Clemson University Extension Agronomist.

The 1985 results opened new yield horizons, with three producers topping the previous yield record by more than 13 bu/A. More growers achieved over 200 bu/A in 1985 than in all the previous years of corn yield history recorded in the state.

The previous corn yield record for South Carolina was 228.75 bu/A produced in 1911 by Jerry H. Moore, then a 14 year-old 4-H boy.

"The 1985 results indicate that corn growers have opportunity and challenge at their door," Dr. Zublena notes. ■

Seeking the Upper Limit of Corn Productivity

By M. Tollenaar

Maximum yield research and advances in technology are pushing closer to the upper limit of corn productivity for conditions in the U.S. Corn Belt. This analysis sets the practical limit at about 500 bushels per acre (bu/A).

ESTIMATING THE UPPER LIMIT of corn yield is indeed difficult.

The question arises whether an intelligent guess of the upper yield level can be made at all. Actually, a precise estimate of the upper limit of corn yield cannot be made because of our limited knowledge of yield formation, but a **range** of values encompassing the upper limit can be defined. An estimate of potential corn yield will have to include effects of environment and management practices on corn production.

Some environmental effects cannot be controlled in practical corn production. They include **duration of the growing season, accumulation of temperature sums or degree days,** and **soil texture.** Management practices are designed to minimize environmental constraints on crop production. Among management practices which may effect the limit of corn yield are **water management, optimal application of macro- and micronutrients, tillage and crop rotation to obtain optimal soil structure, selection of corn hybrid which yields most under the particular environmental conditions, and an optimal plant density and plant spacing.**

Dry Matter Accumulation

A first estimate of the upper limit of corn productivity can be derived from maximum rate of corn dry matter accumulation reported in the literature: 460 lb /A/ day total dry matter including the roots, which has been reported for corn grown in California and Ontario. Whereas a full season corn hybrid grown in the Corn Belt will mature in approximately 150 days (from May to October), the period of complete light interception by the corn canopy (i.e., the period of maximum crop growth rates) will be much shorter. A corn canopy with a leaf area index (area of leaves per unit ground area) of higher than 3 to 4 will intercept most sunlight. The period will therefore usually extend from the end of June to the middle of September, a period of approximately 90 days.

Assuming a crop weight of 2,600 lb /A at the onset of the period of complete light interception by the corn canopy, maximum crop weight at maturity will be 2,600 + 90 x 460 = 44,000 lb /A. Results of our experiments have indicated that the allocation of dry matter of a good yielding corn crop at maturity (e.g., 150 bu/A) is approximately: roots (10%) and of the remaining above-ground dry matter, grain (50%), cob + husks (9%), stem (28%) and leaves (13%). Since a bushel of dry corn weighs 47.3 lb, total weight of a 150 bu/A corn crop will be 15,780 lb /A **(Table 1).** Estimation of grain yield of a 44,000 lb /A corn crop is complicated by the unavailability of crop-component distribution data of 300+ bu/A corn crops. The distribution pattern will likely change since leaf area does not have to increase (all light is intercepted already!) and the increase in stem weight is not likely proportional to the increase of total plant weight (the plant structure of a 150 bu crop has only to be strengthened to support the additional ear weight).

Since root weight of a 150-bu corn crop has supported crop growth rates of 460 lb/A/day, it could be argued that root weight does not have to increase. The function of roots, however, goes beyond the uptake of water and nutrients, and a growing root system may be required to sustain high crop growth rates over the 90-day period. As shown in **Table 1,** my estimates of dry matter distribution of a

Dr. Tollenaar is with the Crop Science Department, University of Guelph, Guelph, Ontario N1G 2W1.

Table 1. Average and hypothetical distribution of dry matter at maturity of corn crops yielding 150 and 502 bu/A, respectively.

Crop component	Corn Yield bu/A 150	502
	------- lb/A -------	
Grain	7,100	23,730
Cob + husks	1,280	5,200
Stems	3,880	7,760
Leaves	1,940	2,910
Roots	1,580	4,400
Total	15,780	44,000

44,000 lb/A corn crop will result in a yield of 502 bu/A. An increase beyond 90 days of the period of complete light interception with high crop growth rates will result in the addition of approximately 6 bu/A/day to the estimated upper yield limit of 502 bu/A. The major weakness in this calculation of the upper yield limit of corn is that maximum crop growth rates of corn will only be sustained at high incident irradiance (sunlight). Incident irradiance declines continuously from the end of June to the end of September and so will (probably) crop growth rates.

Solar Energy

A second estimate of the upper yield limit of corn will be based on amount of solar energy absorbed by the corn canopy and the efficiency of conversion of solar energy into grain dry matter. Crops collect solar energy by means of photosynthesis and convert solar energy to chemical energy which is stored in carbon-to-carbon bonds of organic matter. The potential efficiency of these processes can be estimated theoretically or can be determined experimentally.

In the theoretical estimate, 8 quanta of photosynthetic active radiation are required for the reduction of 1 mol CO_2 to glucose (an efficiency of 28%), photosynthetic active radiation constitutes 50% of total incident solar energy, and 15% of incident energy is lost by either reflection or transmission of light by the crop canopy. In addition, approximately 30% of the energy fixed by gross photosynthesis is required for building of corn plant constituents and structure, translocation and maintenance of plant structure (i.e., respiration). The theoretical photosynthetic efficiency is therefore 0.28 x 0.5 x 0.85 x 0.7 = 8.3%.

The experimentally determined quantum efficiency for corn leaves is approximately 16 (i.e., a photosynthetic efficiency of 4.15%), although we have measured a canopy photosynthetic efficiency of 6.45% for corn grown hydroponically under controlled-environment conditions. Incoming solar radiation from May 1 to September 30 does not vary much among locations in the central U.S. and southern Canada, although the radiation is substantially higher in the south (i.e., Texas) or west (i.e., California) of the U.S. Corn dry matter production will be related to radiation absorbed by its leaf canopy and hence estimates of potential corn yields are presented in **Table 2** for various scenarios of leaf area development (and thus light absorption) of corn grown at an average Corn Belt location.

Table 2. Potential grain yield of corn during a growing season extending from May 1 to Sept. 30 at an average Corn Belt location for various periods of complete interception.

Period of complete interception of solar radiation	Canopy photosynthetic efficiency (%) 8.3	6.45	4.15
	---------- bu/A ----------		
May 1—Sept. 30	1,860	1,445	868
July 1—Sept. 30	1,312	952	569
July 15—Sept. 15	928	669	398
Aug. 1—Sept. 15	651	467	301

The estimates presented in **Table 2** suggest that the theoretical limit for corn yield in the Corn Belt is 1,300 bu/A (unless one would consider to grow corn in greenhouses to attain complete light interception at May 1). A corn yield of 1,300 bu/A in the Corn Belt is not likely to be ever attained, because a canopy photosynthetic of 8.3% has never been measured and more importantly, maximum photosynthetic efficiency is attained only at low incident radiation and efficiencies decline with increasing incident radiation. Theoretically, a corn yield between 569 and 1,312 bu/A could be attained if incident solar radiation could be uniformly distributed over an entire corn canopy with a leaf area index of 8 to 10.

(continued on next page)

Interactions

Whereas the former two estimates of the upper limit of corn yield are based on a few simple assumptions, the third estimate will be derived from a large number of complex equations describing development and dry matter accumulation of a corn crop.

Final grain yield of corn is the end product of a large number of interacting processes, our knowledge of which is still very limited. We have attempted to compile our current understanding of a field-grown corn crop by quantifying experimental evidence in mathematical equations and to arrange these equations in a logical sequence: a simulation model of the corn crop.

The model requires a number of inputs, including daily maximum and minimum temperature, incident solar radiation, rainfall, planting date, relative maturity of the corn hybrid and plant density at which it is grown. This corn simulation model has been used during the last 2 years to predict yields of corn grown at 10 locations in Ontario and one location in Manitoba.

The major use of the corn simulation model, however, is not as a predictor of corn yields but as a tool for initial testing of hypotheses without expensive field experimentation. In estimating the upper limit of corn productivity, one will generally agree that increased productivity must be the result of enhanced canopy photosynthesis, but opinions will vary widely about the magnitude of the increase and the relative importance of various photosynthetic parameters; the corn simulation model can give us an initial guess. For this purpose, growth of corn is simulated under the 10-year average environmental conditions of the Harrow Research Station, Ontario, a location of Corn Belt maturity. Corn is planted May 1 at a plant density of 32,400 plants/A, corn is grown under apparent optimal conditions of water, nutrients, and soil structure, and grain is harvested on October 10.

Simulated grain yield of this corn crop is 221 bu/A. Canopy photosynthetic rate may be enhanced by an increase in leaf photosynthetic rate under light saturation, by an increase of leaf photosynthetic efficiency or by a decrease in respiration. When maximum leaf photosynthetic rate is doubled, crop yield increases by 17%. When leaf photosynthetic efficiency is increased by 50%, crop yield increases by 33%. When maintenance respiration is reduced by 25%, crop yield increases by 14%. When all three changes are applied simultaneously, grain yield becomes 403 bu/A (an increase of 82%).

A further increase in grain yield would be achieved by increasing plant density to 40,500 plants/A (424 bu/A). The latter increase was due mainly to an increase in ears/A rather than to an increase in total dry matter productivity. A decrease in either dry matter portioned to the stem or the roots did not result in appreciable increases in grain yield. The only other factor which could significantly affect grain yield is the light distribution in the crop canopy (i.e., leaf angle). Although our model cannot simulate the effect of leaf angle on canopy photosynthetic rate, results of experiments reported in the literature suggest that yield may increase by an additional 10 to 25%, when the angle of the leaves in the top of the canopy is increased. **Hence, the results of this computer simulation exercise indicate that the maximum grain yield of a corn crop grown under average Corn-Belt conditions is approximately 500 bu/A.**

Summary

This discussion on the current upper limit of corn productivity has been restricted to a growing season of 150-160 days, typical for the U.S. Corn Belt. Much higher yields could be calculated for environments which allow for year-round corn production, either by growing two crops of corn or, possibly, by growing corn of 350-day maturity. For a Corn Belt growing season, however, a cautious estimate of the upper limit of corn yield will be as high as 1,312 bu/A. It is safe to predict that this limit will never be exceeded.

