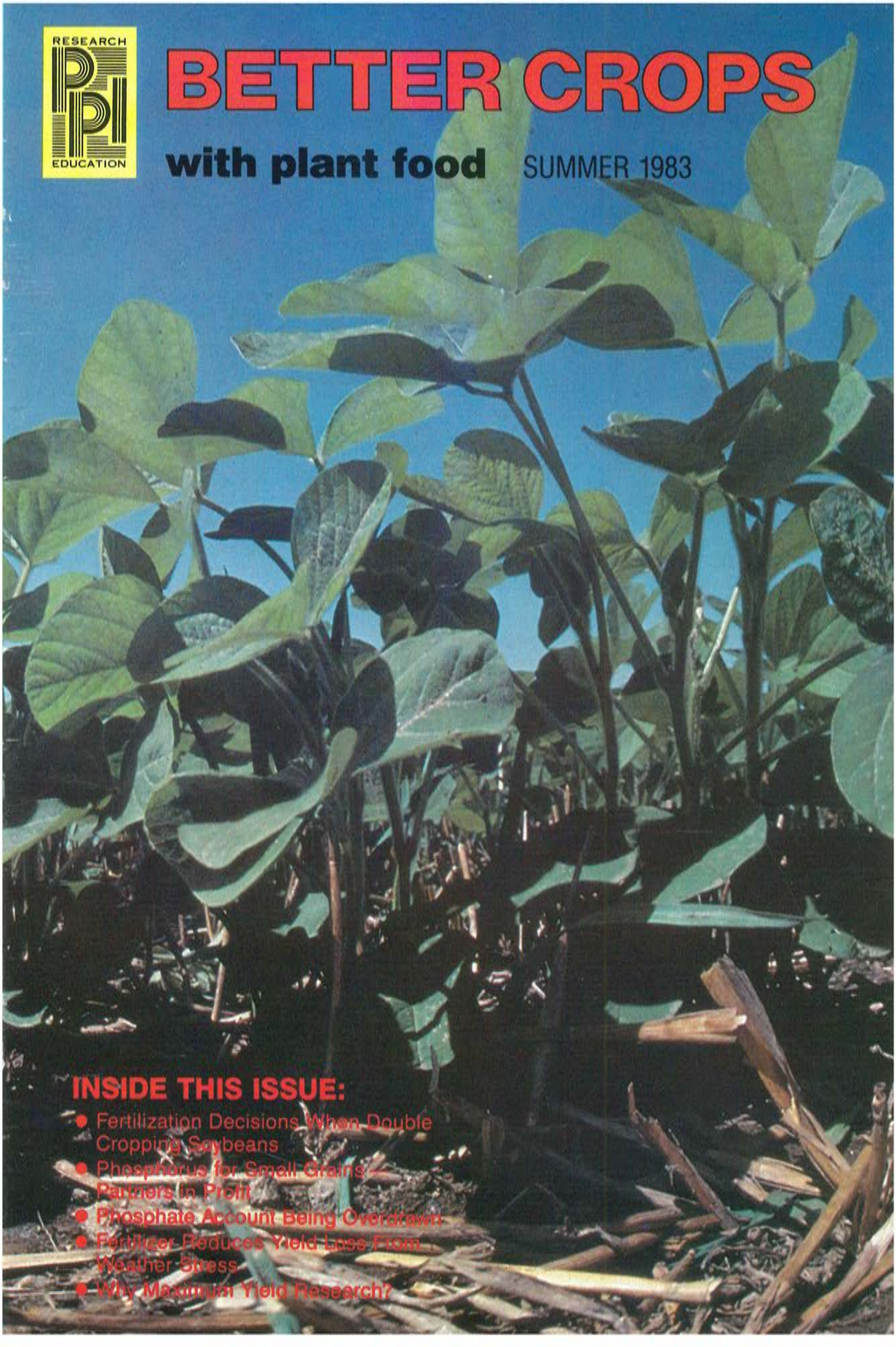
RESEARCH
EDUCATION

BETTER CROPS

with plant food

SUMMER 1983



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BETTER CROPS with plant food

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Vol. LXVII Summer 1983

BETTER CROPS (USPS 396850) is published quarterly by the Potash & Phosphate Institute. Subscription price is $5.00 per year or $1.25 per copy. 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.

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Our cover: Doublecrop soybeans planted in small grain stubble, Carroll County, Maryland. USDA photo.

Fertilization Decisions When Double Cropping Soybeans

By James H. Herbek

FERTILIZATION is only one of the many production factors in a management package for successful doublecropping. Too often, though, fertilization is overlooked or given a low priority.

Sound fertilization decisions should involve the following: (1) Soil testing; (2) Crop nutrient removal; (3) Lime and fertilizer use; (4) Timing of fertilizer applications; and (5) Methods of application.

While there are numerous doublecropping systems involving many different crops, this article is primarily concerned with small grain-soybean combinations.

Soil Testing

A chemical analysis can determine nutrient levels in the soil and provide a guideline for fertilizer and lime needs. Test results should be considered in conjunction with past fertilizer management, cropping history and soil types for reliable fertilizer recommendations.

Because doublecropping is more intensive than normal cropping, closer monitoring for acidity and fertility changes is needed. Annual soil testing is best for doublecropping.

Crop Nutrient Removal

Total nutrient uptake and removal in a doublecropping system is the sum of nutrients removed by both crops. As yield level increases, nutrient removal increases. Also, harvesting the whole plant as either silage or grain plus residue will result in more nutrient removal than if the grain alone were removed.

Phosphorus (P) and potassium (K) are the primary fertilizer nutrients to consider. In many cases, the P and K removed in the grain alone total more than the nutrients applied in fertilizer. **Table 1** shows amounts of plant nutrients removed in cropping systems.

Table 1. Plant nutrients removed in several cropping systems (lb/A).

	N	P_2O_5	K_2O
Barley, 80 bu	88	32	26
Soybeans, 40 bu	159	32	56
Total	247	64	82
Wheat, 60 bu	72	33	20
Soybeans, 40 bu	159	32	56
Total	231	65	76
Wheat, 60 bu	72	33	20
Wheat straw	34	8	108
Soybeans, 40 bu	159	32	56
Total	265	73	184
Oat silage, 6 Tons	83	23	176
Corn silage, 20 Tons	166	71	166
Total	249	94	342
Corn grain, 150 bu	113	65	43
Soybeans, 60 bu	240	48	84
Soybean stover	84	16	58

For soils testing medium or lower in fertility, we recommend a maintenance plus buildup program. This means applying fertilizer equal to the amount of nutrients removed by the two crops, along with an additional amount to improve soil test levels. **(continued on page 4)**

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(Doublecropping . . . from page 3)

Soil pH is one of the most important considerations in any fertilization program. Liming to maintain a soil pH of 6.2 to 6.8 would be adequate for both the small grain and soybean crops and optimum for most soils. In addition to yields, liming benefits include: improved fertilizer efficiency for P and K; greater availability of nutrients such as molybdenum, magnesium, and calcium; reduction of high concentrations of aluminum and manganese that reduce plant growth; and improved nodulation and nitrogen (N) fixation for soybeans.

Nitrogen

Nitrogen needs in doublecropping depend on the crops being grown. For example, N fertilization for small grain is very important, but N fertilization for soybeans has very limited use.

The University of Kentucky currently recommends a total of 60 to 90 lb of N/A for soft red winter wheat. Lodging could be a problem at higher rates. Most recommendations in the Southeast call for split applications to avoid N losses during winter.

A high yielding soybean crop also requires large amounts of N. Ensuring effective N fixation is the most economical way to supply N to soybeans, although N application may increase yields under very limited situations.

Phosphorus and Potassium

Both small grain and soybean crops are responsive to P and K if the nutrients are made available. Good yield increases are generally expected with P and K on soils testing in the low-to-medium range. However, it is at the high soil test levels that maximum yields of the two crops can be expected. So, the fertility objective for P and K in a doublecropping system should be aimed at building soil tests to a high level.

Table 2 shows yield response of doublecropped soybeans to residual soil levels of P and K.

Table 2. Yield response of doublecropped soybeans to residual soil levels of P and K.

Soil Test K (lb/A)	Soil Test P (lb/A) 56 (H. Med.)	69 (High)	157 (V. High)	Avg.
	Soybean Yield (bu/A)			
144 (Low)	32.5	31.9	28.6	31.0
183 (Med.)	37.5	38.8	36.7	37.6
374 (V. High)	40.1	40.8	40.8	40.6
Avg.	36.7	37.2	35.4	

University of Kentucky

Table 3 shows results of a five-year Tennessee study on effects of P and K rates on wheat and soybean yields and soil test levels. All P and K was applied in fall at wheat seeding on a Loring silt loam soil; 30 to 60 lb of N/A was topdressed each spring.

Several trends emerge from the five years of data: (1) Additions of P_2O_5 increased both wheat and soybean yields slightly; (2) 60 lb of P_2O_5/A was needed to maintain initial P soil test levels; (3) Additions of K_2O did not seem to affect yields, probably because initial K soil test levels were in the high-medium range; (4) 60 to 90 lb of K_2O was needed to maintain initial K soil test level.

Timing and Methods of Application

On most soils and for most doublecropping systems, there is considerable flexibility in P and K applications. P does not move readily in the soil and has a long residual value. K losses are negligible except on sandy soils. Thus, large amounts of P and K can be applied at one time to build up soil test levels rapidly. P and K can also be applied in the fall for both crops and be as effective as annual applications to each crop.

Broadcasting is likely to be the most practical and simplest method of applying fertilizer, especially where high rates are being used or on medium-to-high testing soils.

Table 3. Effect of annual applications of P_2O_5 and K_2O on doublecropped wheat and soybean yields and soil test levels (1976-80).

