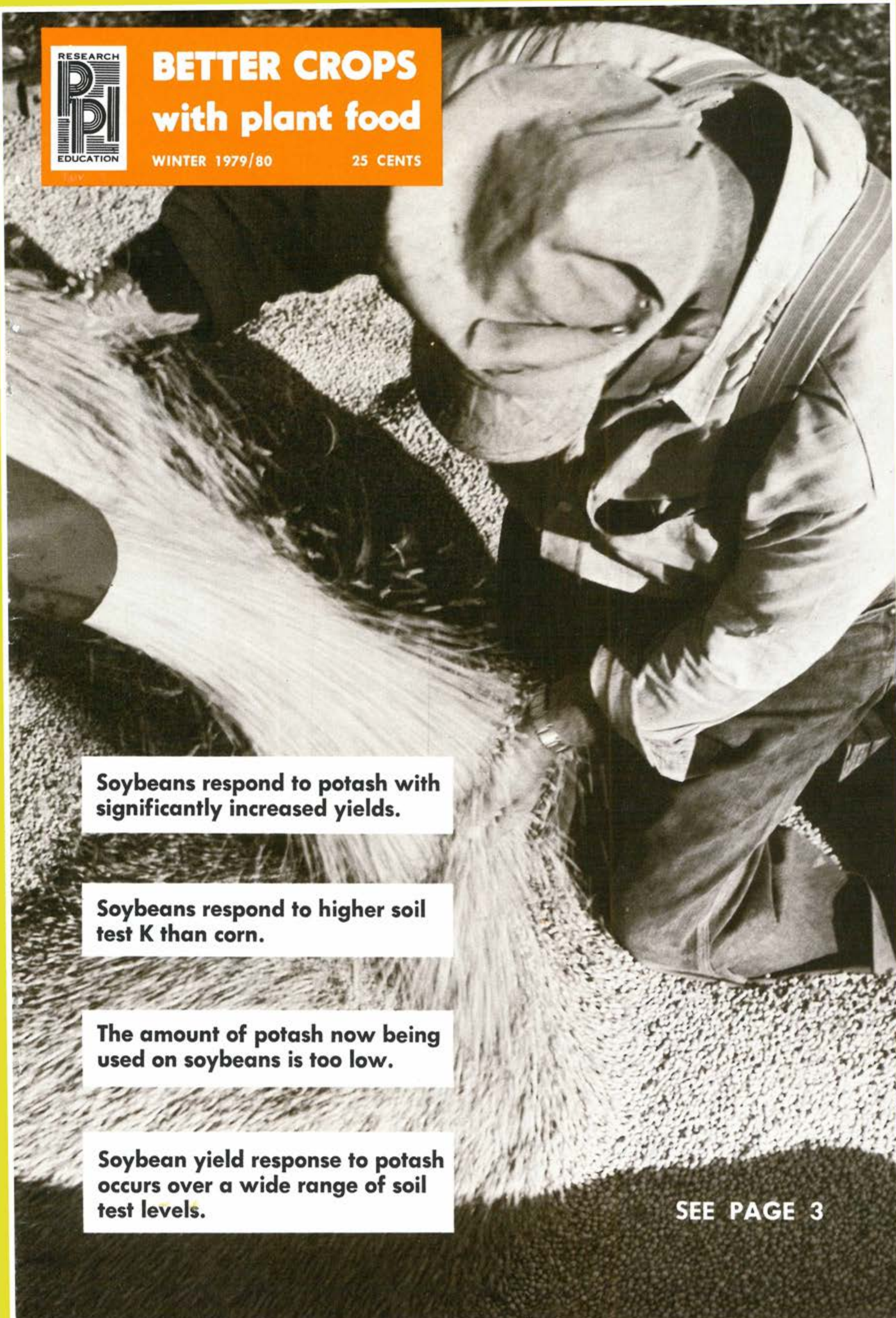
BETTER CROPS with plant food

WINTER 1979/80 25 CENTS



Soybeans respond to potash with significantly increased yields.

Soybeans respond to higher soil test K than corn.

The amount of potash now being used on soybeans is too low.

Soybean yield response to potash occurs over a wide range of soil test levels.