With the information presented here as background, my guess for the current upper limit of corn productivity in the Corn Belt is 500 bu/A. ■

Ontario Corn Research Achieves 293 bu/A Yield

Researcher Ken Stevenson of Ridgetown College of Agricultural Technology reports corn yields of 293 bu/A (irrigated) and 275 bu/A (non-irrigated) for 1985.

CORN RESEARCH yields in Canada took another step upward in 1985. Researcher Ken Stevenson and co-workers at Ridgetown College of Agricultural Technology (RCAT) recorded corn yields of 275 bu/A, non-irrigated, and 293 bu/A with irrigation.

These results continue a pattern of outstanding yields in the research plots at Chatham, Ontario. **Table 1** shows the figures for maximum yield treatments from 1982 through 1985. The four-year average of 251 bu/A without irrigation is believed to be the highest in North America.

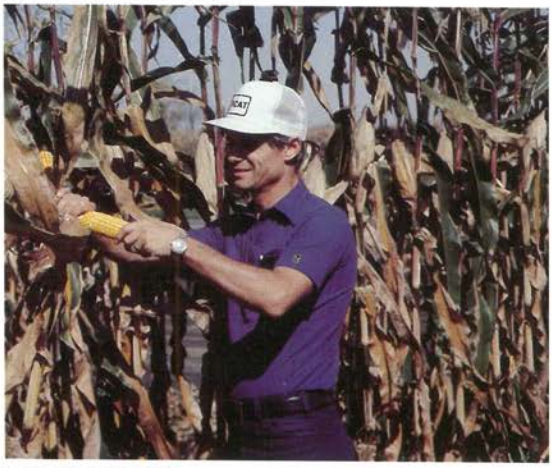
Table 1. Maximum Yield Treatments at Chatham, Ontario.

Year	Irrigated	Non-Irrigated
	------ Yields(bu/A) ------	
1982	251	246
1983	249	235
1984	257	251
1985	293	275
Avg.(4 years)	263	251

Source: Ridgetown College of Agricultural Technology

The top 1985 yields were obtained with very high rates of nutrients supplied by both commercial fertilizer and cattle manure. The rates were approximately 600 lb/A nitrogen (N), 100 lb/A phosphate (P_2O_5), and 400 lb/A potash (K_2O), plus sulfur, magnesium, copper, iron, manganese, and zinc. Although nutrient removal is very high at these yield levels, high fertilizer rates have maintained the original high soil test values.

Hybrid selection is very important in designing a maximum yield system for corn, Mr. Stevenson says. Only about 5% of the hybrids currently available to farmers may respond to maximum yield management. In 1985, Pioneer 3540 outyielded Pioneer 3707 by 20 bu/A; however, Pioneer 3707 had the highest yields over the three previous years.



KEN STEVENSON

An increase in plant population from 26,000 to 42,000 plants per acre (ppa) gave an overall response of 39 bu/A or an average of 2.4 bu/A of corn for every extra 1,000 plants harvested, up to about 35,000 ppa.

"History has proven that farmers must depend on their ability and ingenuity to increase yields for higher profits. Their economic survival has depended on it. The purpose of maximum yield research is to provide information for the development of maximum economic yield systems for farmers to use in achieving higher profits," Mr. Stevenson notes.

The maximum yield research project at Ridgetown College of Agricultural Technology is jointly funded by Ontario Ministry of Agriculture, The Fertilizer Institute of Ontario, and the Potash & Phosphate Institute. ■

Fertilizing Alfalfa for Maximum Economic Yields

By Lester R. Vough

Maryland studies indicate that standard fertilization practices on alfalfa, particularly for potash, may not be adequate for achieving maximum economic yields.

SOIL FERTILITY AND FERTILIZER practices are key elements in high yield alfalfa management. As alfalfa yields increase, nutrient needs increase. High yields cannot be obtained without proper fertility and fertilization, particularly with potassium (K).

While the 1985 yields of 31 alfalfa varieties in a yield trial of the Agronomy Dairy Forage Research Farm in central Maryland were all in excess of 8 tons/A (12% moisture), the 1985 average Maryland alfalfa yield reported by the Maryland Crop Reporting Service was only 4.0 tons/A. Fertility is certainly one of the limiting factors contributing to the state's low average yield. Many of the better alfalfa growers in Maryland typically topdress alfalfa with about 150 to 200 lb K_2O/A annually. When you consider that the average K_2O removal rate is 60 to 70 lb/ton of hay harvested, it follows that the average yields correspond with the typical fertilization practices. **Most farmers are fertilizing for 3-to-4 ton yields.**

Current alfalfa fertilization research being conducted at the Forage Research Farm by Dr. R.R. Weil, Dr. A.M. Decker and myself illustrates the importance of potassium fertilization. This research trial was seeded in the fall of 1981. Fertilizer treatments and the four-year summary yield data are shown in **Table 1.**

Table 1. Alfalfa Yield Responses to Annual Application of Phosphorus, Potassium, Sulfur and Magnesium (4-Year Summary).

Annual Fertilization (lb/A)				Yields (tons/A) @ 12% moisture				
P_2O_5	K_2O	S	Mg	1982	1983	1984	1985	Total
0	0	0	0	4.18	5.91	4.94	5.82	20.85
0	645	67	134	4.27	6.36	5.68	6.79	23.10
153	645	67	134	4.44	6.52	5.43	6.76	23.15
307	645	67	134	4.56	6.45	5.30	6.96	23.27
460	645	67	134	5.00	6.71	5.84	7.15	24.70
460	430	67	134	4.73	6.82	5.54	6.82	23.91
460	215	67	134	4.58	6.28	5.13	6.46	22.45
460	0	67	134	4.38	5.43	4.30	5.51	19.62
460	645	0	134	4.64	6.42	5.54	6.98	23.58
460	645	22	134	4.48	6.47	5.50	6.90	23.35
460	645	45	134	4.60	6.46	5.72	7.14	23.92
460	645	67	0	4.86	6.44	5.70	7.20	24.20
460	645	67	134*	4.61	6.85	5.95	7.56	24.97
153	215	22	45*	4.66	6.31	5.89	6.85	23.21

*8.9 tons/A (dry matter basis) dairy heifer manure plowed down.

Dr. Vough is Forage Crops Extension Specialist, University of Maryland.

The highest yields were obtained from applications of 460-645-67-134 lb/A (P_2O_5-K_2O-S-Mg), with and without manure. (These yields were lower than the top yields in the alfalfa variety trial. The alfalfa stand in 1984 was marginal due to losses from Phytophthora root rot.) The response to potassium was highly significant, but there was no significant response to phosphorus, sulfur, or magnesium.

Table 2 shows the costs and returns for three levels of potash fertilization. Maximum net returns per acre for the three application rates shown in **Table 2** are obtained at 430 lb K_2O/A. If the cost of K_2O drops to 11¢/lb and hay price to $75/ton, as is presently the case in some locations, maximum net return is still obtained at 430 lb K_2O/A application rate. The data supports the information being obtained in other states indicating that alfalfa should receive annual applications of 100 lb P_2O_5/A and 400 lb K_2O/A for yield goals of 6 to 8 tons of hay per acre.

Table 2. Costs and Returns of Potash Fertilization on Alfalfa (4-year Summary).

K_2O (lb/A/yr)	Cost of K_2O*	Increased Yield (T/A)	Increased Return ($/A)**	Return per $ Invested	Net Return ($/A)
215	$129	1.60	$200.00	$1.55	$ 71.00
430	258	3.06	382.50	1.48	124.00
645	387	3.85	481.25	1.24	94.25