Treatment (lb/A)		Yield (5-yr. avg.) (bu/A)		Soil Test (lb/A)* Oct. 1980	
P_2O_5	K_2O	Wheat	Soybeans	P	K
0	0	50	27	10	123
30	90	55	28	13	193
60	90	57	30	17	170
120	90	60	32	28	183
90	30	57	30	22	120
90	60	56	31	23	180
90	120	53	30	26	200

*Initial soil test levels: P, 16 lb/A (medium); K, 180 lb/A (medium); pH, 6.5. University of Tennessee.

With increasing use of no-till for doublecrop soybeans, there has been some concern about concentrations of P, K, and lime near the surface. Still, nutrient uptake by plants has been comparable to that with conventional tillage, most studies show.

Summary

Fertilization is an important part of a doublecropping system. Soil testing to determine nutrient needs should be the first step in making fertilizer decisions.

Doublecropping intensifies nutrient removal. Crop yields and method of harvest will influence the amounts of nutrients removed. Responses to P, K, and lime can be expected for small grains and soybeans at low soil test levels. For small grains, N is also important.

Building and maintaining soil test levels to a medium-to-high range ensures top yields. Fall fertilizer application to meet the needs of both crops before seeding the small grain crop is effective and practical. Broadcast surface applications of fertilizers in no-till doublecropping systems have been effective and comparable to fertilizer incorporation. ■

Maximum Economic Yield Systems – How They Work for Conservation

THE ONLY proven way for the individual farmer to stay in business is to farm at the Maximum Economic Yield level. Research and farmer experience show that higher yields **reduce the cost of production per unit.**

Yet, there is some concern that these high yields may increase erosion or be harmful to the soil. Actually, the opposite is true. Proper fertilization and other high-yield management practices can reduce erosion and **build soil productivity.**

Conservation tillage and maximum economic yields can go hand in hand. A recent folder from the Potash & Phosphate Institute (PPI) describes how these important ideas work together.

Titled **"Maximum Economic Yield Systems – How they Work for Conservation"**, copies of the folder are available now. **The cost: 15¢ each (10¢ each for PPI member companies, universities and government agencies).**

For more information, contact: Potash & Phosphate Institute, 2801 Buford Hwy., N.E., Atlanta, GA 30329. Phone: (404) 634-4274.

Fertilizer Reduces Yield Loss From Weather Stress

By Jay Johnson

WITH TODAY'S narrow profit margins, farmers must reduce any risk that lowers yields and income. High production costs take away the luxury of going broke slowly. A year of sharply reduced yields is now more economically painful than ever before.

Of the many factors that control yield, soil fertility is one that can reduce risks due to weather extremes. Research in many states has shown that a good fertility program reduces yield loss from bad weather. Research in Ohio adds further credence to this fact.

Response to Potassium

A research site near Springfield, Ohio experienced alternate wet and dry years on two occasions: first in 1976 and 1977 and again in 1980 and 1981.

Table 1 shows the corn yields in 1976 and 1977. The excellent growing season of 1976 produced corn yields of over 160 bu/A on a Crosby silt loam – excellent yields for this light-colored soil. There was no response to K in 1976.

Table 1. Effect of K_2O on corn yields and profits in a year of good rainfall and in a dry year.

K_2O Annual	Good year 1976	Stress year 1977	Yield loss
lb/A	------------- Yield,	bu/A -------------	
0	163	81	82
50	163	113	50
100	167	121	46
200	163	129	34
Response to K_2O	0	48 bu/A	
Profit from K_2O	0	87 $/A	

Average of two harvest dates. Corn $2.65/bu, K_2O 13¢/lb, 30¢/bu harvesting cost deducted. Soil test prior to treatments: 162 lb K/A (medium). N rate: 300 lb/A. P_2O_5 rate: 80 lb/A. Row width: 30 in. Seed drop 27,800/A. Hybrid: Pioneer 3330.

Weather in 1977 was cooler and drier than in 1976 and there was a 48 bu/A response to K on this medium K soil. Yield loss from 1976 to 1977 was reduced from 82 bu/A with no K_2O to 34 bu/A with 200 lb/A K_2O.

The profit from adding 200 lb/A K_2O to the corn was $87/A in 1977. When the zero response in 1976 is included, the profit becomes $30/A/yr over the 2-year period.

In 1980 and 1981, with soybeans as the test crop, the study was changed to include comparisons of residual versus directly applied K_2O. The K_2O rates in **Table 2** are the amounts applied every other year.

The 1980 season was favorable and the soybeans yielded over 60 bu/A. There was a 4 bu/A response in 1981 to the optimum K_2O rate of 100 lb/A. The profit was $18/A.

The 1981 season was wet early but dry during podfill. The response to K_2O was 18 bu/A in 1981, even though overall soybean yields were lower than in 1980. The profit from K_2O was $105/A on this soil with the control plots now testing low in K.

Yield loss from 1976 to 1977 was reduced from 26 bu/A with no K_2O to 10 bu/A with 200 lb/A K_2O.

Note that after five years of adding K, the soil test on the control plot had dropped to 129 lb K/A from the original 162 lb/A. The annual K_2O rate of 100 lb/A only slightly increased the soil K level and 200 lb/A of K_2O per year had still not built the soil to a high level of K.

Soybean Response to Phosphorus

At another site on the same farm, soybeans in a corn-soybean rotation had

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Table 2. Effect of K_2O on soybean yields and profits in a year of good rainfall and in a dry year.

K_2O	Good year 1980	Stress year 1981	Yield loss	Soil Test Fall 1980
lb/A	----------- Yield, bu/A		-----------	lb K/A
0	56	30	26	129
50	59	42	17	152
100	60	48	12	196
200	58	48	10	236
Response to K_2O*		4 bu/A		18 bu/A
Profit from K_2O		18 $/A		105 $/A

*At the 100 lb/A K_2O rate. K_2O rates applied every other year. Soybeans $6.50/bu, K_2O 13¢/lb, 30¢/bu harvesting cost deducted. P_2O_5 rate: 50 lb/A. Row width: 7 in. Seed drop: 225,000. Variety: Sprite.

Table 3. Effect of P_2O_5 on soybean yields and profits in a year of good rainfall and in a dry year.

P_2O_5 Annual	Good year 1980	Stress year 1981	Soil Test Fall 1980
lb/A	Soybean Yield, bu/A		lb P/A
0	46	46	18
40	48	49	26
80	47	50	36
120	47	52	40
Response to P_2O_5	1 bu/A		6 bu/A
Profit from P_2O_5	0 $/A		4 $/A

Soybeans $6.50/bu, P_2O_5 28¢/lb, 30¢/bu harvesting cost deducted. K_2O rate: 120 lb/A. Row width: 7 in. Seed drop: 225,000/A. Variety: Hobbit.

shown little response to P until the poor growing season of 1981. **Table 3** compares 1980 and 1981 yields. In 1981, there was a 6 bu/A response to P with a profit of $4/A on this low P soil.

Dry Weather Reduces Leaf P and K

Research shows that the P and K content of the corn and soybean leaves was reduced in the dry year of each "good year-dry year" comparison. Even the highest K_2O rate failed to bring the leaf K content up to sufficiency levels in the dry years. This inability to take up adequate amounts of nutrients probably contributed to the lower yields of the dry years. See **Table 4.**

The data illustrate a limitation of using plant analysis to evaluate the success of a fertility program. Dry weather restricts root growth and reduces nutrient uptake. Fertilizer additions can only partially offset this effect. This is why it is important to consider all factors affecting plant growth when interpreting plant analysis data.

Ohio research shows that a good fertility program reduces yield losses from bad weather. Profits and yield responses to P and K were greatest in dry years. While a farmer cannot completely avoid yield losses from weather extremes, he can reduce the risks by following good management practices. ■

Table 4. Effect of K_2O and P_2O_5 on K and P content of corn and soybean leaves in years of good weather (1976 and 1980) and in years of dry weather (1977 and 1981).

	Corn[2]		Soybeans[3]			Soybeans[3]	
K_2O[1]	1976	1977 Stress	1980	1981 Stress	P_2O_5 Annual	1980	1981 Stress
lb/A	----------------------	%	K ----------------------		lb/A	--------%	P--------
0	1.60	0.70	1.41	0.77	0	0.39	0.25
50	1.65	1.11	1.80	1.03	40	0.42	0.28
100	1.73	1.38	2.23	1.23	80	0.45	0.30
200	1.65	1.43	2.41	1.43	120	0.41	0.31
Sufficiency	-------------------	1.70% K	-------------------			----- 0.26% P -----	

[1] For 1976 and 1977 K_2O rates were annual. For 1980 and 1981 K_2O rates were for every other year.
[2] Ear leaf at initial silk.
[3] Uppermost fully developed leaf at initial bloom.

High Residual Potassium Level, Early Planting Give Top Soybean Yields

By Doyle Peaslee, Ted Hicks and Dennis Egli

BUILDING SOIL TEST potassium (K) to very high levels improved soybean yield, seed size, and quality in University of Kentucky research. The response to K was greater at earlier than at later planting dates.

The study was on a Maury silt loam site that had previously been in a corn fertility study. The corn received annual rates of phosphorus (P) and K for 12 years from 1960 to 1971. No P and K had been applied in the five years immediately prior to 1977 when soybeans were grown.

Because the soil originally tested high in P, the soybeans did not respond to residual P. The discussion here will be limited soybean responses averaged over all P rates.

Soil K Levels

The effect of the corn fertilization on soil K was reflected in samples taken in the fall of 1976, as shown in **Table 1.** The 12 years of fertilization and crop residue removal had caused the soil K levels to segregate into low, medium, and very high categories according to University of Kentucky classifications.

Table 1. The effect of 12 years of corn fertilization on soil K levels.