SEE PAGE 3

BETTER CROPS with plant food

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Contents

Soybeans RESPOND To Potash

JAY JOHNSON
Ohio State University

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Columbus, Ohio

BASED ON evidence accumulated during the past 4 years in Ohio, these conclusions can now be made about soybean response to fertilizer:

Conclusion 1: Soybeans respond to K with significantly increased yields.

Conclusion 2: Soybean yield response to K occurs over a wide range of soil test levels.

Conclusion 3: Soybeans respond to higher soil test K than corn.

Conclusion 4: The amount of K now being used on soybeans is too low.

YIELD INCREASES DUE TO POTASH. A study started in 1976 at Ohio's Western Research Branch near Springfield has shown consistent yield increases to K.

Table 1 shows yields from the control treatment (no K_2O) and the highest K treatment (120 lb K_2O/A/year). The 120 lb rate gave highest yield in three

Table 1. Soybeans respond to potash at Springfield, Ohio.

K_2O	1976	1977	1978	1979	Four year average
lb/A			bu/A		
0	49.1	54.0	43.3	39.6	46.5
120	56.5	56.9	49.4	47.6	52.6
Yield increase	7.4	2.9	6.1	8.0	6.1

Soil: Crosby silt loam

Table 2. Soybeans respond to potash with increased yield and profit. 1979 was the fourth year for both locations.

Annual K_2O applied lb K_2O/A	Soil test Fall, 1978 lb K/A	Soybean yield bu/A	Profit per acre $/A	Return from potash* Return on last increment of K_2O-applied %
Springfield, Ohio, 1979. Crosby silt loam				
0	182	39.6	—	—
40	179	43.2	17.52	365
80	246	45.2	25.12	158
120	241	47.6	35.20	210
Wooster, Ohio, 1979. Wooster silt loam				
0	119	41.5	—	—
50	142	45.7	20.00	333
100	164	48.7	32.64	211
150	159	50.0	34.70	34
200	211	52.1	41.72	117

*$6.50/bu soybeans, $.12/lb K_2O, $.30/bu harvest cost deducted.

out of four years. The yield increase averaged 6.1 bu/A over 4 years.

Table 2 analyzes the 1979 yield data from Springfield in more detail. Yields from a different study in 1979 at Wooster are also included.

There were good yield increases to the highest K rates in 1979, even though the soil tests had been built up during the first three years. The almost linear yield increase with higher K rates at Springfield means the 120 lb K_2O/A rate could have been too low for maximum yields.

The economics of K use were excellent. At Springfield, 120 lbs K_2O/A increased the yield 8 bu/A and the profit \$35.20/A. At Wooster, 200 lbs K_2O/A increased the yield 10.6 bu/A and the profit \$41.72/A.

The economics of the last increment of K_2O applied were also very good, shown in **Table 2.** At Springfield, going from 80 lb K_2O/A to 120 lb K_2O/A returned 210% on the investment. At Wooster, the return was 117% on the last 50 lb K_2O increment.

SOYBEANS RESPOND TO HIGHER SOIL TEST K THAN CORN. Both soybeans and corn have responded well to K in Ohio research conducted during the last 4 years at several locations in the state.

When all the data were summarized by comparing yield, soil test level, and amount of K_2O applied from over 700 individual plots, soybeans needed a higher soil test K level than corn.

The summary shows for a soil with a cation exchange capacity (CEC) of 10 meq/100g, the optimum soil test **for corn is 265 lb K/A.** This agrees well with Ohio's current recommendations.

The optimum soil test **for soybeans is 325 lb K/A,** according to the recent data—or 60 lb K/A higher than for corn.

To learn the optimum soil test K for each soil, Ohio uses the equation:

Optimum K soil test (lb K/A) = 220 + (5 × CEC)

The yield data collected over the last 4 years support the accuracy of this equation for corn. But for soybeans the optimum soil test should be increased another 60 lb K/A.

For example, for a soil with CEC of 30, such as a silty clay loam or clay, Ohio would recommend building to a soil test of 370 lb K/A (220 + 5 × 30) for all crops. Recent yield data support this value for corn but not for soybeans. For soybeans the optimum soil test should be 430 lb K/A (370 + 60) for this soil.

The important point here is that while **both** corn and soybeans respond to K, soybeans respond over a wider range of soil test levels.

The data also show that soybeans respond to K when direct applications are made in the spring or fall preceding the crop.