*K_2O cost = $0.15 **Hay price = $125/T

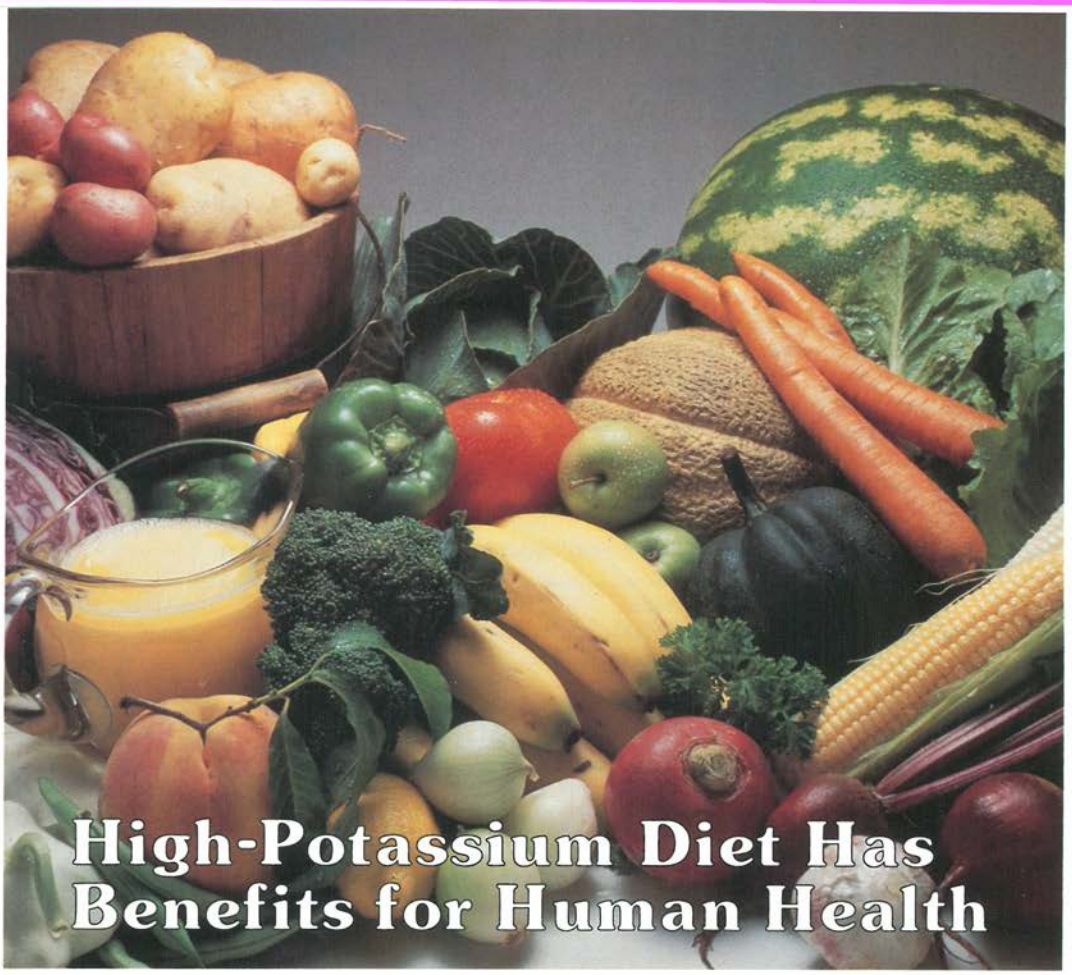
Table 3 shows the potash soil test values in the fall of 1985. Note that the potash level in the 0-6 inches depth for the 460-430-67-134 treatment was in the very high range, and yet there was a yield increase when additional potassium was applied to the soil.

Table 3. Potash (K_2O) Soil Test Values as Affected by Fertilizer Application and Depth of Soil Sampling (Fall 1985).

Treatments(lb/A)				Depth of soil samples (inches)		
P_2O_5	K_2O	S	Mg	0-2	2-6	0-6*
0	0	0	0	140 M**	75 L	96 M
460	0	67	134	107 M	59 L	75 L
460	215	67	134	245 H	85 M	138 M
460	430	67	134	578 VH	253 H	360 VH
460	615	67	134	689 VH	476 VH	579 VH

*Calculated as (0.33 × 0-2 in.) + (0.67 × 2-6 in.)
** lb/A if based on 7.9 inch depth.

High yield management of alfalfa requires some modification of current standard fertilizer recommendations. For example, using University of Maryland fertilizer recommendations for a yield goal of 6.75 tons/A on a soil testing very high in potash, the recommended amount of potash would be only 145 lb/A. The situation is similar to the high yield, small grain program that some farmers are now adopting—a special fertilizer program is followed that differs from the standard recommendations. Extension agents and agribusiness representatives working with farmers interested in high yield alfalfa management may need to follow a similar program. ■



High-Potassium Diet Has Benefits for Human Health

POTATOES, BANANAS, MOST VEGETABLES, melons, orange and grapefruit juice, and other foods rich in potassium (K) are important for healthy human diets. University of Minnesota researcher Dr. Louis Tobian reports that a shortage of potassium damages the arteries and is partly responsible for the prevalence of heart disease, stroke, and kidney failure.

Dr. Tobian, Chief of the Hypertension Section at University of Minnesota Hospitals, has found in tests with laboratory animals that potassium prevents the typical "thickening of artery walls" associated with high blood pressure. In a paper given at a symposium of the American Heart Association, he said that a high-potassium diet might keep coronary and cerebral arteries fairly clear of artery-clogging deposits.

"We intend to find out in a rabbit experiment whether or not a high potassium diet will retard deposition of cholesterol in the walls of arteries," Dr. Tobian says. He believes that strokes, heart attacks and kidney disease are partly the consequence of modern mankind's "relatively low potassium diet."

Prehistoric peoples got most of their food from roots, nuts and fruits, supplemented by game or fish. Their bodies became extremely efficient both at conserving sodium and getting rid of potassium. Over the past 10,000 years or so, the diets of many people have become rich in sodium and low in potassium. **Processed foods have made the problem worse.**

Some of the evidence about potassium-protection against arterial-thickening comes from experiments at the University of Minnesota on rats that develop high blood

pressure when they are fed salt (sodium). The rats suffered severe kidney damage on the normal diet fed to them. The damage was reduced by 50% when they were given potassium supplements, even though their blood pressure remained high.

The arteries of the kidney-damaged rats were 38% thicker than normal—and so narrow the blood flow through them was impaired—and those of the potassium-supplemented rats were of normal thickness.

"This was a totally unexpected finding," Dr. Tobian says.

In further experiments, the researchers found that they could reduce the death rate of hypertensive rats by 98% by giving them extra potassium. Dr. Tobian says it has been established that a high potassium diet, "affords a remarkable protection against death from strokes as well as kidney damage."

He strongly believes in a low salt (sodium) intake to help prevent and treat high blood pressure, but now recommends that people eat "natural foods that have both low sodium and high potassium content."

Those foods include potatoes, bananas, vegetables, all fruits, orange juice, grapefruit juice, skim milk and melons.

Prehistoric man probably had 10 grams or one-third of an ounce of potassium in his daily diet. Healthy, modern people do not consume that much.

None-the-less, Dr. Tobian believes that a worthwhile 5 or 6 grams a day can be attained by prudent eating. Two notes of caution. Processed tomato juice, while rich in potassium, may be too heavily salted to be a good source. And potatoes should be baked or steamed. Their potassium leaches out into the water if they are boiled without skins.

The accompanying chart lists the potassium content of selected foods. ■

Table 1. Potassium (K) Content of Selected Foods and Beverages.

Food and portion size	Portion wt† grams	K content milligrams
Apple, fresh, whole, 2¾	13.6	152
Apricot, fresh, whole, three	114	301
Avocado, raw, one-half, pitted	125	680
Bacon, cooked, two thick slices	24	57
Baking powder biscuit, from mix, one	28	33
Banana, raw, whole, one medium	175	440
Beef rib roast, lean, two thin slices	85	269
Beer, 12 fluid ounces	360	90
Bologna, prepackaged, one slice	28	65
Bread, white, one slice	28	29
Bread, wholewheat, one slice	28	72
Cake, devil's food, one piece	69	90
Chili, canned, 1 cup	255	594
Corn, canned, ½ cup	83	80
Corn oil, 1 tablespoon	13.6	0
Cornstarch, 1 tablespoon	8	Trace
Dates, pitted, 10	80	518
Egg, hard-cooked, one large	57	65
Flour, all-purpose, 1 cup	125	119
Gin, rum, whiskey, 1 fluid ounce	28	1
Green beans, canned, ½ cup	67	64
Haddock, fillet, baked	110	383
Ham, baked, two slices	85	282
Ice cream, 10% fat, 1 cup	133	241
Lima beans, canned, ½ cup	85	188
Milk, 2%, solids added, 1 cup	246	431
Orange juice, fresh, 1 cup	248	496
Peanuts, roasted, 10	27	127
Pizza, frozen, cheese, baked	398	455
Potato, baked, with skin, one large	202	782
Rice, parboiled white, cooked, 1 cup	175	75
Soybeans, cooked, ½ cup	90	486
Sugar, granulated, 1 tablespoon	12	Trace
Tomato juice, canned, 5½ fluid ounces	167	379
Wine, table, 3½ fluid ounces	102	94

† Weights of fruits and vegetables include skin and seeds or pits unless indicated.
Source of figures: USDA

New Members Named to PPI Advisory Council

THE ADVISORY COUNCIL of the Potash & Phosphate Institute (PPI) has four new members and a new Chairman for 1986. They succeed other agricultural leaders whose three-year terms were completed recently.

The four new members are: **Mr. Henry M. Neutens, Mr. John C. Schaefer, Dr. William I. Segars,** and **Dr. M.B. Tesar.** The new Chairman, **Dr. E.C.A. Runge,** is Professor and Head, Soil and Crop Sciences, Texas A&M University, College Station, Texas.

"Each year, we're proud to announce the new members who will serve on the Advisory Council," said Dr. R.E. Wagner, President of PPI. "These agricultural leaders help determine the direction of our research and education program efforts. With the input from various disciplines, there is mutual benefit for all."

• **Mr. Henry Neutens** is Partner and Vice President of Kent County Fertilizers Limited, of Ridgetown, Ontario, Canada. The firm consists of three manufacturing (blending) plants; Mr. Neutens is Manager of the Ridgetown operation, the head office. During the past several years, he has been very active in The Fertilizer Institute of Ontario (T.F.I.O.), including service on various committees and a term as President. He has helped coordinate Maximum Yield Test Plots for corn and alfalfa, jointly funded by T.F.I.O. and the Ontario Ministry of Agriculture and Food.

• **Mr. John C. Schaefer** is Vice President, Agricultural Services, for the First State Bank of Monticello, Monticello, Illinois. The First State Bank is the lead bank of a three-bank holding company, the First State Bancorp of Monticello, Inc. Mr. Schaefer is directly responsible for the agricultural loan portfolio of the First State Bank of Monticello, and coordinates the agricultural activities of the other two banks. His responsibilities include direct management of 4,500 acres and indirect management of 4,000 acres.

• **Dr. William I. Segars** is Extension Agronomist, University of Georgia, Athens, Georgia. Dr. Segars received a Ph.D. in Agronomy from Clemson University in 1972, after working as an assistant county agent and area extension agronomist in Georgia. From 1975 to 1979, Dr. Segars was with Gold Kist, Inc. In 1979, he returned to Cooperative Extension Service as Extension Agronomist, Soils & Fertilizer. In 1984, he received the Distinguished Achievement in Public Service and Extension Award. Dr. Segars has served as Educational Advisor, Georgia Plant Food Educational Society.