K_2O	lb/A	K	
Annual rate for 12 years[1]		Soil test Fall 1976[2]	Soil test level index
0		144	Low = less than 165
60		204	Medium = 165 to 250
241		429	Very high = greater than 375

[1]The K was applied as muriate of potash from 1960 to 1971. Cropped to corn annually, and stover removed.
[2]Ammonium acetate extractable K.

Soybean Yields

The yields **(Table 2)** tended to increase with increasing soil test levels of K at all planting dates, but the effect was much greater at the May 27 planting dates. A 13 bu/A increase in soybean yield was measured in comparing the low to the very high K levels, and a 6 bu/A increase in comparing medium to very high soil test levels at the earliest planting date. There was a 6 bu/A response at the June 16 and July 8 planting dates, with most of the response associated with an increase of soil test K to the medium level.

Yield as affected by planting date is also shown in **Table 2.** Later planting decreased soybean yields 9 bu/A at the low soil K level and 16 bu/A at the high K level. Clearly, both planting date and K nutrition had to be optimized in order for each factor to

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Table 2. Effect of K soil test level and planting date on soybean yield.

Planting date	Soil test K level			Response to K
	Low	Med.	Very High	
	soybean yield, bu/A			
May 27	40	47	53	13 bu
June 16	40	44	46	6 bu
July 8	31	36	37	6 bu
Response to planting date	9 bu	11 bu	16 bu	

Soybean variety: Cutler 71

have a maximum effect on yield. We have observed the response to the very high levels of soil K in this experiment when environmental conditions favor disease.

Seed Number and Seed Size

Seeds per acre and seed size were measured to identify the yield factor which was most affected by K nutrition. It was found that the **number of seeds per acre increased more in response to K levels than did seed size.**

Seeds per acre were increased both by higher K levels and earlier planting **(Table 3).** Seed numbers increased 14 to 16% for the low compared to the very high K level and increased 26 to 28% for early compared to late planting.

Table 3. Effect of soil test K level and planting date on soybean seeds per acre.

Planting date	Soil test K level			Increase due to higher K level
	Low	Med.	Very High	
	Seeds per acre (100,000s)			%
May 27	53	57	63	19
June 16	53	57	59	11
July 8	43	46	49	14
Increase due to earlier planting	23%	24%	29%	

Table 4 shows that seed size was increased both by higher soil K levels and by earlier planting. While the percent increase in seed size was smaller than for seed number, the larger seeds had a significant effect on yield.

Seed size was affected more by K at the earlier planting date. Similarly, planting date had the greatest effect on seed size at the higher soil K level.

Table 4. Effect of soil test K level and planting date on soybean seed size.

Planting date	Soil test K level			Increase due to higher K level
	Low	Med.	Very High	
	Seed size, grams/100 seeds			%
May 27	17.8	19.6	20.0	12
June 16	18.0	18.4	18.4	2
July 8	17.1	18.4	18.0	6
Increase due to earlier planting	4%	7%	10%	

(continued on page 10)

(Soybean yields . . . from page 9)

Seed Disease

Harvested seed was visually scored for purple discoloration and moldy seeds. The rating scale was 1 to 5, lowest to highest incidence of disease symptoms. **Higher soil K levels sharply reduced the amount of seed disease. Table 5** shows that at all planting dates the high soil K level had the lowest disease scores, and the earliest planting date had the highest disease scores.

Because earlier planted soybeans fill their pods and mature during warmer, more humid weather, the disease pressure is greater. Consequently, plants need to be more resistant to infection and growth of seed diseases. Note that earlier planting increased seed disease least at the high soil test K level.

Table 5. Effect of soil test K level and planting date on soybean seed disease.

Planting date	Soil test K level			Decrease due to higher K level
	Low	Med.	Very High	
		Disease score (1 = low, 5 = high)		
May 27	4.3	3.0	2.4	1.9
June 16	3.3	2.3	2.2	1.1
July 8	2.8	2.2	1.8	1.0
Increase due to earlier planting	1.5	0.8	0.6	

Conclusions

The advantage of building the soil test K from low to a very high level was about 13 bu/A of soybeans at the optimum planting date. To take full advantage of improved soil K levels, soybean yields needed to be optimized by earlier planting.

Most of the improvement in yield came from increased number of seeds produced per acre while a smaller — but significant — improvement in yield resulted from increased seed size.

Soybean seed diseases were reduced by raising the soil K level but were increased by planting earlier. Higher soil K levels eliminated most of the increase in disease due to earlier planting. ■

Planning Ahead for Fall-Winter?

THE FALL-WINTER fertilization season is fast approaching, and the opportunities and questions it brings could be unique for several reasons. Don't overlook the effects of **increased nutrient uptake associated with high crop yields,** or the need for **special management for fields which have been in reduced-acreage programs.**

The Potash & Phosphate Institute (PPI) is preparing information materials with fall-winter fertilization decision-making facts. For example, a credit-card-size wallet booklet compiles crop nutrient uptake figures in a handy package. New folders focus attention on the economics of fertilizer as a high-yield investment and on the need to balance crop nutrients for best efficiency. A set of color slides shows and tells how fall-winter fertilization fits modern management.

For more information, contact: Potash & Phosphate Institute, 2801 Buford Hwy., N.E., Atlanta, GA 30329. Phone (404) 634-4274.

P_2O_5 Account Is Being Overdrawn by U.S. Farmers

PHOSPHATE REMOVAL by the three major rotation crops – corn, wheat, and soybeans – in 1982 exceeded application by almost 600,000 tons P_2O_5, states Dr. John Douglas, National Fertilizer Development Center. Yields for each of these crops reached all-time record highs. Yet P_2O_5 use was down by 11% nationwide and an estimated 16% on these three crops combined.

These heavy overdrawals will soon reduce residual fertility to the danger point on some soils. Two crops in particular – wheat and soybeans – were badly shorted in 1982.

"In many areas of the U.S., farmers apply phosphate to their corn crop expecting the carryover to be there for either soybeans or wheat in rotation. Although soybeans and wheat have traditionally received much less phosphate than they removed, it appears these two crops are being shortchanged even more now," Dr. Douglas points out.

There has been much talk about soil phosphate buildup because for several years more phosphate was applied than was used by the major farm crops. However, in recent years this situation has turned around. With increased yield levels and stable or lower application of phosphate, many farmers are already "overdrawing" on soil bank accounts, Dr. Douglas cautions.

"U.S. farmers can ill afford a major reduction in the use of important crop nutrients. If farmers are to continue increasing their output to satisfy the domestic and international demands for grain and other foodstuffs, it will be necessary to turn the trend around and increase amounts of phosphate fertilizers applied during the next decade," Dr. Douglas concludes. ■

Dr. John Douglas
National Fertilizer Development Center

Four Outstanding Graduate Students Receive 1983 PPI Fellowship Awards

UPHOLDING A TRADITION of excellence, four outstanding graduate students in soil and plant science have been selected as winners of Fellowship Awards by the Potash & Phosphate Institute (PPI). The fellowships of $2,000 each are awarded to deserving candidates for either the M.S. or Ph.D. degree.

The 1983 recipients are: William H. Darlington, Michigan State University, East Lansing; Robert L. Hanson, Colorado State University, Fort Collins; Oran B. Hesterman, University of Minnesota, St. Paul; and Beth Nelson, Purdue University, West Lafayette, Indiana.

"We are truly proud of this elite group of young scientists," said Dr. R.E. Wagner, President of PPI and the Foundation for Agronomic Research (FAR). "The Committee to select the winners had a difficult task, because many excellent candidates submitted applications."

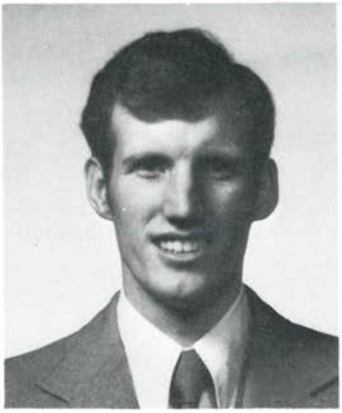
Scholastic record, excellence in original research and leadership were among the qualifications evaluated. The fellowships are to be used for continuation of study and research. Each of the winners received a certificate and a check for $2,000 from the Potash & Phosphate Institute.

William H. Darlington plans to gain field experience as a farm advisor after completing his M.S. program at Michigan State University. Later, he will work toward a Ph.D. degree. He received his B.S. degree in 1981, graduating with highest honors from the University of California at Davis. At Michigan State, Mr. Darlington has studied the effects of primary tillage practices on yield and nutrient uptake of corn and soybeans. Eventually, he hopes to work as an extension soils specialist.

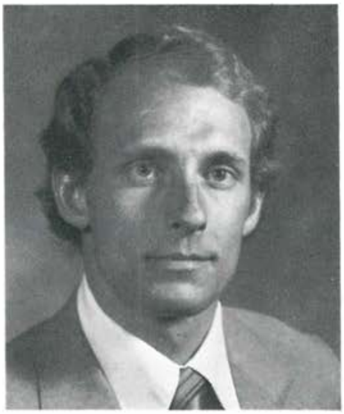
Robert L. Hanson is seeking the M.S. degree at Colorado State University. His research is evaluating the effectiveness of dual nitrogen and phosphate application on irrigated and dryland crops. Mr. Hanson received his B.S. degree from Colorado State in 1981, graduating with High Distinction. He intends to work in international agriculture and to continue his education majoring in soil fertility or soil chemistry.

Oran B. Hesterman has a unique combination of study for a Ph.D. as an agronomy major and a business administration minor at the University of Minnesota. He received the M.S. degree in agronomy at the University of California at Davis in 1981. From 1973 to 1979, Mr. Hesterman was sole proprietor and manager of a wholesale nursery for commercial production of alfalfa sprouts. His Ph.D. thesis is determining contributions of annual alfalfa to a subsequent corn crop, with agronomic and economic evaluation.