This **refutes** the idea that soybeans respond **only** to residual fertility. Soybeans **do respond** to direct applications of K.

FERTILIZER USE ON SOYBEANS IS TOO LOW. Table 3 shows the average rates of P and K applied to the 1979 soybean crop in 17 states.

Table 3. Average P and K use on soybeans in 1979 (USDA).

	Average rate applied	
	P_2O_5	K_2O
	lb/A	
Ohio	26	30
Illinois	11	21
Indiana	23	44
Iowa	4	6
Missouri	12	22
Minnesota	8	12
Kansas	6	2
Nebraska	6	2
Kentucky	40	42
North Carolina	32	55
Tennessee	30	43
Georgia	41	66
Alabama	42	51
South Carolina	35	77
Arkansas	13	19
Louisiana	17	19
Mississippi	19	28
17 states	17	26

Many farmers are probably missing higher yields because of the low P and K use in most states. In the eastern Midwest and lower South where the soils are generally lower in K, soybean yields could be increased substantially with higher K rates.

Table 4 shows how 43% of the soy-

Table 4. Soybean yields in Ohio could be substantially increased with higher rates of K, based on USDA fertilizer use data and Ohio State University yield response data.

Acres	% of total Acres	Average K use	Additional K needed	Yield increase	Increased profit statewide
million	%	lb K_2O/A		bu/A	million $
1.7	43	0	70	4	27.9
2.3	57	53	17	.5	2.4
				Total	30.3 million

*\$6.50/bu soybeans, \$.12/lb K_2O, \$.30/bu harvest cost deducted.

bean fields in Ohio received no K at all in 1979, according to USDA.

The average soil test in Ohio is about 200 lb K/A. The summary of the yield response data collected in Ohio over the last four year shows that on a soil testing 200 lb K/A, an application of 70 lb K_2O/A would increase soybean yield by 4 bu/A.

The other 57% of Ohio's soybean fields received an average of 53 lb K_2O/A in 1979. An additional 17 lb K_2O/A would increase yields by at least 0.5 bu/A on these fields.

The soybean farmers in Ohio could increase their income by about \$30 million a year with more use of K, after deducting fertilizer costs, shown in **Table 4.**

These numbers are approximate. But they do indicate the potential income being lost in Ohio.

Use of potash on soybeans is low across the U.S. It is likely that potential income is being lost by underfertilization in many soybean producing areas.

PHOSPHORUS SOIL TEST SUMMARY
Percent Testing Medium Or Less

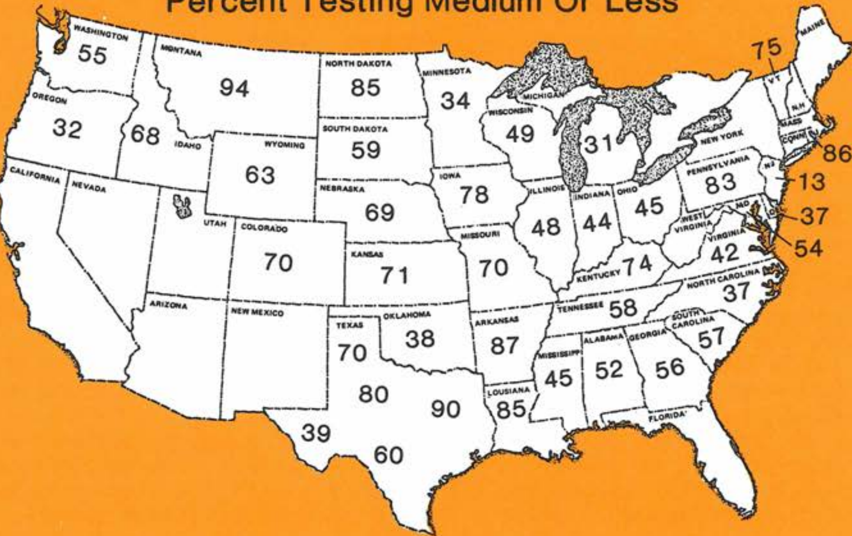


FIGURE 1

WERNER L. NELSON
West Lafayette, Indiana

Soil Test Summaries

SOIL TEST SUMMARIES on a soil area or state basis have been used to call attention to broad nutrient needs and help motivate educational and action programs. They also help indicate trends.