• **Dr. M.B. Tesar** is Professor, Department of Crop and Soil Sciences, Michigan State University, East Lansing, Michigan. An internationally known leader in forage crop research, Dr. Tesar's distinguished career in agronomy began after service in World War II. His publications include over 130 journal articles and six book chapters on the physiology, management and nutritive value of forage crops, primarily alfalfa. He is a Fellow of the American Society of Agronomy (ASA) and won the 1984 Agronomic Achievement-Crops Award. ■


Mr. Neutens


Mr. Schaefer


Dr. Segars


Dr. Tesar

Sulfur Fertilization — An Increasing Need

By Bobby R. Wells and Bob Darst

Occurrences of sulfur (S) deficiency are increasing for several reasons. Wheat research in Arkansas indicates profitable response to treatment in some conditions.

CROP DEFICIENCIES of sulfur have been observed with increasing frequency worldwide during the last 20 years and, in particular, during the last 10 years. For example, in the U.S., sulfur deficiencies had been identified in only 13 states by 1962. At present, at least 37 states have reported crop responses to sulfur.

There are several factors that have contributed to the growing interest in and need for sulfur fertilization, including:

- **An increased awareness of sulfur's role in crop production.**
- **Lower atmospheric sulfur content.**
- **Less sulfur as an impurity in fertilizers.**
- **Increasing crop yields.**
- **Declining sulfur reserves in surface soils caused by reduced organic matter levels.**
- **Decreased use of sulfur in pesticides.**

Sulfur Deficiencies Recognized

According to Dr. Stanley Chapman, Extension Soils Specialist, "We didn't think we had a major sulfur deficiency problem with any crop in Arkansas until the early spring of 1984. Sulfur deficiency was diagnosed and confirmed on wheat in two counties where yield comparisons were obtained."

Table 1 shows the influence of sulfur, added in the form of ammonium sulfate, on yield and sulfur content of wheat at one location in Jefferson County, Arkansas in 1984.

Table 1. Sulfur increased wheat yield and plant tissue sulfur, Jefferson County, AR, 1984

Sulfur(S) Source	S Rate lb/A	Yield bu/A	Percent Tissue S
Ammonium Sulfate	47	35.6	0.21*
Ammonium Sulfate	95	34.2	0.52*
Check	0	20.3	0.04**

* Plant samples taken on May 11
**Values never exceeded 0.05 during test period

At another site in the county, not shown in **Table 1,** application of 47 lb/A of sulfur as ammonium sulfate increased yields by 25 bu/A while 95 lb/A increased yields by only 9 bu/A. Plant tissue sulfur was more than doubled by increasing sulfur rates from 47 to 95 lb/A.

According to Dr. Chapman, sulfur deficiency symptoms and low levels of plant tissue sulfur have also been detected in corn and grain sorghum growing on those sandy soils that are low in organic matter. However, yield responses have not yet been confirmed on these crops.

Arkansas Research on Wheat

In the spring of 1985 a field study was established to evaluate the response of wheat exhibiting what appeared to be sulfur deficiency symptoms. The study was located at the University of Arkansas Vegetable Substation, Kibler, Arkansas. Symptoms were observed on wheat growing on a sandy loam soil during the third week of March, when the wheat was in the tillering phase of growth.

(continued on next page)

Dr. Wells is Professor, Department of Agronomy, University of Arkansas, Fayetteville, AR. Dr. Darst is Southwest Director, Potash & Phosphate Institute, Stillwater, OK.

(continued from page 15)

SULFUR DEFICIENT WHEAT is shown in plots at Kibler, Arkansas. This effect could be confused with nitrogen (N) deficiency.

WHEAT PLOTS shown in mid-April, three weeks after sulfur application, illustrate dramatic effects of treatment.

Sulfur fertilizer was applied at rates of 5, 10, 20 and 40 lb/A as potassium sulfate (K_2SO_4). Separate treatments containing equivalent rates of K as KCl were also included as was a control and a 40 lb/A rate of elemental sulfur as water-slaking particles. Three weeks later, samples of the top two leaves were taken and analyzed for sulfur. At maturity, plant heights were measured and grain yields taken.

It should be noted that the test area had received 60 lb/A of N as ammonium nitrate in late February and an additional 30 lb at the same time sulfur treatments were applied.

Grain yields, plant heights and plant tissue S concentrations are shown for selected treatments in **Table 2.** Grain yields were increased from 15.3 to 44.4 bu/A with the first 5 lb increment of S. Higher rates suppressed yields when compared to the yield attained with the 5 lb/A rate.

Applications of K as KCl had no significant effect on yield, thus establishing that the S, not the K in K_2SO_4, was responsible for the yield increases. Elemental sulfur, applied as water-slaking particles at a rate of 40 lb/A, increased yields, but at a significantly lower level of response as compared to 5 lb/A if SO_4-S.

Leaf S concentrations at three weeks after S applications showed that each successive increment of SO_4-S significantly increased S levels. Neither the KCl nor elemental S had an effect on leaf S content.

Plant heights were significantly increased (7.1 inches) with the first 5 lb increment of S as K_2SO_4, but additional increments had no effect. The 40 lb/A rate of elemental S showed trends of increasing plant height, but none of the KCl treatments had a significant influence on plant height.

Table 2. Sulfur increased wheat yield, plant tissue sulfur and plant height, Kibler, AR, 1985

Treatment	Yield bu/A	Percent Tissue S	Height Inches
Control	15.3	0.11	25.2
5 lb/A S as K_2SO_4	44.4	0.25	32.3
20 lb/A S as K_2SO_4	35.7	0.42	33.1
40 lb/A S as K_2SO_4	36.0	0.50	32.7
40 lb/A Elemental S	29.3	0.11	28.3
26 lb/A K as KCl	18.5	0.07	27.6
52 lb/A K as KCl	18.8	0.08	25.2

The photos show the dramatic effects sulfur had on wheat growth. A close look at the top photo might lead one to suspect a nitrogen deficiency. The photograph was taken on March 21, 1985. **How often has sulfur deficiency been diagnosed as a nitrogen problem on winter grasses?**

Some Conclusions and a Look into the Future

This research and other tests conducted by the University of Arkansas Division of Agriculture demonstrate that readily available SO_4-S is an effective corrective treatment on wheat during early spring growth when sulfur deficiencies are detected. Although elemental S was less effective, it did increase yields significantly. The fact that it did not increase plant tissue levels of S shows that its dissolution and conversion to the SO_4-S form did not occur rapidly enough to provide optimum levels for plant growth. This is further substantiated by its lack of influence on plant height.

There is a need for further research to assess the importance of sulfur on wheat grown in Arkansas. There may be as many as a quarter of a million wheat acres in the state that would be responsive to fertilizer sulfur, especially in those years where fall and winter rainfall amounts are high.

Research on other crops, such as corn and grain sorghum, is also needed. In addition, timing, sources and rates of sulfur should be evaluated.

Based on this and other research, Extension projects and general observations during the past two years, Arkansas now makes a S recommendation for wheat: 20 lb/A, in the sulfate form, for fall planted wheat on all well drained alluvial soils low in organic matter. ■

Potatoes: Phosphorus Fertilization

By D.T. Westermann, G.E. Kleinkopf and G.D. Kleinschmidt

Phosphorus (P) is an important nutrient in managing for quality and maximum economic yields of potatoes. This article presents a review of soil testing, fertilization and monitoring considerations.

THE OBJECTIVE of a plant nutrient fertilization program is to provide sufficient available nutrients at the right time, in the right place, and in the right amount for maximum economic plant yields. This requires using a good preplant soil testing and fertilization program, as well as monitoring nutrient concentrations in plant tissues during crop growth.

Sufficient soil P must be available preplant for early vegetative potato plant growth and for continued P uptake during tuber growth, if tuber yields are to be maximized. Phosphorus uptake increases rapidly during tuber initiation and then parallels tuber growth until the start of plant maturation. Phosphorus can then be lost from the vegetative parts of the plants to the tubers without any yield reduction during plant maturation (senescence).

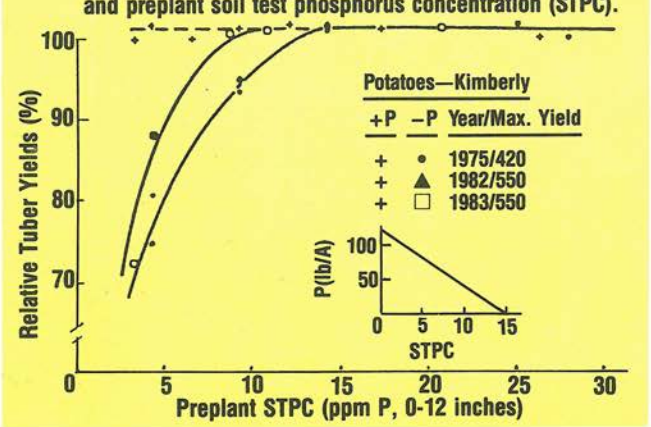
Preplant P Fertilization

Experimental data show that preplant soil test P concentrations (STPC) should be 15 ppm or above for maximum potato tuber yields **Figure 1.** This STPC will provide sufficient available P for early plant growth and for much, if not all, of tuber growth.

Growers are also encouraged to take the necessary soil samples to identify and correct soil variability problems in their potato fields. Eroded or scraped field areas (white, high lime soil conditions) present special P availability problems for potatoes and their STPC's should be maintained between 20 to 30 ppm P. In many fields this problem may be corrected by fertilizing the problem areas at twice the recommended P fertilization rate.