Beth Nelson earned a B.S. in agronomy and a B.A. degree in German at Purdue University in 1981, and is now working toward the M.S. degree in agronomy. Her thesis project, "The Effect of Altered



William H. Darlington



Robert L. Hanson

Oran B. Hesterman

Beth Nelson

Reproductive Development on Nitrogen Assimilation by Soybeans," is aimed at improved understanding of key physiological processes in the plant. In the future, Miss Nelson hopes to continue research training with direction toward improved crop productivity, and especially limiting factors in high yield environments.

The fellowship winners were chosen by a committee of five members: two from the PPI staff and three from the PPI Advisory Council. Dr. J. Fielding Reed, President (Retired) of PPI and Chairman of the Selection Committee, noted the outstanding qualifications and academic records of applicants. "This is our fourth year for the Fellowship Awards, and the response has been very good. We are proud to encourage excellence among the future leaders in soil fertility and related sciences." ■

Phosphorus for Small Grains – Partners in Profit

By W.K. Griffith

FACT: Phosphorus must have a **TRIPLE-A** rating for profitable small grain production:

Available soil test P levels in medium-high range;

Annual P applications;

Adequate P fertilizer for maintenance and yield.

Small grains can't tolerate shortcuts in P fertilization. Soil test levels should be built to the medium-high level. Then, with annual applications, phosphorus is readily available and in position to be used from seeding to harvest.

Why?

Small grains are a cool season crop. They are planted either in the fall and must sustain the rigors of winter, or they are planted early in the spring.

During periods of cold soil temperatures, small grain yield potential depends on the vigor, health and persistence of the young plant. During this critical period the root systems are the smallest, P movement the slowest, and P availability the lowest.

Phosphorus can be "positionally unavailable" if concentration levels are low. If this occurs, plant stress results and yield potential is reduced.

Where?

In the North, South, East and West, small grain experiments have repeatedly shown positive responses to phosphorus. The results are consistent, large and profitable, as **Table 1** shows.

Table 1. Small grains respond well to phosphorus.

		P_2O_5	Yield	Return above P & harvest costs*
		lb/A	bu/A	$/A
North:	Eastern Montana - Spring wheat	0	28	103.60
	Low P soil	46	40	135.12
		92	46	144.44
South:	Texas - Irrigated wheat	0	51	188.70
	Medium P soil	80	64	232.40
East:	New York - Six barley varieties	0	37	99.90
	Medium P soil	20	47	121.30
		40	52	129.20
West:	Iowa - Oats	0	94	183.30
	Medium P soil	46	120	221.12

*Costs and prices: P_2O_5 = 28¢/lb; Harvest cost = 30¢/bu; Wheat price = $4.00/bu; Barley price = $3.00/bu; Oat price = $2.25/bu.

Too often, small grains are grown on soils testing low in phosphorus. Resulting poor yields put the squeeze on profits. The problem gets worse each year as production costs rise, pushing profitable yield levels higher and higher.

Dr. Griffith is Eastern Director of the Potash & Phosphate Institute.

Experimental evidence proves that the best small grain yields come from soils with a good supply of readily available soil P, supplemented annually with adequate fertilizer P.

Barley tests in New York illustrate the value of building soil fertility. Barley headed earlier, withstood winter stress better, and had the highest yields when grown with the top P rate and soil P test. Results with wheat were similar. **Table 2** summarizes the data.

Table 2. High P soils for high barley yields and profits.

Applied P_2O_5	Grain yield - Soil test level			Return above P & harvest costs		
	Low	Medium	High	Low	Medium	High
lb/A		bu/A			$/A	
0	7	26	70	18.90	70.20	189.00
20	14	34	89	32.20	86.20	234.70
40	15	40	95	29.30	96.80	245.30
80	21	46	100	34.30	101.80	247.60

If you omit annual P application, there is a high risk of having insufficient P supplies for good yields. You may lose the cumulative benefits that come with a good soil fertility program over a period of years.

A study in Indiana gives an example of the consequences when a good P fertilization program stops. The site received 50 lb/A of P_2O_5 for 19 consecutive years. **Table 3** shows what happened when P fertilization ceased and the comparison with continuous P. Wheat yields began to drop three years after the P was omitted in 1974. By 1980, yields were **19** bu/A below the continuous P applications.

Table 3. Wheat needs annual P application.

	Yield-1980	Soil test
	bu/A	P-lb/A
Continuous P_2O_5 (50 lb/A)	73	45
Omit P_2O_5 (since 1974)	54	23
Omit P_2O_5 (since 1952)	42	11

Balance nitrogen

The most efficient and beneficial results from N applications occur when balanced with adequate phosphorus. Two "**don'ts**" for profitable small grains are:

- Don't cut back on recommended N use.
- Don't cut back on needed P, or N dollars could be wasted.

Studies from Ohio (**Table 4**) point out the importance of NP balance.

Table 4. Nitrogen-Phosphorus Balance Pays.

P_2O_5	Yield	Return above P & harvest costs
lb/A	bu/A	$/A
0	67	229.90
40	71	231.70
79	79	250.30

Medium P soil test Ohio-Wheat with 90 lb/A N.

Here are some recommended phosphorus fertilization practices to consider for profitable small grain production:

- Use soil testing to help establish fertilizer needs.
- Build P levels to the medium-high range.
- Apply fertilizer annually for good small grain yields and to maintain medium-high soil test levels.
- Maintenance rates help ensure readily available P for the crop and the best opportunity to benefit financially from good management practices and climatic conditions.
- Balance P with N and K. Rates of nitrogen ranging from 80 to 120 lb/A are often recommended for top yields. Consider applying 40 to 80 lb/A of P_2O_5 . . . or more if soil test levels are below the medium-high range. ■

Why Maximum Yield Research?

By L. Fred Welch

THE TITLE for this article is in the form of a question. It is always appropriate to consider alternatives. For example, if one is not interested in maximum yield research, does this mean that he is more interested in pursuing mediocre or minimum yield research? Most of my acquaintances, whether growers or researchers, would not find it very challenging to settle for less when they can go for more.

Maximum Economic Yield Is Usually Close to Maximum Yield

Maximum economic yield refers to maximum profit to the grower. This is usually slightly less than maximum yield. But, whether referring to maximum yields or maximum economic yields, we are talking about the almost flat part of the yield response curve. In this article, I will present some of the reasons why we should be interested in maximum yield research.

Growers' Management Practices Are Heavily Based on Economic Considerations

Our research results should provide data for growers to weigh alternatives when making decisions. Economic evaluations are generally the final determinant in choice of decisions. Growers are interested in profit. So it seems appropriate that we be mindful of economics in our research efforts. This does not mean that we should let economic feasibility at the present dictate whether we include a particular treatment in our research plots. A treatment that is uneconomical today may be feasible in the future. Let us determine how much crop yields are affected by a particular treatment, then we can determine whether the economics are favorable for growers. In fact, we don't have to tell growers if a practice is economically feasible. Once we provide them with inputs and crop yields, they are perfectly capable of deciding if a particular treatment will result in a profit for their farming operation.

Increased Yields Generally Result in Increased Efficiency of Inputs Used to Produce the Crop

We make better use of our natural resources like sunlight, water, and land when we produce high crop yields. Increased yields usually result in more efficient use of labor and petrochemical energy. (I use efficiency to refer to the input in relation to unit of output. The total input per acre of land may actually increase as crop yields are increased, but the increased input often is less than the increase in crop yields).

Surely most people are for increased efficiency rather than increased inefficiency. Improved efficiency through increased crop yields has been responsible

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for agriculture remaining one of our most highly productive and efficient industries.

I have trouble coming up with instances where inefficiency has contributed toward greatness whether for an individual, a farm unit, or for a nation. If we are too inefficient, the cost of goods and services becomes so great that we price ourselves out of the world market and create inflation in our own country.

I am for efficiency. Most of the people I know are for efficiency. It is my understanding that lack of increased efficiency in certain industries has contributed to some of the financial and unemployment problems facing us as a country today. Our research should be concerned with improving efficiency through increased crop yields.

Doing Maximum Yield Research Causes One to Become Committed

Once committed, we try harder. Once we make high yields one of our research objectives, we start asking ourselves and others different questions. In recent years I have asked corn breeders questions that had not even occurred to me before I became interested in maximum economic yield research. I think that the same thing is likely to happen to others once they make a commitment to increase crop yields.

Maximum Yields Cannot Be Attained Unless Plant Stress Is Kept at a Low Level

Plant stress reduces crop yields. This stress may be caused by many factors. An inadequate supply of essential nutrients will produce stress and result in low yields because of the deficiency. Other stresses may be caused by too much or too little water, high or low temperature, diseases, insects, soil compaction, or other conditions. When doing high yield research, one starts trying to reduce stress. You will likely be more innovative in your approaches as you attempt to ensure that the plant has a favorable environment in which to grow.

Who Else Will Identify Factors That Limit Crop Yields?

"We" above refers to many persons other than just those researchers affiliated with a land-grant university. "We" refers not only to the university researchers, but to fertilizer dealers, seedsmen, chemical suppliers, and to growers themselves. We can all learn from each other. The challenge is so great that the solution will require the best efforts of all who are close to agriculture. We are the ones who must study factors that affect crop growth, and how we can alter those factors through management to obtain high yields and high profits.

Increased crop yields are too important to leave to chance. It is not sufficient for us to just hope that someone will become interested in this subject to the point that they just wander into it. It likely will not be done unless we either do it ourselves or else get our colleagues interested in doing it.