The Potash & Phosphate Institute staff made a summary for the United States. The summary maps **(Figures 1 and 2)** show the approximate percentage of soils analyzing medium or less in P and K as tested by university laboratories.

Five of the state summaries were completed in the 1960's and the rest in the 1970's. "Medium" was selected as an arbitrary break point, realizing that interpretation varies among crops, soils, and states.

With few exceptions, states west of the Mississippi show 60 to 90% testing medium or less in P. With few exceptions states east of the Great Plains show 50 to 75% testing medium or less in K.

WHAT ABOUT TRENDS? The latest summary is compared with an earlier one where available, shown in **Table 1.**

Phosphorus: In the Midwest, there is an apparent decrease in percentage of samples testing medium or less in P in Michigan, Ohio, and Minnesota. But little trend elsewhere.

The more important point is that states such as Iowa, Missouri, Nebraska, Kansas, North and South Dakota, and Kentucky still have about 70% or more testing medium or less.

Elsewhere in the nation, there is an apparent increase in P levels in Maryland, but no trend in states such as North Carolina, Alabama, Mississippi, and Oklahoma.

POTASSIUM SOIL TEST SUMMARY
Percent Testing Medium Or Less

FIGURE 2

And Their Interpretation

Potassium: In the Midwest, there is an apparent decrease in percentage testing medium or less in K in Wisconsin and Iowa but an increase in percentage testing medium or less in Ohio and Missouri.

The change in Kansas is due partly to

Table 1 .Trends in P and K as shown by comparing an earlier summary with the latest.

% MEDIUM OR LESS

	P		K	
	Earlier	Latest	Earlier	Latest
North Dakota	77 (72-3)	85 (77-8)	8 (72-3)	3 (77-8)
Kansas	67 (67-8)	71 (76-7)	29 (67-8)	21 (76-7)
Nebraska	70 (58-65)	69 (66-72)	5 (58-65)	5 (66-72)
Minnesota	45 (64)	34 (77)	58 (64)	59 (77)
Iowa	80 (64-67)	78 (68-73)	64 (64-67)	53 (68-73)
Missouri	68 (64)	70 (76)	64 (64)	69 (76)
Wisconsin	50 (68-73)	49 (74-7)	82 (68-73)	76 (74-77)
Michigan	59 (67)	31 (76-7)	77 (67)	76 (76-7)
Ohio	54 (71-2)	45 (76)	46 (71-2)	52 (76)
Kentucky	60 (67)	74 (75)	67 (67)	71 (75)
Mississippi	44 (66)	45 (79)	69 (66)	63 (79)
Alabama	53 (67)	52 (77)	60 (67)	59 (77)
Tennessee	57 (61-3)	58 (75-8)	59 (61-3)	60 (75-8)
Deleware	40 (68)	37 (72)	73 (68)	65 (72)
Maryland	63 (65)	54 (76)	59 (65)	54 (76)
North Carolina	37 (70)	37 (77)	72 (70)	57 (77)

a greater percentage of the samples now coming from western Kansas.

The more important point is that east of the Great Plains 50-75% of the soils tested are medium or less in K.

Elsewhere in the country, there is an apparent increase in K levels in Mississippi and North Carolina. In such states as Alabama, Tennessee, and Oklahoma there is no real trend.

pH: In the Midwest there is an apparent decrease in acidity in Kentucky, Missouri, and Iowa. The liming is showing, as **Table 2** documents. But in Ohio, Michigan, and Wisconsin acidity appears to be increasing.

Table 2. Trends in pH as shown by comparing an earlier summary with the latest.

	Earlier	Latest
	% < pH 6.0	
Michigan	15 (67)	20 (76-7)
Ohio	26 (71-2)	31 (76)
Kentucky	50 (67)	36 (75)
Missouri	75 (64)	64 (76)
	% < pH 6.5	
Iowa	80 (64-7)	50 (68-73)
Wisconsin	40 (68-73)	48 (74-7)
	Average pH	
Kansas	6.3 (67-8)	6.7 (76-7)

SOME KEY QUESTIONS. How well does a summary portray the nutrient status of soils in a soil region or state? Is it biased upward or downward? Here are some thoughts:

Source of Information: All are from state labs except in Wisconsin where a combination of state and commercial labs is used.