Preplant fertilizer should be plowed down or disked into the seedbed 4 to 6 inches for maximum benefits. Banding or sidedressing of preplant P materials at planting or at hilling were not as effective as plowdown or disking under southern Idaho growing conditions in terms of tuber yields or P uptake from the P fertilizer **(Table 1).** Starter fertilizer materials, containing P, should be placed above the seed piece at planting for maximum benefits.

Figure 1. Relationship between relative potato tuber yields and preplant soil test phosphorus concentration (STPC).



Plant P Concentration

The P concentration in the petiole during tuber growth is a good indicator of the P status of the potato plant. The soluble P concentration in the petiole should be greater than 1,000 ppm until the start of normal plant maturation or 20 days before vine kill. Both the P and dry matter balance of the potato plant are satisfactory for continued growth above this concentration of soluble P.

Dr. Westermann is a soil scientist at the USDA-ARS, Kimberly; Dr. Kleinkopf is a plant physiologist at the University of Idaho Research and Extension Center, Kimberly; and Dr. Kleinschmidt is an Extension Potato Specialist at Twin Falls.

Table 1. Effect of P fertilizer placement on total potato tuber yields.

Method of Placement	P Rate, lb/A			
	0	30	120	300
	Tuber yields, cwt/A			
None	364	—	—	—
Banded	—	388	441	—
Plowed	—	464	473	489
Disked	—	415	490	—

Petiole concentrations may drop below 1,000 ppm during tuber growth even when the STPC is adequate because of increasing severity of root diseases, different plant and tuber growth rates, and other environmental constraints. Growers are encouraged to monitor the P concentrations and other nutrients in their potato fields to ensure an adequate plant nutrient concentration for maximum tuber production.

As a general rule, the first petiole sample should be taken when the tubers are 1-inch diameter or greater. Additional petiole samples can be used to predict future petiole P concentrations.

Seasonal P Fertilization

Management practices that might be used to raise low plant P concentrations are (1) the application of foliar sprays directly to the plants and (2) applying P fertilizer solutions with an irrigation or as a dry material followed by an irrigation. Research data indicate that a mid-season application of a high water soluble P fertilizer material can help maintain an adequate plant P status until normal plant maturation. A single application of 20 to 40 lb P/A on 25 July increased total plant P uptake 4 to 5 lb P/A and maintained an adequate petiole P concentration during all of tuber growth. Final tuber yields, total USDA #1, and the (#1 + #2) > 10oz were also increased.

Both 10-34-0 and 12-62-0 were equally effective at the rates used in our studies. An optimum single mid-season application rate was about 40 lb P/A. Sprinkler applications have generally proven to be more effective than an application of dry materials. Growers need to be cautioned that a sprinkler application of some P fertilizer solutions is not recommended under certain water quality conditions because a precipitate forms and clogs sprinkler nozzles upon injection of the material. The possibility of this problem occurring can be identified by the formation of a white precipitate when ½-teaspoon of the intended fertilizer solution is added to 1-gallon of fresh irrigation water (equivalent to 40 lb P/A in 1.3-inch water per acre). If a precipitate forms, growers should use the same test to check other P-solutions (e.g., urea-phosphoric acid, phosphoric acid, or 10-34-0) or consider other application methods. None of the P-solutions should be applied directly to plants in their concentrated forms. However, an aerial application of 1 to 2 gallons of 10-34-0 has been included in blight sprays but will have to be repeated to be as effective as a sprinkler application. Foliar nutrient sprays containing P may be effective if correctly applied and if the amount of P needed for the plants to reach maturity or vine kill is small.

An average tuber growth rate of 7 cwt/acre-day requires a P uptake rate of 0.3 lb P/acre-day to satisfy the tuber's P needs for growth. An additional 3 lb P/A taken up by the plant and used for tuber growth could increase final tuber yields 70 cwt/A if P was limiting during late seasonal tuber growth.

The mid-season P fertilizer application is most effective when applied to a healthy growing crop. Applications should be scheduled as soon as possible after determining that the plants will be low in P before natural maturation or vine kill. This will allow a longer time interval for the plants to obtain the applied P before plant diseases become a significant problem.

Summary

Growers are encouraged to use a good preplant soil testing and fertilization program and then monitor the nutritional status of their potato fields during the growing season. These techniques will identify seasonal and environmental effects and allow the grower to make the necessary corrections to maintain maximum plant and tuber growth rates until normal plant maturation or scheduled vine kill. This practice should help maximize tuber yields and quality if there are no other production constraints. ■

For Alabama

30-Year Summary of Soil Tests Reveals Trends in pH, P and K

By C.C. Mitchell, Jr. and C.E. Evans

Deeper tillage, soil erosion, and under-fertilization may be related to patterns of soil test levels over the past 30 years in Alabama.

WHEN AUBURN UNIVERSITY began its soil testing project for Alabama farmers in 1953, one of the three objectives was to "...collect information by summarizing soil test data which may be used for educational purposes." Each year soil test summaries have been compiled. These summaries give the fertilizer industry, Extension workers, and researchers a chance to observe trends in fertilizer and lime effectiveness from year to year and over several decades. Often the year to year trends are not very dramatic, but when viewed over three decades, interesting changes in soil pH, phosphorus (P) and potassium (K) levels are obvious.

Soil pH

Cotton was the primary crop in Alabama in the 1950s, and the early summaries revealed that soil acidity (low pH) was one of the primary yield-limiting factors. Around 80% of these early soil samples had a pH below 6.0 and 38% were below 5.5. Improved production practices, reduced acreage, and increased lime use reduced the number of samples with very low pH. During the late 1960s and 1970s, soybean acreage in Alabama expanded from 350 thousand to over 2.2 million acres. Vast acreages of marginal land and unimproved pastureland were brought into soybean production. This resulted in an increase in the percentage of samples needing lime. Currently, around 25% of all samples have a pH below 5.5 and would receive a lime recommendation.

Soil Test Phosphorus and Potassium

The 30-year trend in soil test P and K shows striking contrasts **(Figure 1).** Soil samples testing "high" and "very high" in P and K increased rapidly during the first 15 years of soil testing in Alabama. Both P and K levels began dropping during the acreage expansion of the late sixties and seventies. Since then, K levels have recovered and are again increasing while soil test P levels continue to drop.

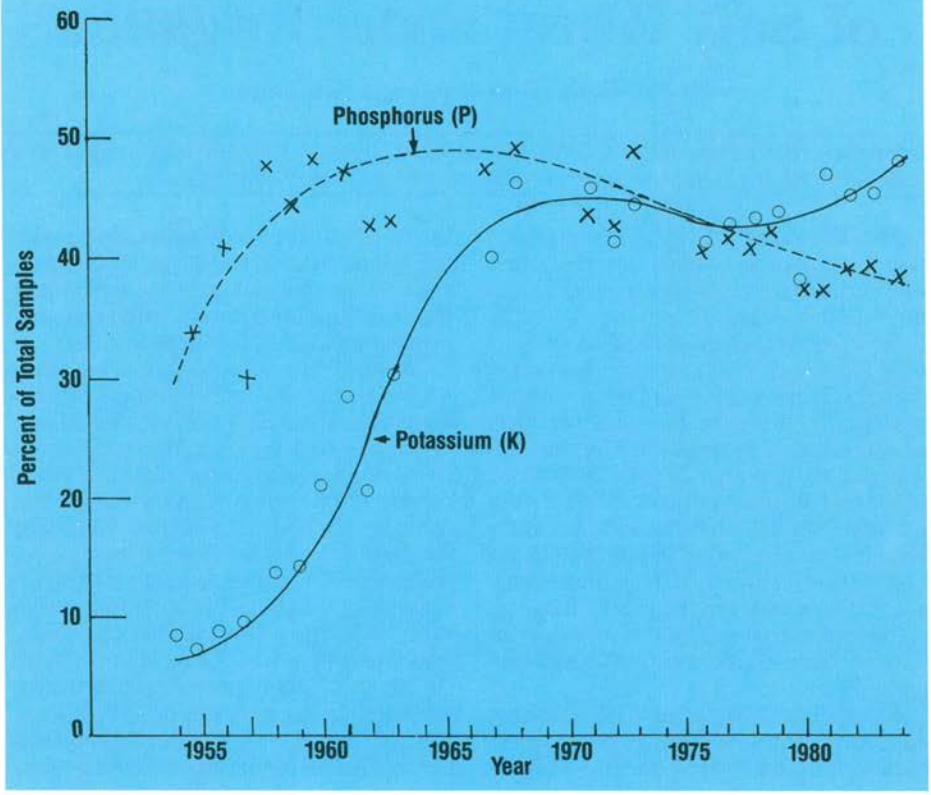
There are at least three possible explanations for these trends: deeper tillage, soil erosion, and under-fertilization.

(1) Deeper tillage. With an increase in use of heavier equipment there is the possibility that deeper tillage has mixed the fertilizer with more infertile subsoil. This subsoil generally has more clay, is higher in exchangeable K, is very low in P, and has a higher P fixing capacity.

(2) Soil erosion. The second explanation may be that soil erosion is actually removing residual P in the plow layer. Two soil areas of Alabama have been targeted because of excessive cropland erosion. These are the lower coastal plain soils of Southeastern Alabama and the Limestone Valley soils of Northern Alabama. Both regions are major crop production areas. These same two areas are the only

Dr. Mitchell and Dr. Evans are Extension Agronomists with Auburn University.

Figure 1. Alabama soil samples testing "high" and "very high" in P and K. Soil test K continues to increase, while soil test P decreases.



soils in the State where soil test P dropped dramatically over the past 10 years.

Soil region	Percent change in soils testing "high" since 1975 P	K
Lower Coastal Plain	−19	0
Upper Coastal Plain	+ 4	+15
Limestone Valley	−26	0
Black Belt	+85	+47

Other soil regions have not experienced this decrease in soil test P levels. Soil erosion would not be expected to decrease soil test K because of an increase in clay in the plow layer.