Others Follow Once It Has Been Done

There is a strong psychological motivation for others to try once they know something is possible. If we grow high crop yields, we encourage others to grow high crop yields. Not many of us will freely admit that we are less capable than the individual who first did it. As a researcher, I have been strongly influenced in my thinking because of high yields attained both by other researchers and by growers.

There Is a Hungry World To Be Fed

The above is ample reason within itself for us to learn how to produce high crop yields. We learn how to produce high crop yields by doing it. We cannot

(continued on page 18)

(Research . . . from page 17)
teach until we first know ourselves. Once we have experienced the joy of discovery, we will be anxious to share it with others.

Be a Good Friend to the Soil; Grow High Crop Yields

One of the best ways to be a friend of the soil is to manage it such that high crop yields will be produced. One cannot produce high crop yields (for very long at least) if the soil is abused. A lush growth of plant material is one of the most effective protective covers that we can provide for soils.

The high yields of roots and unharvested plant tops, in the case of grain crops, provide organic material that has favorable effects on soil properties. We cannot produce high crop yields if we mine the soil of nutrients. So, in producing high crop yields we must do those things that help maintain the productivity of our soils.

If properly used and if we guard against erosion, our soils should last forever. This is contrary to our thinking on other matters. In many instances we have become a "throw away" or "use and discard" society. We are concerned about how long some of our natural resources will last. We mine a ton of coal in southern Illinois, burn it, and it is gone. Our automobiles "rust out" or "wear out." Soils are different. If properly managed they do not depreciate with time. Soils should last forever. We grow a good crop on the soil and the soil could very well be better than before the crop was grown. Unless we become negligent, our soils will "not wear out."

We Need Maximum Yield Research to Help Agronomists and Soil Scientists Maintain Respectability

The above almost seems like a self-serving goal. This is not the intent. People have to demonstrate a certain amount of ability and expertise before others are interested in listening to them. I think that it would be difficult to keep the attention of an audience if your yield data are only two-thirds as great as theirs. If this happened frequently, I think your audience would soon stop listening and would cease seeking your advice.

You would not have read to this point unless you thought I could grow more than 75 bu/A of corn on my field research plots. Lest I leave you with lingering doubts, I acknowledge Mother Nature's cooperation in permitting me to grow 242 bu/A of corn on my research plots at Urbana in 1982. Let us learn how to grow even higher yields. We can then apply economics to determine the most profitable management practices for growers. ■

On the Lighter Side

Do you sometimes feel "dog tired" at the end of the work day? Maybe you're burning up more energy than you realize. These are some common forms of exercise, and the number of calories consumed per hour:

Beating around the bush — 75; jogging the memory — 125; jumping to conclusions — 100; climbing the wall — 150; swallowing pride — 50.

Passing the buck — 25; grasping at straws — 75; beating your own drum — 100; throwing your weight around — 300; turning the other cheek — 75.

Wading through the paperwork — 300; eating crow — 225; dragging your heels — 100; pushing your luck — 250.

* * * * *

A farmer was asked to write a reference for a man he fired after only one week's work. He would not lie, and he did not want to hurt the man unnecessarily. So he wrote this: "To whom it may concern: John Jones worked for us for one week, and we're satisfied."

Phosphorus for High Yields on Newly Cleared Cropland

EXTRA PHOSPHORUS (P) and proper pH are two of the keys to growing top yielding crops on newly cleared Coastal Plain and Piedmont soils, according to Dr. Mark Alley, research agronomist at Virginia Tech.

"Adding phosphorus is a function of getting land into production," he says. "You can do it the first year or over a period of several years. But applying adequate phosphorus to satisfy fixation sites as well as crop needs the first year will improve the possibility of obtaining high yields on new ground."

Dr. Alley conducted fertility and liming tests on recently cleared farmland in Virginia. Once the soil was brought into the proper pH range, the amount of phosphorus added made the difference between high and low corn yields.

He compared corn yields in plots with broadcast rates of 0, 200, 400, and 600 lb P_2O_5/A. Some plots received liquid phosphate (10-34-0) in bands, while other plots received granular diammonium phosphate (18-46-0) in bands. Other than the phosphorus levels, the plots were fertilized and limed according to soil tests.

Differences in yields were surprising, Dr. Alley reports. The first year (1979) corn yields ranged from zero to 158 bu/A, with the difference due to amount of phosphorus added.

"The highest single treatment yield was with 600 lb P_2O_5/A, followed by 50 lb/A in the row. Although the extra yields wouldn't pay for that much phosphorus, you can't allocate the cost against just the first year's crop," the researcher points out. "We found we needed at least 200 lb/A broadcast plus 50 lb/A in a band."

Dr. Alley recommends 300 lb/A if a grower doesn't plan to come back with banded phosphorus. He found no difference in yields between the liquid and granular applications.

Table 1 shows soybean yields from a 1981 experiment which compared various rates and methods of phosphorus application. Soybean yields increased with broadcast rates up to 400 lb P_2O_5/A. Sideband applications of 50 lb P_2O_5/A increased soybean yields at the 0 and 200 lb P_2O_5/A broadcast rates. The 200 lb P_2O_5/A broadcast plus 50 lb P_2O_5/A sideband treatment produced the same yield (43 bu/A) as 400 lb P_2O_5/A broadcast.

Table 1. Soybean Yields as a Function of Phosphorus (P) Applications on Newly Cleared Land.

Broadcast P_2O_5 lb/A	Band P_2O_5 lb/A		Broadcast P Means
	0	50	
	— Soybean Yields (bu/A) —		
0	16	35	25
200	35	43	39
400	43	44	43
600	44	45	45
Band P Means	35	41	

Kempsville sandy loam soil, Virginia.

For fertilizing new land, Dr. Alley suggests applying lime as soon as possible after clearing. That way it has plenty of time to react in the soil and raise pH. He advises holding off phosphorus applications until close to planting time.

Some soils with a high clay content have a greater capacity to lock up phosphorus and prevent plants from using it. In that case, higher initial applications may be needed. ■

Vegetable Crop Fertilization for High Yields and Quality

By D.L. Coffey

VEGETABLE CROP fertility requirements vary considerably among species and soils, and it can be difficult to maintain consistently high yields. Economic and environmental conditions magnify the importance of proper production and management decisions.

Soil-improving practices such as green manure crops and crop rotations, in conjunction with optimum fertilization, appear necessary for best results in commercial vegetable production.

More information on optimum nutrient levels is needed for making vegetable crop recommendations. A recent five-year study at three locations in Tennessee was conducted to determine annual maintenance application rates of nitrogen (N), phosphorus (P) and potassium (K) for tomatoes, cabbage, lima beans and snap beans.

Soils which had been in vegetable production in recent years were chosen for test plots. Locations were: A, the Main Experiment Station at Knoxville; B, West Tennessee Experiment Station at Jackson; and, C, the Plateau Experiment Station at Crossville. The silt loam soils at sites A and B tested high in available P and K. The loam soil at site B tested medium in available P and K.

Varieties used at locations A and B were: tomatoes, Big Seven; cabbage, Market Victor; and lima beans, Jackson Wonder. The same cultivars were planted at site C, except snap beans (Early Gallatin) were used instead of lima beans. Recommended commercial production practices were followed.

Tomatoes

Table 1 shows marketable yields of tomatoes at the three locations. In all cases, plots receiving no fertilizer for the duration of the tests had lowest yields.

No significant average yield differences were found at any location between 60 and 120 lb/A rates of either N, P_2O_5, or K_2O when levels of the other two nutrients were held constant.

Tomato yields varied considerably among years at all locations and tended to decrease substantially over the years at sites A and B. The no-fertilizer treatment resulted in the smallest fruit size at all locations. Fruit cracking was more prevalent from the higher fertilizer treatments, particularly from higher levels of N and more frequent irrigation at site A.

Dr. Coffey is Professor, Plant and Soil Science, University of Tennessee, Knoxville.

Table 1. Marketable yields of tomatoes from varying rates of N, P_2O_5, and K_2O at three locations, 1975-79[1].

Treatment		Marketable yield (T/A)		
Nutrient	Rate[2] (lb/A)	A	B	C
N	60-120-120	20.9	24.3	16.1
	120-120-120	21.4	23.3	17.3
P_2O_5	60-60-120	19.6	23.0	15.9
	60-120-120	20.9	24.3	16.1
K_2O	60-120-60	19.6	23.6	15.1
	60-120-120	20.9	24.3	16.1
Check	0-0-0	14.9	17.9	9.8
	60-0-0	18.7	20.2	11.4
	60-60-60	18.8	22.2	15.1

[1] Yield values are five-year averages
[2] $N-P_2O_5-K_2O$

Table 2. Marketable yields of cabbage from varying rates of N, P_2O_5, and K_2O at three locations, 1975-79[1].

Treatment		Marketable yield (T/A)		
Nutrient	Rate[2] (lb/A)	A	B	C
N	60-120-120	14.8	20.7	9.5
	120-120-120	17.4	23.8	12.6
P_2O_5	60-60-120	14.1	19.9	7.9
	60-120-120	14.8	20.7	9.5
K_2O	60-120-60	13.4	19.8	10.2
	60-120-120	14.8	20.7	9.5
Check	0-0-0	6.8	10.4	1.5
	60-0-0	11.5	17.1	2.8
	60-60-60	12.7	18.6	9.1

[1] Yield values are five-year averages
[2] $N-P_2O_5-K_2O$

Cabbage

As with tomatoes, average yields of cabbage were highest at location B and lowest at location C. At all locations, yields from 120 lb N/A were significantly greater than those from 60 lb N/A. Yields from no fertilizer or only 60 lb N/A were the least. See **Table 2.**

The size of the individual cabbage heads related closely with yields: the larger the head size, the higher the yield. To be marketable, heads must weigh 1.5 to 2 lb each. Many of the heads from the no-fertilizer treatment were unmarketable because they were too small.