Above 55% of the soil samples in the U. S. are now analyzed by state labs. But in some states commercial labs may be analyzing 50% or more of the samples.

Company labs may prepare area summaries for use by dealers:

Number of Samples Tested

	Government	Commercial
1968	1,295,000	2,242,000
1977	1,727,000	1,448,000

Accuracy: Wisconsin prepares a computer summary from samples sent to both state and cooperating private labs. A summary from a systematic sampling of two percent of the crop area in parts of a six-county area agreed well with the computer summary.

A systematic sampling study in Duplin County, North Carolina was compared with a summary from voluntary samples. While there were small differences, these were not considered great enough to invalidate a summary of results from farmer samples.

In the Purdue soil testing laboratory, a summary of soil samples from 200 farmers, reporting their corn yields in 1976-77, showed an average of 105 bushels of corn per acre. The average corn yield in Indiana for those two years was 106 bu.

What Crops Do The Majority of the Samples Represent? In a Kentucky summary, K averaged 211 lb, but 25% came from tobacco, lawns, and gardens testing 276 to 345.

In Oklahoma in 1976, about one fourth of the soil samples in the OSU computer summary came from urban areas. In some states, such samples are excluded from summaries. On the other end of the scale, few samples come from small grains and pastures—and these soils are likely to be lower in fertility.

Median Versus Mean: Michigan uses the median to help avoid distortion from a few extremely high testing soils. With median value, 50% of the soil test values are below and 50% above the median.

So the median is not influenced by extremely high values as is the mean. Michigan State University recently compared median and mean values for P and K for the state. Note the lower median P and K values:

	P	K
	Lb/A	
Mean	98	182
Median	67	155

SAMPLING. Closely related to the median vs. mean question is soil test variation within a field. In an Illinois soil sampling study, 12 separate samples from a 40-acre field were compared with a composite sample:

	pH	P	K
Composite	5.9	49	344
12 Samples	7 below 5.9	9 below 49	10 below 344

In this study, the composite is biased upward by a few areas high in a nutrient. At least 75% of the field was lower in P and K than the composite.

If the recommendations were based on the composite, much of the field would be underfertilized. This problem would be more important in areas having a fairly long history of fertilizer use.

A study on three 20-acre fields in Wisconsin showed that apparently uniform fields aren't necessarily so. In a Kansas study, the following data was obtained from 16 cores in a 5-acre field:

	pH	P	K
Range	5.4-6.8	18-19	134-241
Field Composite	5.9	35	188
No. below composite avg.	9	11	5

The farmer has at least three choices: (1) He can sample systematically according to soil type and/or by previous management as best he can and then spot treat. (2) He can apply according to the composite average. (3) He can apply a heavier amount over the whole field to make certain there are few areas short in nutrients.

This point is mentioned because it affects the interpretation of the values making up a summary.

WHAT DO SOIL TESTS MEAN? Let's look at soil test calibration. In the 1940's and 50's, soil fertility levels and yield levels were low and fertility level was an important controlling factor in crop yields.

Now fertility and yield levels are higher and as the better farmers strive for higher yield and quality, other factors become increasingly important along with fertility.

In Montana, for example, the correlation (r^2) of the K soil test with yield was .40. Adding site temperature made it .51. Adding slope made it .61. Adding K/Ca + Mg made it .73.

In Alberta, correlation of the K soil test was improved by considering drainage, parent material, soil order and crop. In many areas such factors as planting date, N rate, plant row width, variety, and tillage will enter in..

In such areas as Wisconsin, Iowa, and Ontario, no-till and minimum tillage result in lower uptake of K by corn than with conventional tillage.

The job of soil test calibration is challenging and urgent. It is especially important in relation to Public Law 208 implications. Agriculture should be ready with the answers, for, in a sense, we are at a crossroads.

Soil Test Interpretation and Recommendations. Many factors contribute to higher yields. One is adequate plant nutrients.

State recommendations for higher yield goals bear this out. Over the years changes have taken place in interpretation. And the soil test level considered medium has increased in some states, particularly for K.

This shift will continue into the 1980's. It is mentioned here because the attached soil test summary maps are made on the basis of percentage testing medium or less.