(3) Under-fertilization. The third possibility is under-fertilization. Fertilizer sales records indicate that considerably less fertilizer has been used in recent years than is needed, based on soil-test recommendations. No drastic changes in sales are obvious from year to year so one could conclude that under-use of fertilizer has been a factor for several recent years.

Overall fertility levels have improved most noticeably in the clay soils of Alabama's Black Belt prairie region. This was also the region of the most rapid acreage expansion into soybeans. However, much of the marginal lands in the Black Belt which were cultivated 10 years ago have been abandoned, and these growers are apparently doing a better job of fertilizing a smaller acreage.

Thirty years of soil test summaries in Alabama have provided some valuable long-term observations in the pH, P, and K status of the State's cropland soils. Many of these trends can be related to long-term changes in cropping practices and soil management, while others are not fully defined. ■

Maximizing Yields of Soft Wheat under Irrigation

By B.T. Roth, G. Reynolds and D.J. Major

Intensive crop management (ICM) looks promising as an alternative for growers of soft white spring wheat to improve returns per unit of production.

IN THE PAST 20 YEARS, semidwarf soft white spring wheat has become a more common crop in the irrigated areas of southern Alberta.

Now, approximately 450,000 acres of soft wheat are grown under irrigation in Alberta. During this time the agronomic practices being used have mainly been adaptations of production practices developed to produce cereals under the semiarid conditions that exist in Western Canada. Practices such as wide row spacings, low seeding rates, dryland fertilizer application technology, irrigation as only a supplemental practice, etc. have all combined to ensure that soft wheat yields were unable to reach their potential maximums.

Irrigated soft wheat yields in southern Alberta over the past five years have averaged 65 to 70 bu/A over the 350–450,000 acres of soft wheat grown. Under good growing conditions and good conventional management, field yields of 100 to 120 bu/A have been reported by wheat growers. Under irrigation, water becomes just another input that can be controlled, to some degree, thus differentiating irrigation intensive crop management (ICM) work from that conducted under rainfed conditions.

The objective of this study was to incorporate all appropriate ICM technology available into one irrigated field scale trial to obtain an indication of the maximum yield potential for soft white spring wheat and to determine the maximum economic yield level of management. **The objective of this study was achieved in 1985 with a maximum yield of 172 bu/A and a maximum economic yield of 156 bu/A. Thus, the study provided us with sufficient data to decide to enthusiastically pursue the management techniques that can provide growers with increased returns and 60–70% higher yields.**

In 1985, through a grant from the On-Farm Demonstration Program of Farming for the Future of the Alberta Research Council, one seven-acre site under pivot irrigation was chosen to maximize yields of soft white spring wheat utilizing ICM techniques. The rates of two variables, seed density and fertilizer applications, were varied on this non-replicated field-scale study while all other inputs were used uniformly throughout the plots. Each treatment was .32 acres in size with .18 acres of each plot being swathed, harvested by rotary combine and weighed through a weigh wagon. All field operations, including irrigation, were performed by the cooperating farmer, Dennis Friesen of Bow Island, Alberta.

The plot received the following treatments: soil moisture was maintained at or above 70% of field capacity as possible using weekly neutron probe readings (total moisture applied, 16.6 inches; growing season precipitation, 1 inch; soil stored moisture in the root zone, 7 inches; total available moisture, 24.6 inches); the semidwarf variety Owens was selected for its resistance to stripe rust which is always a disease threat under irrigation. The fungicide "Tilt" was applied at Zadoks growth stage 39 for the control of tan spot and stripe rust. Herbicides (2,4-D/Banvel and Mataven) were applied as required to eliminate any weed competition. No growth regulators were applied. The previous crop was dry peas.

Mr. Roth, Mr. Reynolds, and Dr. Major conducted this study under sponsorship of Farming for the Future, On-Farm Demonstration Program, Agricultural Research Council of Alberta. Mr. Roth is with Alberta Agriculture, Lethbridge; Mr. Reynolds is with Bow Island Soil Services, Ltd.; and Dr. Major is with the Research Branch, Agriculture Canada, Lethbridge.

Fertilizer Rates

The three levels of N-P_2O_5-K_2O applied were: 285-240-150, 185-160-110, and 85-60-20 lb/A, respectively. Of the total N added, 42 lb/A was applied to foliage at Zadoks growth stage 39.

A blend comprised of N, 25; P_2O_5, 12; K_2O, 12; S, 2; Zn, 4; Cu, 1; and B, 0.6 lb/A was drilled with the seed. The remaining quantities of plant nutrients were broadcast in the spring and incorporated by cultivating.

Residual N at the site was 98 lb/A in the top 2 feet and available soil P was also very high.

Seeding Rates

The plot was cross-seeded using a 28-foot hoe-drill, with 45 lb/A seeding in one direction and the balance seeded in 28-foot wide strips in the perpendicular direction. The seeding rates were 92, 141, 190 and 240 lb/A.

The 1985 crop year was characterized by below average rainfall and above average temperatures until late July. This resulted in very low incidence of disease pressure and greater than usual lodging.

The 240 lb/A seeding rate resulted in extensive lodging which substantially reduced the number of productive heads per square meter (m^2) and resulted in lower yields. Hopefully, the use of plant growth regulators (PGR's) in the future will reduce this lodging pressure. **The seeding rates which gave a population of close to 400 plants/m^2 resulted in the highest yields.**

The variety Owens, while offering some resistance to stripe rust, displayed a greater potential for lodging than the more popular variety Fielder. Owens in this trial lodged much earlier than did Fielder grown in an adjacent field.

Maximum Economic Yield

In a comparison of the net return over the cash costs of production for the various management levels **(Table 1)** the net return in all cases, except one, was highest at the lower fertilizer application rate.

The maximum economic yield (MEY) of 156 bu/A occurred with the 85-60-20 fertilizer application rate and the seeding rate that provided 392 plants/m^2. Cash costs per bushel at the MEY were $1.32/bu, compared to the costs at the maximum yield of $2.01/bu and at the area average yield of $1.96/bu.

Conclusions

This preliminary field-scale trial showed a promising potential for intensive crop management practices for irrigated soft white spring wheats. The two main factors contributing to the greatly increased yields appear to be: 1) A high seeding density of nearly two times the seeding rate, and 2) Intensive irrigation applications which brought total moisture available to nearly 25 inches. This study has also demonstrated that, in a world market where wheat prices are declining, the use of intensive crop management to improve the return per bushel is a sound economic alternative for the individual grower. ■

Table 1. Soft Wheat Maximum Yield—Return Over Cash Costs Comparison (per acre).

Direct Cash Costs	Area Average Production ($)	240 lb Seeding Rate 285-240-150	240 lb Seeding Rate 185-160-110	240 lb Seeding Rate 85-60-20	190 lb Seeding Rate 285-240-150	190 lb Seeding Rate 185-160-110	190 lb Seeding Rate 85-60-20
Seed	$ 11.88	$ 31.26	$ 31.26	$ 31.26	$ 24.80	$ 24.80	$ 24.80
Cross-Seeding	—	3.00	3.00	3.00	3.00	3.00	3.00
Fertilizer	37.03	172.14	115.93	48.13	172.14	115.93	48.13
Appl. of Foliar N & Tilt	—						
Herbicide	15.25	15.25	15.25	15.25	15.25	15.25	15.25
Fungicide	—	14.00	14.00	14.00	14.00	14.00	14.00
Machinery—Fuel & Repairs	55.50	55.50	55.50	55.50	55.50	55.50	55.50
Water Rates & Tax	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Misc. Overhead	4.00	4.00	4.00	4.00	4.00	4.00	4.00
Interest on Operating Capital	20.36	40.32	33.01	24.20	39.48	32.17	23.36
TOTAL	$156.68	$350.47	$286.95	$210.34	$343.17	$279.65	$203.04
Yield (bu/A)	80 bu	115 bu	107 bu	124 bu	172 bu	122 bu	156 bu
Gross Return (@ $3.80/bu)	$304.00	$437.00	$406.60	$471.20	$653.60	$463.60	$592.80
Net Return	$147.32	$ 86.53	$119.65	$260.86	$310.43	$183.95	$389.76

100 Bushel Wheat Yields, North of the 53rd Parallel

By K.G. Briggs, J.P. Tewari, W.H. Vanden Born and D. Audette

A team of researchers in Alberta reports progress in implementing integrated crop management techniques for wheat in northern latitudes.

THE CROP YEAR OF 1985 was a difficult one for most farmers of Alberta. Those in the South suffered from chronic drought and those in the more northerly areas, fortunate enough to receive reasonable summer rains, suffered from very wet harvesting conditions.

At Spruce Grove, west of Edmonton (53.5 North), the first year of a three-year project was nevertheless successfully completed. It is intended to determine the maximum yield potential of spring wheats in the Parkland Region, by applying integrated crop management (ICM) techniques.

Yield values reported are based on replicated large plots, of a minimum size of 2.5 acres each, with the crop being straight combined and hot air-flow dried. Yields were corrected to a 14.5% moisture basis. Rainfall patterns were very favourable both in amount and distribution, atypically so for the general area.

The ICM work in this region of Canada in 1985 demonstrated that spring wheat yields of over 100 bu/A can be obtained, and that application of ICM techniques can raise yields of spring wheats by up to 46%. The high yields obtained in these experiments compare to the 1985 regional yield estimate for spring wheat of 35-40 bu/A in the same area.