Beans

Fertilization had little yearly influence on lima bean yields at locations A and B. The five-year average from the no-fertilizer treatment was less than that from the 60-120-120 treatment (site A) and the 120-120-120 treatment (site B). There was very little yield difference among plots at site C. See **Table 3.**

Table 3. Yields of lima and snap beans from varying rates of N, P_2O_5, and K_2O at three locations, 1975-79[1].

Treatment		Beans (T/A)		
		Lima		Snap
Nutrient	Rate[2] (lb/A)	A	B	C
N	60-120-120	1.1	1.4	3.3
	120-120-120	1.0	1.5	3.2
P_2O_5	60-60-120	1.0	1.4	2.9
	60-120-120	1.1	1.4	3.3
K_2O	60-120-60	1.0	1.3	3.0
	60-120-120	1.1	1.4	3.3
Check	0-0-0	0.9	1.1	2.3
	60-0-0	0.9	1.2	2.6
	60-60-60	1.1	1.1	3.4

[1] Yield values are five-year averages, except at site B
[2] $N-P_2O_5-K_2O$

Because of their shorter growing season, snap beans were included instead of lima beans at location C. There was considerable variation in yields among years and treatments. Fertility had little influence on yield the first two years of the study, but afterward yields dropped considerably on plots receiving no fertilizer or N only. The 60 lb/A level of N, P_2O_5, and K_2O appeared sufficient for snap beans.

Summary

Yield responses were small in the early years of the test but increased as the study continued. The highest yields of tomato and cabbage were obtained from annual applications of 120 lb/A each of N, P_2O_5, and K_2O. Highest yields of lima and snap beans were obtained with 60 lb/A of each nutrient. ■

P and K Produce Higher Yields Plus Better Quality Cotton

By W.R. Thompson, Jr.

COTTON GROWERS looking for ways to increase yields and profits and to reduce production costs might look more closely at fertilization.

It can pay off in dollars and cents, because fertilization improves both the **quantity** and the **quality** of the cotton and can help lower costs. Higher yields help lower the **cost per pound** of lint produced.

Potash and phosphate are important nutrients in cotton fertilization programs. For example, a Georgia study showed how a crop producing 2,000 lb/A of seed cotton absorbed 134 lb of N, 61 lb of P_2O_5 and 120 lb of K_2O, a total of 315 lb of the nutrients.

The cotton crop absorbs nutrients at different rates. The growing plant rapidly takes up both nitrogen (N) and potassium (K) in the early stages of development.

The plant absorbs phosphorus (P) more slowly until the early "square" stage. From that stage to maturity, the crop takes up 89% of its total P needs.

These varying absorption rates mean soils must have good, **full-season fertility** to supply plant food needs through the whole growing season.

As the plant matures, **total** nutrient content and dry matter increase. Yet, research shows that the percentage concentration of these nutrients in plant tissue declines because the pounds of dry matter are increasing more rapidly than the pounds of nutrients absorbed.

The exception is the cotton boll. Potassium content remains high in the developing cotton boll, especially the bur. This high K content may be associated with favorable water content in the boll.

The bur continues to accumulate K, sometimes up to 5.5% concentration at maturity. Burs contain about one-third (37%) of the K in the plant at maturity.

Even late in the growing season the plant continues to need much P and N. The cotton seed alone takes up 52 to 62% of the crop's total P need and about 50% of its total N need.

High cotton yields and especially **high yields in the first picking** are closely tied to good fertilization practices. The first picking always grades higher in quality. This earns the grower more money. So, when fertilization increases yields and percent in the first picking, it pays off in extra profits.

Arkansas tests showed how P increased yields and percent of crop harvested in the first pick. Even on a soil testing high in P, additional phosphorus increased the first pick from 67 to 75% of the total seed cotton yield. This added 236 lb/A of seed cotton to the first picking – for better quality and more return.

Cotton's response to applied P and K has been reported throughout the cotton production region.

Long-term studies of phosphorus response showed an increase in pounds of seed cotton and lint in Arizona and an in-

Dr. Thompson is Midsouth Director for the Potash & Phosphate Institute.

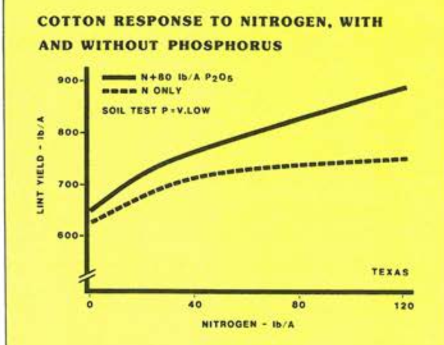

Figure 1

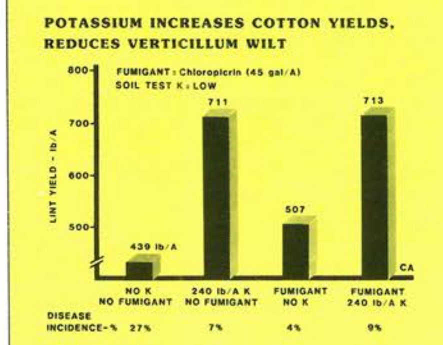

Figure 2

crease in seed cotton in Alabama.

In Texas, cotton responded more to applied N when P was also applied, as **Figure 1** shows. When P was omitted, there was no response to N above the 40 lb/A rate. But when P was added, yields increased significantly at **all N rates**.

Other studies show cotton's response to K, including increased seed cotton yield in Arkansas. Studies on fertile Delta soils in Mississippi recorded increased lint yields from potash, even when some of the soils tested high in K.

Proper fertilization also improves **cotton quality** – another bonus to the grower. Improved quality can make profits even greater.

Many crop research reports have shown that fertilization can sharply improve quality. In Alabama studies, applied K increased boll size, fiber quality, and micronaire. Plants not receiving potash fertilizer were completely defoliated by September 1 in the Alabama tests. Missouri scientists also report the role of potassium in boosting cotton **yield and quality**.

Wilt diseases of cotton reduce cotton yields and quality. It has been known for years that potash reduces the severity of *Fusarium* wilt in cotton. Recent studies in California reported that potash reduced the severity of *Verticillium* wilt and increased cotton yields. The additional use of a fumigant was needed before K deficiency symptoms could be eliminated. See **Figure 2.**

WHAT ABOUT COSTS AND RETURNS? It costs about $400 to produce an acre of cotton. Assuming that 100 lb of N, 80 lb of P_2O_5 and 80 lb of K_2O per acre will cost about $50 to $55, the investment for fertilizer is only about 12 to 15% of total production costs. The first 75 to 80 lb/A of increased lint yield will pay fertilizer costs when cotton brings 70¢/lb of lint.

BALANCED FERTILITY is important to efficient cotton production. Optimum balance means plant nutrients and other production inputs are used most efficiently.

Cutting back on P and K can drastically reduce cotton's yield and profit potential. Tennessee work showed that plants suffering nutrient deficiency stress cannot produce top yields of quality cotton.

In Louisiana tests, balanced NPK fertilization influenced seed cotton yields. The top yield was clearly produced by the balanced NPK fertilizer program.

SOUND ECONOMICS. Fertilizer cost is a small slice of the production cost pie in the cotton budget. Yet, tests show fertilizer applications give good returns on your investment dollar. ■

How to Establish Alfalfa by No-Till

By Harry T. Bryant

ALFALFA is a nutritious forage for sheep, dairy and beef cattle. And although it is adapted to a wide range of land sites, alfalfa is frequently relegated to hilly land. No-till seeding, without plowing and disking, allows seeding in hilly locations with little soil loss to water and wind erosion.

Successful no-till seeding of alfalfa requires a suitable environment for seeds to germinate and grow. Several methods of changing the environment near the seeds were studied in a no-till experiment. Alfalfa seeds were no-tilled into tall fescue sod in the fall of 1980 and 1981. The silt loam soil was high to very-high in phosphorus (P).

The soil environment was changed by increasing the availability of P in the immediate vicinity of the seed. Phosphorus was applied in the row at seeding: 73 lb/A P_2O_5 in 1980 and 62 lb/A in 1981. The environment was also changed by either reducing or eliminating competition from the existing sod by spraying with paraquat herbicide. The paraquat application methods compared were: (1) 12 days prior to and at seeding; (2) 12 days prior to seeding; (3) at seeding; and (4) none. Another variable affecting the seed environment was the influence of mixing 14 lb/A of Furadan 10G insecticide with the seed.

An estimate of alfalfa seedling growth the fall of each seeding year was obtained by drying and weighing the above ground portion of 50 alfalfa plants. The total seasonal yield of alfalfa the year following seeding was calculated by multiplying percent alfalfa per harvest (determined from hand separations) times total yield per harvest.

Table 1 shows alfalfa seedling growth the fall of the seeding year and

Table 1. Alfalfa Seeding Year Weight and Yield First Harvest Year as Affected by Phosphorus (P), Paraquat and Furadan. (2-Year Average).

	Seedling Weight Fall of Seeding Year				First Harvest Year Yield			
	No P or Furadan	P[2]	Furadan[3]	P and Furadan	No P or Furadan	P	Furadan	P and Furadan
	Grams/50 Plants				Tons/A (Minus Weeds and Fescue)			
Paraquat[1]								
0	0.53	1.14	1.30	1.37	0.8	1.4	1.8	1.6
12 days before seeding	3.00	4.70	5.21	4.59	2.5	2.8	3.5	3.6
At seeding	2.44	3.43	4.10	4.56	1.7	2.6	3.4	3.5
Both before and at seeding	5.25	4.59	6.50	8.18	2.9	3.1	4.3	4.3

[1]Paraquat at 1 qt./A. [2]P_2O_5 at 73 lb/A (1980) and 62 lb/A (1981) in the row at seeding on soils testing high to very high in phosphorus. [3]Furadan 10G at 14 lb/A applied with seed.