But if the dividing line between medium and high is now 210 for K, it could well be increased to 250 in some areas in the 1980's. This could mean an even higher percentage of soils could be testing medium or less.

S. A. Barber of Purdue says, **"Long term field experiments with corn, soybeans, and wheat have shown that medium to high soil test levels are necessary to obtain maximum yields."**

Maintenance fertilizer is recommended in the medium range and high receives less than maintenance. A question might be raised if a "high" (not very high) soil should be depleted in the 1980's.

John Garrett of Missouri says that **when soybean cyst nematode is present, soils that were thought to be adequate in K really are not. Higher K helps to overcome some of the problem.**

On the other hand, W. C. Danke of North Dakota says **when he gets more P calibration data, he will probably drop the dividing line between medium and high from 26 to 18.**

M. L. Vitosh of Michigan says **it is better to overestimate the yield goal than to underestimate it.**

LOOKING TO THE 1980's. The goal should be to build soil productivity, not just fertility.

This takes in the total picture including **(1) production of more residues through higher yields, (2) proper use of residues by incorporation or being left on the surface, (3) chiseling or subsoiling**

to break a pan and/or to deepen the productive soil surface layer over the years in some soils, (4) proper control of pests, (5) water management through drainage and/or irrigation, and **(6) more adequate levels of nutrients for the coming higher yields.**

All of this should gradually improve the moisture situation in the soil and "deepen the water trough."

A Michigan researcher said many years ago, **"The practices we perform to grow our top yields do the best job in conserving and building our soils."**

Land values have doubled in the past 5 years and are expected to double again before the end of the 80's. This along with increasing costs of most inputs give a strong incentive to the farmer to increase yields.

R. Rominger, Farmer and Director of the California Department of Food and Agriculture says, **"The ability to produce higher yields has kept farmers in business over the years."**

The soil test as related to crop response to added nutrients will come under increased scrutiny as farmers push for higher yields and quality. A determined effort on calibration research is needed at maximum yields for each region.

Then new soil test summaries in line with soil test interpretation and yield and quality goals for 1980 agriculture must be developed. **The End**

WATER And Its Uses

ROY L. GOSS
In Northwest Turfgrass Topics

THE SHORT WATER situation (over) two years ago brought into focus more clearly the problems that face us in the future with regard to available water.

According to Dr. J. R. Watson, **only 1% of the Earth's water is available for use. The rest is tied up in polar ice caps and with the oceans and seas which is not considered immediately usable.**

To more clearly bring the water situation into focus Herb Schulbach and Tom Aldrich from the University of California published in the Fall, 1978 edition of **Soil and Water** the water necessary to produce food.

Part of the table is reproduced on p. 11 to give you an idea of what is required for food production.

FURTHER INFORMATION presented by these writers indicated that it requires **4,533 gallons of water to grow the daily food requirements for one person.** For one year this is equal to 1,641,-405 gallons, or **5.08 acre feet.**

This is in addition to each individual's average daily needs of 223 gallons. So you can see this adds up to a whopping water situation. And you can imagine that with each additional person that consumes water and food, someone has to come up with that additional 5-acre feet of water per year.

It appears, then, that water will become one of our most precious resources and one of the most critical. It has already become that critical in certain areas. Without question, deep wells have to be sunk deeper and from all indications **ground water levels are dropping.**

Estimated Crop Water Requirements to Produce Quantities of Selected Foods

Crop	Yield lb/Acre	Water Use Acre Ft. Per Acre	Gal. Water Lb/Food
Beans, Green	10,000	3	98
Cabbage	25,000	3	39
Carrots	30,000	3	33
Celery	60,000	4	22
Corn (ear)	8,000	3	122
Cucumbers	25,000	3	39
Lettuce	28,000	2	23
Onions	40,000	2	16
Potatoes	40,000	3	24
Spinach	16,000	3	61
Tomatoes (process)	50,000	3.5	23
Apples	20,000	3	49
Apricot	12,000	3.5	95
Cantaloupe	16,000	2.5	51
Cherries	5,000	3.5	358
Grapefruit	25,000	4	52
Oranges	20,000	4	65
Prunes, Dried	4,000	3.5	285
Watermelon	20,000	3	49
Grapes	14,000	3	70
Corn	6,000	3	163
Wheat Bread	4,000	1.5	122
Rice	4,000	3.5	285
Beans, Dry	2,000	2	326
Almonds (meats)	1,500	3	188
Walnuts (meats)	2,000	4	325
Margarine	400	4	2962
Sugar (beats)	9,000	3.5	127
Milk	10,000	4	130
Beef (Live)	500	4	
(Dressed)	250	4	5214
Pork			1630
Bacon			1630
Chicken			815
Egg			544

Commissions have been established to study the water situation and to come up with guidelines for future survival.