Three varieties of spring wheat were grown in large-scale replicated plots on the Fuhr farm at Spruce Grove in 1985, at two management levels: the 'O' good management level for inputs, and the '+' level (ICM) with high inputs of fertilizer, plant growth regulators, high seeding rates and fungicide use. The intention of this trial was to establish data on maximum yield potential, rather than to explain the main causes for any yield increases. The varieties used were Neepawa (the most popular Canadian Western Red Spring variety), HY320 (a high yielding late-maturing semidwarf wheat in the Prairie Red Spring class), and Oslo (an unlicensed American semidwarf

This on-farm, field-scale project is being carried out by the Department of Plant Science, Faculty of Agriculture and Forestry, University of Alberta, on behalf of the Canada Grains Council,* funded by the New Crop Development Fund (Agriculture Canada), and agricultural companies (Uniroyal Chemical, Esso Petroleum, BASF Canada Inc., Union Carbide, Ciba-Geigy, Rohm and Haas Canada Inc., Hoescht Canada, and Cooperative Federee de Quebec). It is also supported by the On-Farm Demonstration program of Farming for The Future, Agricultural Research Council of Alberta. All field operations were carried out by the cooperating farmer, Mr. Bruce Fuhr, using his own equipment.

*The Foundation for Agronomic Research (FAR) is providing financial support to the Canada Grains Council project.

The authors are with Department of Plant Science, Faculty of Agriculture and Forestry, University of Alberta, Edmonton, Alberta, Canada T6G 2E1.

Table 1. Treatments used in Integrated Crop Management Project.

'O' Fertility - 90 lb/A of N, anhydrous, banded, plus 50 lb/A of P_2O_5.

'+' Fertility - Same as 'O', plus another 90 lb/A of banded N, anhydrous, plus 100 lb/A of P_2O_5, half with the seed and half banded.

Plant growth regulators - Cycocel was applied at Zadoks stage 31 (June 22) to all three varieties at the rate of 2.5 litres/hectare in 200 litres of water/hectare. Cerone was applied at Zadoks stage 39 (July 4 for Neepawa and Oslo, July 8 for HY320) at the rate of 0.83 litres/hectare in 200 litres of water/hectare.

Fungicide - Tilt was applied to all varieties at Zadoks stage 36 at the rate of 0.5 litres/hectare in 200 litres of water/hectare, even though very little disease developed until the ripening stage in all varieties. Low temperatures and intermittent rains during ripening allowed mildew and Septoria to develop to high levels during grain dry-down (early September) and the fungicide was, not surprisingly, ineffective in controlling this development. Disease effects on yield were probably negligible.

wheat with reputed high yield potential and early maturity). All plots were seeded on May 17 using a hoe-drill seeder with 9″ row spacing. Earlier seeding was not possible due to low soil temperatures and untimely rains. The field was in barley in the previous year. Planned seeding rates of 250 seeds/square yard for the 'O' treatment and 420 seeds/square yard for the '+' treatment were not generally achieved due to equipment limitations for the large seeded varieties used. Avadex was sprayed on May 7 at 3.5 litres/hectare to control wild oats. In addition, Blagal was applied on June 17 at the rate of 2.3 litres/hectare in 100 litres of water to suppress Canada thistle and field horsetail.

Substantial yield increases were obtained by applying ICM methods, leading to a maximum yield level of 114 bu/A for HY320, at a 14.5% moisture basis. This is

Table 2. Spring Wheat Results in Intensive Crop Management Project.

	Variety	'O'	'+' CCC	'+' Cerone	% Change From 'O' CCC	% Change From 'O' Cerone
Yield, bu/A	Neepawa	68	87	78	+28	+15
	HY320	78	114	108	+46	+38
	Oslo	80	97	99	+21	+24
Kernels/m²	Neepawa	13200	16280	14790	+23	+11
	HY320	13110	17890	16290	+36	+24
	Oslo	14860	17540	17490	+18	+18
Height, cm.	Neepawa	98	91	77		
	HY320	74	75	66		
	Oslo	82	80	68		
Lodging 0.2-9 (Belgium Index)	Neepawa	3.0	-	2.0		
	HY320	3.0	-	0.2		
	Oslo	0.2	-	0.2		
Harvest Dates	Neepawa	September 18 (Ready)				
	Oslo	September 23 (Ready)				
	HY320	October 10-15 (Green)				

believed to be a record spring wheat yield for a farm field in this region. The main component of management contributing to yield cannot be determined from this trial, but the expression of high yield seems to be accounted for mainly by an increased number of seeds per unit area. Control of lodging also probably contributed to higher yields in the '+' treatments for HY320 and Neepawa, but the effects of the fungicide on yield were not significant.

The observation was made that high fertilizer levels, as well as application of growth regulators, tended to delay ripening, though this was not quantifiable due to experimental limitations. In an agronomic context it should also be noted that the late maturity of the HY320 '+' plots puts this particular management combination out of practical reach of farmers in this area. While a two-day break in the weather allowed harvest of these large plots, it would not have been possible to harvest large acreages under this regime at Spruce Grove in 1985, due to poor weather during the harvest period.

The 98-bu/A yield of the semidwarf Oslo is of greater interest for further evaluation than is any further testing of HY320, since Oslo matures in a time frame similar to that of Neepawa. However, even Neepawa is considered too late maturing by many farmers in this area. The economic functions of the various production regimes are now being evaluated, to determine which management package, including choice of variety, leads to maximum economic yield. These field-scale experiments will be continued for two more years. They are backed up by small-plot ICM component trials conducted at the University of Alberta Farm, Edmonton, in which yield levels ranging from 90 to 104 bu/A were obtained for seven out of fourteen semidwarf and other cultivars tested in 1985.

Conclusions

Application of Integrated Crop Management techniques on large-scale plots in 1985 under farm conditions has illustrated the following:

1. Spring wheat yields over 100 bu/A are attainable on farm fields in the Edmonton region.

2. A record wheat yield of 114 bu/A was obtained with HY320 in 1985, following application of 180 lb of actual N plus 100 lb/A P_2O_5 with Cycocel growth regulator and Tilt fungicide also applied.

3. The extremely late maturity of HY320 both under normal management and under ICM management in 1985 supports the recommendation that this variety not be grown in the Edmonton area.

4. The high yield and acceptable maturity of the unlicensed semidwarf spring wheat Oslo in this trial, at both management levels, support the need for extensive research concerning the production and market potential of this type of wheat in the Parkland region.

5. These 1985 results clearly illustrate the key problem for wheat producers in this region, namely, the balance of yield potential vs. time to maturity of different varieties under different production regimes. ■

Reference: Zadoks, J.C.; Chang, T.T.; and Konzak, C.F.; 1974. A decimal code for the growth stages of cereals. Weed Res. 14: 415-421.

Nutrient Uptake in High-Yielding Wheat

By B.D. Brown

Higher wheat yields increase plant nutrient uptake. The uptake figures for irrigated wheat in Idaho research and dryland wheat in Washington research are compared.

IRRIGATED SOFT WHITE WINTER WHEAT in the Pacific Northwest has high potential for yield. High yielding wheat can be expected to increase the uptake and need for plant nutrients. This can be illustrated by comparing the nutrient uptake into wheat as reported in research trials within the region.

Dr. F.E. Koehler, Professor in Soil Fertility, Washington State University, reported uptake of N, P, K, S, Ca, Mg, Zn, Mn, and Cu for dryland wheat yielding 108 bu/A. We collected similar data from our wheat research at the University of Idaho, SW Idaho Research and Extension Center, where wheat yields averaged 164 bu/A. The nutrient uptake for the two wheat crops is shown in **Table 1.** Differences in nutrient uptake for the two crops are also shown.

Table 1. Nutrient uptake and differences in nutrient uptake in the aboveground portion of wheat in two wheat research trials in the Northwest.

Trial	N	P	K	S	Ca	Mg	Zn	Mn	Cu
	lb/A								
Idaho (Irrigated-164 bu/A)	233	38.4	222	30	38	23	.33	.80	.05
Washington (Dryland-108 bu/A)	158	42.6	120	10	20	13	.25	.36	.03
Difference (lb/A)	75	-4.2	102	20	18	10	.08	.44	.02
Difference (%)	47	-9.8	85	200	90	76	32	122	67

Grain yield was almost 52% higher in the irrigated trial. Nutrient uptake increased as much as 200% in the higher yielding wheat. Phosphorus was the only nutrient that did not show at least 32% increased uptake.

The results show the increased nutrient uptake associated with a higher yielding wheat crop. The yields were measured with a small-plot combine. The irrigated wheat yield is well above the average for the county, but actually below some of the yields reported by producers. In 1983, there were three undocumented reports of 200 bu/A wheat in the area.

These high yields may or may not require additional fertilizer applications, depending on residual soil fertility resulting from previous applications. For example, P and K fertilizer did not significantly affect dry matter or grain yields in the irrigated wheat trial. In some cases additional fertilizers will be required for maximum economic yields.

Wheat producers should be informed of the increased nutrient requirements in situations where considerable yield increases are expected to result from significant changes in crop management, such as introduction of irrigation. ■

Dr. Brown is with the University of Idaho, Department of Plant, Soil and Entomological Sciences.

From Research to Implementation – Dr. Flannery Goes to the Field

DR. ROY FLANNERY, Rutgers University Professor of Soils and Crops, achieved six-year average yields of 306 bu/A of corn and 103 bu/A of soybeans in maximum yield research plots.

Now, he is moving into a new phase of work, a program to implement production practices in field-scale demonstrations for maximum economic yield (MEY) systems.

A grant of $45,000 from the Foundation for Agronomic Research (FAR) will help support the work over three years.

"We're enthusiastic about moving to this new effort with corn and soybean to help producers lower their unit production costs," said Dr. W.K. Griffith, of Great Falls, Virginia. He is Eastern Director of the Potash & Phosphate Institute, (PPI). FAR is a non-profit organization affiliated with PPI to encourage agronomic research and education programs. FAR now supports about 70 projects in the U.S., Canada, and other countries.