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the yield of alfalfa the first harvest year following the fall seeding. **The size of the fall seedlings suggests that no-till alfalfa seedings do best when there is a combination of paraquat used for suppression of competition, high phosphorus available near the seed and Furadan used for insect control.**

Individual Input Effects

Table 2 shows the effects of not using paraquat, phosphorus or Furadan compared to using them in all combinations. It is apparent that all three inputs are important for successful no-till alfalfa establishment and subsequent yields, since each input increased seedling weight and first harvest-year yields. The vital importance of suppressing competition from grasses and weeds shows up in this table.

The no-paraquat treatments had both the lowest seedling weight and lowest harvest yield. They also showed the greatest increase in weight and yield when paraquat was applied compared to phosphorus and Furadan effects. However, all three inputs show strong positive yield benefits when they were included in the system.

Table 2. Effect of Phosphorus (P), Paraquat and Furadan on No-Till Alfalfa Seedling Weight and Yield the First Harvest Year. (2-year Average).

Treatments	Seedling Weight Grams/50 plants		Harvest Yield tons/A[3]	
No Paraquat	1.08		1.4	
Paraquat[1]	4.71		3.2	
Difference		3.63		1.8
No P, No Furadan	2.81		2.0	
Phosphorus[2]	3.46		2.5	
Difference		0.61		0.5
No Furadan, No P	2.81		2.0	
Furadan[2]	4.27		3.3	
Difference		1.46		1.3
No P, No Furadan	2.81		2.0	
Furadan and P[2]	4.68		3.3	
Difference		1.86		1.3

[1]Average of the three paraquat application dates. [2]Average of the four paraquat treatments. [3]First year yield, minus fescue and weeds.

Interaction Effects

The key to any successful farming practice is to fit the best combination of inputs into a better yielding system. **Table 3** shows the positive yield increases from interaction of paraquat, paraquat timing, and Furadan. Alfalfa yields the first harvest-year were 1.4 tons/A when P was used alone. Add paraquat (average of three application methods) and yields increased 1.4 tons/A (a 100% increase). Combine this system with Furadan and yields jumped another ton, to 3.8 tons/A. A top yield of 4.3 tons/A was achieved when phosphorus, paraquat (applied both 12 days before seeding and at seeding), and Furadan were a part of the system. Phosphorus interacted positively with both paraquat and Furadan in this no-till establishment situation.

Table 3. Phosphorus (P) Interacts Positively with Paraquat and Furadan in Alfalfa Yield First Harvest Year. (2-Year Average)

Treatments	First Year's Harvest tons/A[2]
None	0.8
Phosphorus Alone	1.4
P + Paraquat[1]	2.8
P + Paraquat[1] + Furadan	3.8
P + Paraquat Applied 12 days before seeding and at seeding + Furadan	4.3

[1]Average of the three paraquat application dates. [2]Minus fescue and weeds.

Summing Up

No-till research demonstrates the need for a satisfactory environment for alfalfa establishment. Adding phosphorus to encourage early seedling development combined with Furadan for insect control appeared to have a favorable influence on alfalfa establishment. Reducing competition for water, light and phosphorus from the existing fescue sod by spraying with paraquat had a beneficial influence on alfalfa establishment. ■

Factors Other Than Phosphorus Soil Test Affect Crop Response to Phosphate Fertilizer

By R.D. Munson

A RELIABLE soil test provides a good measure of available phosphorus for a crop. Basically, it helps predict the likelihood of crop response to applied phosphate fertilizer.

Figure 1 shows how corn and soil test P levels responded to annual phosphate applications in an Ohio experiment. However, we know that factors other than phosphorus soil test influence crop response to applied phosphate.

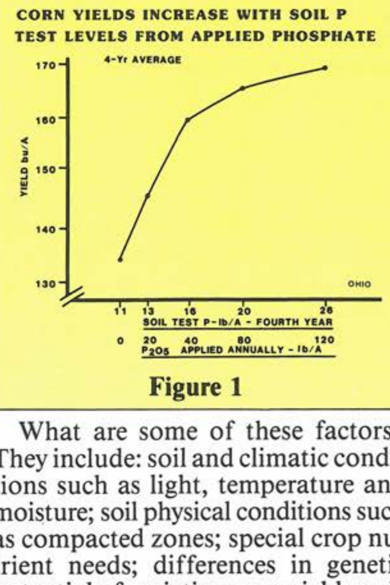

Figure 1

What are some of these factors? They include: soil and climatic conditions such as light, temperature and moisture; soil physical conditions such as compacted zones; special crop nutrient needs; differences in genetic potential of varieties; crop yield goals desired; and special production practices such as planting date, nutrient interactions and fertilizer placement.

GOOD SOIL TILTH IMPROVES phosphorus availability. How? By enhancing root growth and nutrient absorption. These benefits most often occur due to improved aeration and soil temperature. Also, reduced compaction and improved soil drainage tend to increase phosphorus uptake by plants.

Generally, coarse textured or sandy soils give more yield response to applied phosphate than will fine textured or clay soils at the same soil test P level.

AS SOIL TEMPERATURE DECREASES, mineralization of soil phosphorus is decreased. Therefore, with low soil temperature, early planted corn and other crops may be more responsive to or need higher levels of phosphate fertilizer.

SOIL MOISTURE in excess or in short supply, as with drought stress, will also decrease phosphorus availability and uptake. Thus, there is usually greater crop response to applied phosphate for a given level of soil P when soil moisture is low. In Purdue University studies, soybeans were more responsive to phosphate under limited rainfall conditions.

In Iowa, corn yield response to phosphate on a medium P soil was greater with low rainfall than with optimum rainfall. Although yields were higher with optimum rainfall the impact of moisture stress was much less where phosphate was applied.

SOIL ACIDITY exerts considerable influence on P availability. Liming to increase the soil pH above 5.5 will reduce the solubility of iron and aluminum while increasing the availability of phosphorus. A soil pH of 6 to 7 keeps the phosphate in a form more readily available and easily absorbed by plant roots.

Dr. Munson is Northcentral Director of the Potash & Phosphate Institute.

Table 1. Broadcast and row phosphate increase corn yields in a corn-oats-alfalfa rotation (22-year average - Iowa).*

Broadcast P_2O_5 before corn lb/A	Row P_2O_5 for corn lb/A	P soil test after 22 yrs lb/A	Increased yields from P_2O_5 — 22-yr. avg. Broadcast bu/A/yr	Row bu/A/yr	Broadcast + Row bu/A/yr
0	23	5	—	20	20
46	23	10	31	10	41
92	23	13	36	6	42
138	23	22	37	7	44

*Oats and alfalfa also responded.

NUTRIENT BALANCE can improve crop response to applied phosphate. In a Kansas study, response to phosphate was limited when zinc was deficient. The application of 80 lb/A of P_2O_5 and no zinc produced a corn yield of 125 bu/A. When zinc was applied without phosphate corn yield was 122 bu/A. When both nutrients were teamed the yield climbed to 181 bu/A.

CROP SPECIES don't all have the same needs for nutrients to produce optimum growth. Corn takes up more phosphorus than soybeans. Corn and soybeans have a higher critical level of P than wheat. However, wheat is very responsive to phosphate.

Different hybrids or varieties of a specific crop have varied genetic capabilities to produce yields. Research shows significant differences in ability of soybean varieties to take up phosphorus as the P concentration in the soil solution increases.

There is a tendency for total phosphorus uptake by plants to increase with yield level.

Unless the soil alone or the combination of soil and fertilizer can provide the phosphorus needed, higher crop yields won't be achieved even when a variety has the genetic capacity.

PLACEMENT OF PHOSPHATE FERTILIZER can be an important factor in crop response. Many options are available.

Broadcasting phosphate followed by tillage to incorporate the fertilizer has been a traditional method. Research has indicated advantages for localized placement or banding of phosphate, especially on lower testing soils.

Purdue University agronomists compared corn yield response to rates of P_2O_5 using three different methods of application. A five-year average yield of 115 bu/A of corn was measured when phosphate was sidebanded at planting. The yield was 121 bu/A with broadcast and plowdown. When phosphate was banded on the soil surface in two-to-four-inch strips 28 inches apart and plowed under, the top yield was 132 bu/A.

The most effective placement of phosphorus will vary with the soil, the crop, the supporting production practices, climatic conditions and equipment availability to do the job.

Iowa figures indicate that sidebanded row phosphate may increase corn yields, even though broadcast P has been applied over a long period of time. **Table 1** summarizes a 22-year study.

Wisconsin researchers have found that both high and low phosphorus soils may produce corn yield response to row applications.

TILLAGE and other crop management practices can also affect crop response to phosphate. Conventional tillage tends to increase the release of organic phosphorus and may improve uptake because of good soil aeration and tilth.

Conservation tillage or no-till may slow the release of organic phosphorus

(continued on page 29)

Flooding and Draining Rice Soils Influences P Availability to Crops

By D.M. Brandon and D.S. Mikkelsen

WHEN FACTORS affecting phosphorus (P) availability and fertilization of crops are considered, often too little attention is given to the effect of previous crop management. In crops following rice in regions where the soil may be temporarily water-logged (as much as 10 to 14 days), previous soil management history may be very important in relation to the phosphorus status of the soil.

Flooding for a rice crop or sometimes flooding caused by excessive rain or irrigation has a marked effect on increasing levels of soil phosphate and iron availability. The reactions involved in this change of availability are: (1) a reduction of ferric phosphate to the more soluble ferrous form, (2) hydrolysis of iron and aluminum phosphates which occur at the higher soil pH which results after flooding acid soils, and (3) the greater dissolution of apatite (calcium phosphates) because of higher CO_2 pressure in the soil solution.

Following flooding and soil reduction, iron compounds tend to become soluble and then apparently reprecipitate. Precipitated iron compounds change from an amorphous colloidal state to a crystalline state in the process of dissolution and reprecipitation. The process reverses on drying the soil with the concurrent sorption of large quantities of P which are immobilized.

The increase in the availability of P with soil submergence is a well established fact which explains why rice often fails to respond to P applications where other crops cannot survive. On drainage of rice crops or flooded fields, however, P availability often decreases very rapidly and may remain deficient or at very low levels for periods of up to 2 years. Later, P availability gradually returns to the pre-flood soil condition. **Field results indicate that the effectiveness of phosphate fertilizers to crops after rice or flooding will decrease with time after drainage.**

Many California farmers have encountered poor growth of crops on land previously cropped to rice. Upland crops such as sorghum, safflower, corn and small grains often develop chlorotic leaves, exhibit slow development and ultimately produce extremely low crop yields. The intensity and duration of symptoms differ somewhat according to the soil types used for crop production, slightly acid soils being most dramatically affected.

Phosphorus deficiency has been shown to be a frequent problem affecting plant growth and yields of crops following rice. A gradual and natural disappearance of P deficiency occurs with time, however, but P responses have been measured after the second and third years of submer-

Dr. Brandon is Associate Professor at Louisiana State University; Dr. Mikkelsen is Professor at University of California-Davis.

Table 1. Effect of P fertilization[1] on plant growth and nutrient accumulation in wheat and barley seedlings following rice in Myers and Willows soils, respectively.

	Wheat-Myers Series			Barley-Willows Series		
		P concentration in plant top			P concentration in plant top	
P_2O_5	Dry matter yield	P	PO_4-P[2]	Dry matter yield	P	PO_4-P[2]
lb/A	grams	%	ppm	grams	%	ppm
0	7.5	0.178	774	6.1	0.113	690
60	27.3	0.373	2,946	26.5	0.323	2,683
120	32.2	0.413	3,297	31.9	0.366	2,913
180	34.6	0.466	3,426	30.6	0.384	3,497
L.S.D. (0.05)	6.9	0.077	772	4.7	0.047	656

[1]Averaged over P sources and methods of application
[2]2% HAc extractable PO_4-P from dried whole plant tops

gence and drainage in the absence of P fertilization. Apparently the soil transformations that increase P availability during flooding reduce soil P availability after drainage.

Studies have shown that the P deficiency can best be corrected by band placement of P fertilizers either directly below or with the seed. On three typical California soils, alternately cropped with rice and small grains, the average effects of P fertilization increased seedling dry matter 4- and 5-fold with barley and wheat crops. The Myers and Sacramento soils were cropped to wheat and the Willows soil was cropped to barley. There were highly significant increases in plant P concentrations which were correlated with seedling dry matter **(Table 1)** and final grain yields **(Table 2)**.

The highest rate of P_2O_5 (180 lb/A) increased grain yields 3,050 and 2,080 lb/A above the zero P treatment in the Myers and Willows soils, respectively. Application of 120 lb P_2O_5/A increased grain yields 470 lb/A in the alkaline, less severely affected Sacramento clay loam soil. While kernel weight was generally increased by P fertilization, grain protein was reduced slightly. ■

Table 2. Effect of P fertilization on grain yield of wheat and barley on Myers, Willows, and Sacramento soils[1].

	Grain Yield		
P_2O_5	Sacramento[2]	Myers[2]	Willows[3]
lb/A	----------	lb/A	----------
0	5,800	1,970	750
60	6,080	3,580	1,990
120	6,270	4,460	2,630
180	—	5,020	2,830
L.S.D. (0.05)	258	196	437

[1]Averaged over P sources and methods of application
[2]Wheat
[3]Barley
Soil Test P: Myers, high; Willows, low; Sacramento, high

(Factors . . . from page 27)

and increase soil compaction. Such conditions tend to increase crop response to applied P. In Alabama research, corn yield response to row P has been greater in no-till than in conventional tillage. Part of the effect may be due to moisture conservation. The mulching effect of crop residue helps.

For crop rotations, the phosphorus level must be adequate to meet the needs of the most demanding crops.

Summing Up

Soil test results provide important guidelines for phosphate application rates. But, understanding the effects of other factors will be helpful as farmers move toward maximum economic yields. ■

In Colorado

300 bu/A Corn Research Yields Breaking Barriers to Efficiency

"**OUR** research goal is not aimed at increasing surpluses, but rather at making production more efficient. If a farmer can produce the same amount of corn on half the land, his production costs are lower and profits higher," says Dr. Sterling Olsen, USDA soil scientist at Fort Collins, Colorado.

After obtaining an average of 305 bu/A in 1981 with irrigated corn test plots, Dr. Olsen followed with 318 bu/A in 1982 using different varieties on different plots.

His management system includes standard equipment for planting, common herbicides, 30-inch rows with populations of 41,000 plants/A, and 225 lb/A of nitrogen (N), plus an estimated 80 to 100 lb/A of N from initial nitrate and mineralization. The higher yield in 1982 was produced with 460 lb/A of N plus 18 tons/A of manure. Soil at the intermountain research site near Fruita, Colorado, is far from the nation's best.

"With more efficient production, land that was formerly used for corn production can be seeded to crops that are more topsoil conserving," Dr. Olsen adds.

To illustrate his point, he says that a yield of 140 bu/A requires about $52 for fertilizer, bringing total production costs to $376/A. It therefore costs the farmer $2.69/bu to grow corn. But if the farmer could average 300 bu/A with $100 worth of fertilizer, making production costs about $472/A, he could reduce production costs to $1.57/bu. These costs include irrigation.

Dr. Olsen applied about 24 inches of irrigation water to his fields. Cost of the water, delivered by canals, is estimated at $12/A. Center pivot irrigation would cost much more because of the cost of energy for pumping. Corn needs about the same amount of water to produce high or low yields.

"We still do not sufficiently understand the limiting factors that control the soil's ability to enhance healthy root growth and to supply water and nutrients during critical or high growth-rate periods," the researcher states. "More research is needed to determine the reasons why yields are so much less than demonstrated potential yields."

He hopes that further study will generate information and practices that can be used by all growers to lower production costs for corn and perhaps other crops. ■

Let There Be *More* Light?

A MAXIMUM YIELD RESEARCH project at the University of Illinois is aimed at identifying limiting growth factors. One objective is to determine the soil levels of phosphorus (P) and potassium (K) needed for high corn yields with irrigation.

"Once adequate supplies of nutrients and water are present, light seems to be one of the limiting factors," reports Dr. L. Fred Welch, University of Illinois soil fertility specialist. "Although one cannot rule out certain other growth factors, some recent data give at least circumstantial evidence for light."

Table 1 shows that outside rows (which received more light) produced higher yields in 1982 tests.

To get direct evidence for the effect of supplemental light on corn yields, fluorescent lights were used as a treatment variable. The extra light increased yields 25%. The highest replicated average yield was 289 bu/A with added light. This yield was with Agway 849X at 32,500 plants per acre in 15-inch rows. (The Pioneer Experimental was not included in this experiment.)

Table 1. Corn yields as affected by row harvested, relative to outside of field.

Row from outside of the field	Grain yield,* bu/A
1	445
2	299
3	252
4	238
5	237

*Population: 40,000 plants per acre with 15-inch row width. Intended soil test: P, 125 lb/A, K, 300 lb/A. Hybrid: Pioneer Experimental.

Although it's not economically feasible to add electric lights to corn fields, it is important to know how additional light affects yields.

There may be ways of increasing effective light other than by electric lights. Growers are already attempting to get better utilization of natural light through hybrids with upright leaves, special planting patterns, and earlier planting, Dr. Welch notes. ■

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The Teacher

IN TRUTH, all of us are teachers. Every day we teach by example as well as by word. In the realm of agriculture there are many opportunities to teach.

The research scientist teaches through his graduate students, his discoveries and his publications. The extension workers, soil conservationists and vo-ag teachers see their "students" every day.

In the college of agriculture the classroom teacher often occupies a role quite different from that of his colleagues, the professors in such fields as the arts and sciences. He is part of a triumvirate – teaching, research, and extension – and usually is involved in at least two of these areas.

For some unknown reason the classroom teaching job has often been relegated to one of lesser importance. This is not always admitted. Since promotion depends on publishing, the 100% researcher should produce more publications than one "handicapped" by teaching chores. Why, then, get involved in teaching?

It's reached the point, at the college level, where few are willing to teach the introductory courses, whether they be in history, math, or agronomy. And, yet, that's where we need the **best** teachers. What can we do to change this?

The Distinguished Professor chairs are usually occupied by those teaching graduate level courses if, indeed, teaching any courses. The persons teaching the introductory courses should occupy equally prestigious positions in the college. What is really more important than molding minds? We don't teach just subject matter; we teach **students**. Think back. Who influenced your life?

Many years ago at Cornell University I had the privilege of helping Dr. H.O. Buckman teach "The Nature and Properties of Soils" to over 100 students each semester. That's all he did – teach and write the textbook. It took all of his time. The course required 3 hours of class, 2 labs of 3 hours each, and 1 hour of "discussion" scheduled in small groups. For the student, 10 hours of contact a week. Many more for Dr. Buckman.

He was a master. His lectures were organized and exciting. The labs and discussions were stimulating. We **LIVED** soil science. How many introductory courses today cover a book of that scope in its entirety?

We must do better. It's not just **WHOM** we are teaching and **WHAT** we are teaching. It's **WHO'S DOING** the teaching. Let's reward the good ones and entice the promising ones.

— Dr. J. Fielding Reed

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