DR. W.K. GRIFFITH, Eastern Director, Potash & Phosphate Institute (PPI), is shown with Dr. Roy Flannery (right) during presentation of grant.

The field-scale demonstrations will be on farms in New Jersey, with the following objectives:

1) To demonstrate the feasibility of intensively managed corn and soybeans on a field-scale with yield goals of 250 bu/A corn and 80 bu/A soybeans;

2) To evaluate the yields and economic returns of the intensive (MEY) system compared to current recommended practices;

3) To inform corn and soybean producers in the state regarding the benefits of MEY production, based on results of the demonstration.

From his experience with maximum yield research, Dr. Flannery has some definite ideas on certain management decisions in the field-scale plots. For example, an ample and balanced fertilizer program will be maintained through monitoring and multiple applications. Recommended chemicals plus close observation (scouting) throughout the growing season will be used to control yield-limiting pests such as weeds, insects and diseases. A Heath Precision Planter will be used in order to achieve narrow row widths and precision seed spacing within rows for both corn and soybeans. ■

On the Light Side

The airline passenger approached the outbound counter with three items of luggage, and wearily plopped them on the scale.

"Send the big brown one to Madrid, the suit bag to Tokyo, and the black case to Bogota."

"Sorry, sir," said the attendant. "I can't do that."

"Why not?" snapped the passenger. "You did it last year."

An alarmed motorist stopped beside an overturned small sports car.

"Anyone hurt in the accident?" he inquired.

"There wasn't any accident," replied a young man calmly. "I'm changing a tire."

Worry is like a rocking chair. It gives you something to do, but it doesn't get you anywhere.

THE PROBLEM: Poor early corn growth.

Plant Problem Insights

for Maximum Economic Yields (MEY)

POOR EARLY corn growth can limit profits in many ways:

- **Lost yield potential**
- **Uneven stands**
- **Greater erosion potential**
- **Later maturity**

Phosphorus (P) is one of the most important nutrients for vigorous early corn growth.

The picture* shows how starter fertilizer, including P, banded near the seed at planting can increase early plant growth. Recent research has shown more and more situations where yield responses have resulted from this early growth advantage.

Cool soil temperature is one of the factors most often associated with starter P yield response. Cool soils tend to slow root growth and decrease P diffusion to the root, both limiting P uptake.

Management practices which compound this effect are **earlier planting** and a shift to **conservation tillage** . . . the added surface trash means that soils warm up more slowly.

Response to starter P is most consistent as you move to the northern part of the Corn Belt. . .where cool, wet, spring conditions are more frequent. . . but more frequent responses are being seen even as far south as Alabama, South Carolina and Georgia. Responses often occur even on high P testing soils, where management for high yield potential is being used.

Even if soils are built up to high P levels, it's important to consider some method of applying maintenance amounts. Banding maintenance rates of P along with nitrogen (N) as a starter is a good option to consider. It will help early corn plant growth, maintain P soil fertility levels, and provide the opportunity for those bonus bushels in the years when response occurs. ■

*Photo courtesy of Dr. W.I. Segars, University of Georgia.

This message is available on a 3½ x 7½-inch information card. Other topics also currently available in the "Plant Problem Insights" series are: ***Weak and Thinning Alfalfa Stands, Poor Early Wheat Growth, Lodged Corn,*** *and* ***Soybean Cyst Nematode.*** *For more information, contact: Potash & Phosphate Institute (PPI), 2801 Buford Hwy., NE, Atlanta, GA 30329 (404) 634-4274.* *(See order form on page 31.)*

Soil Disinfection and Fertilization Help Offset "Apple Replant Disease"

By John T. Slykhuis

Here are some techniques for improved growth of young apple trees.

FREQUENTLY, apple trees planted after old apple, pear, and sometimes after stone fruit trees, grow very poorly in spite of the best of care with respect to soil pH adjustments before planting good quality trees, adequate irrigation, nitrogen fertilizers, and minor element sprays, and good insect, leaf disease and weed control.

Greenhouse tests on 133 apple orchard soils showed that soil disinfection increased the growth of test seedlings by 50% to more than 500%, with an average increase of 86%, in 61% of the soils.

Growth increases averaging 153% occurred in 86% of the soils from use of ammonium phosphate fertilizer (11-55-0) alone. A combined treatment including soil disinfection and 11-55-0 fertilizer significantly increased the growth of apple seedlings in all old orchard soils tested. The average increase was 294%, but in several soils growth was increased by 7X to 11X with the combined treatment. In some soils, disinfection was of no benefit but the fertilizer was. In soils with very high levels of available phosphorous (P), a nitrogen (N) fertilizer was as beneficial to growth as 11-55-0.

Seedling growth tests in the greenhouse have given good indications of effects of treatments on the growth of young trees in the orchard. It is advisable to have results from such seedling growth tests and of chemical soil analysis before deciding the best treatments and fertilizers to use in your orchard.

Soil Disinfecting Treatments

Soil disinfecting treatments that have been effective in some regions or orchards may not be effective in some others where there are different causal organisms and different nutrient levels. Disinfectants that kill a wide range of organisms are effective in more soils than the more specific treatments, but they also eliminate more of the beneficial soil organisms.

Commercial formalin containing 37 to 40% formaldehyde is very effective in most replant disease soils, but has been of questionable value in a few.

Excellent control of apple replant disease has been achieved with dazomet in some field trials but it will cause tree damage and death if fumes have not all escaped before planting.

Heat at 70 °C for 1 hr. has been the most effective and convenient soil treatment for greenhouse tests. It kills most of the harmful fungi and nematodes but many beneficial organisms survive.

Captan (100-200 grams of 50% WP/tree site) or Mancozeb (30-60 grams of 80% WP/tree site) thoroughly mixed in the soil before planting have resulted in fair to good growth in some replant problem soils, but have been ineffective in others.

Fertilizers for replanting apple trees

Ammonium phosphate fertilizer (11-48-0, 11-51-0 or 11-55-0) should be used at 100 to 200 grams per tree site (one level measuring cup of 11-55-0 weighs 240 grams).

Since P does not move readily in the soil like N, the fertilizer should be mixed with the soil before planting. Care must be taken to avoid concentrations of the fertilizer close to the roots or burning and death may result. Various methods have been used to mix the fertilizer with the soil while digging or augering the planting holes, or before returning the soil around the roots while planting. One method is to place some of the fertilizer on the center of each planting site before augering.

Some growers have suspended the fertilizer in a volume of water in a spray tank and while agitating, pumped the required amount around the base of each tree. ■

Dr. Slykhuis recently retired from the Agriculture Canada, Research Station, Summerland, British Columbia. His current address is R.R.1, Site 2, Summerland, B.C., Canada VOH 1Z0.

Information Materials from PPI

HERE'S HOW to order materials from the Potash & Phosphate Institute (PPI). A complete catalog of publications and visuals from PPI will be returned with your request.

Plant Problem Insights for Maximum Economic Yields See page 29. This is a colorful series of photo-cards, each with a concise discussion of a specific field problem, along with positive tips for increasing yields and profits. Specify your choices: **Poor Early Corn Growth ____; Weak and Thinning Alfalfa Stands ____; Lodged Corn ____; Poor Early Wheat Growth ____; Soybean Cyst Nematode ____. Cost per card: 10¢ each (5¢ MC*)**

Quantity **Cost**

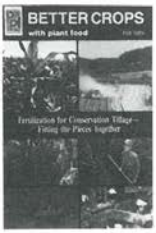
_____ $ _____

Right Inputs for MEY and the new Farm Bill This useful folder offers ideas for managing crop production in 1986 to achieve maximum economic yields. **Cost: 25¢ each (15¢ MC*)**

_____ $ _____

Fertilizing Soybeans for Maximum Economic Yields This is a new slide set aimed at improving farmer yields through sound management practices, including fertilization. The research data serve as a basis for showing that higher, more profitable yields are practical for today's farmer. **The set contains 41 slides: $15 per set ($10 MC*), with printed script.**

_____ $ _____



Fertilization for Conservation Tillage—Fitting the Pieces Together Additional copies of the Fall 1985 issue of *Better Crops with Plant Food* are available. Focus of the entire 40-page issue is on conservation tillage and related fertilization practices. **Cost: $1.25 each ($1.00 MC*)**

_____ $ _____

***The MC* symbol indicates Member Cost: For members of PPI, contributors to FAR, to university and government agencies.**

Total cost $ _____

20% discount on orders of 1,000 or more copies of a single item

☐ **Payment enclosed**
☐ **Bill me, add shipping to invoice**

Name _____

Address _____

City _____ **State** _____ **Zip Code** _____

Organization or Firm _____

Send to Potash & Phosphate Institute, 2801 Buford Hwy., NE, Suite 401, Atlanta, GA 30329 (404) 634-4274

Do You Want to Stay in Business?

"WHEN are you going to turn off that 'Maximum Economic Yield' record?", I was asked, "Haven't you worn it out?"

The answers are "never" and "no".

Anyone who doesn't believe in producing at the maximum economic yield (MEY) level, just doesn't understand it. It does **not** advocate producing the highest possible yield. It **does** promote producing at the yield level that results in the lowest cost per unit, the level that results in the greatest profit per acre. Can anyone honestly say there's anything wrong in that?

MEY is a moving target. It varies with the conditions. Still, it is the **only** way American farmers can hope to compete in the domestic and world markets—to become more efficient. That's true of every business—become more efficient to stay in business.

The individual farmer can do little about crop prices, surplusses, interest rates, the strong dollar, or the federal deficit. But he **can** strive to produce his own crops at the lowest possible cost per unit—and that's MEY.

What do you mean, "It won't work?"■

—J. Fielding Reed

Better Crops
WITH PLANT FOOD
Potash & Phosphate Institute
2801 Buford Hwy., N.E., Suite 401, Atlanta, GA 30329

Second-Class postage paid at Atlanta, GA