THE CRUX OF this whole dissertation with regard to human water needs is that we, as turfgrass managers, must do a much better job of managing water in the future.

One of the alternatives, of course, is to use recyclable water such as sewage affluent or to use water from sources of runoff, impoundment, where we can trap runoff water annually.

Water is probably one of the most abused factors on nearly all managed turfgrass areas where water is "usually plentiful." The price hasn't caught up with us yet but I have no doubt that someday it will. We should learn to judiciously apply water and only when it is necessary.

This means that there will need to be a great deal of education among ourselves individually to settle for a little less quality in certain areas while maintaining an acceptable level of aesthetics.

EXCESSIVE WATER can be very harmful to turfgrass production and maintenance.

It hardly seems necessary to delve into all of the points in detail, but among them would include an increase in **soil structural deterioration, soil compaction, reduced soil oxygen, shallow rooting characteristics, nutrient leaching,** and **oxygen exclusion from the soil profile.**

1 believe it is time that the professional turfgrass manager must begin an educational program with his clientele to convince them that we must do with a little less. **The End**

Corn Production and Soil Fertility: Response Surface Approach to Yield Maximization

J. F. MONCRIEF, L. M. WALSH,
E. E. SCHULTE
University of Wisconsin

MANY OF OUR BETTER FARMERS have been getting good corn yields by applying recommended agronomic practices.

Some have reached a yield plateau in recent years and want to know any additional steps they can take to move yields further up the yield ladder.

In some cases, physical condition of the soil may be the yield limiting factor or it may even be moisture, population, temperature, variety, etc.

NUTRIENT BALANCE is important to high yields. Low yielding crops can tolerate a fairly wide range of nutrient composition, work by E. R. Beaufils (1973) and M. E. Sumner (1974) points out.

As yields increase, nutrient balance becomes increasingly important. At very high yields, nutrient levels must be balanced within fairly narrow limits.

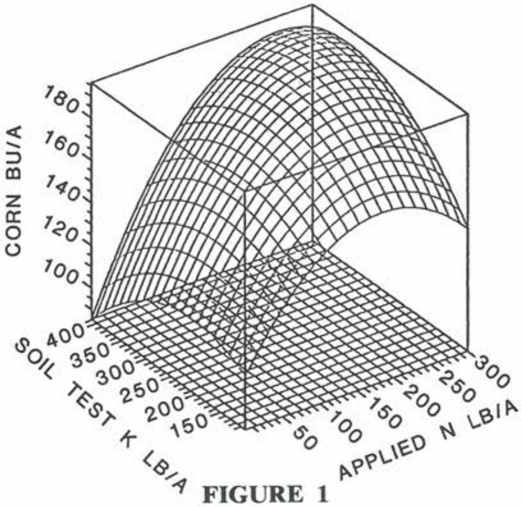


FIGURE 1

Through the use of factorial experiments in which two or more nutrients are varied at the same time, a model can show the interaction of nutrients and the importance of nutrient balance on crop yield.

In a corn trial, we adjusted soil P between 25 and 100 lb/A and soil K between 100 and 400 lb/A on a Plano silt loam soil at the Arlington Experimental Farm. We also added 300 lb N/A in 60-lb increments.

Since broadcast P influenced yield little on this soil, we will discuss the effects of N and K on high yielding corn.

THE RESPONSE SURFACE shown in Figure 1 was generated by mathematically relating grain yield to applied N and soil test.

Low N and K are represented at closest corner of the box—O-N, 100 lb soil test K/A. The corresponding yield is shown in the lower left corner of the box as 85 bu/A.

As you move along the surface in the box, note how changes in applied N or soil test K affect yield.

As you move toward the back corner of the box, both nutrients are increasing.

Yields increase as you move upward in the box. Steepness of the surface relates to the amount of yield response to a given amount of applied N or soil test K.

Highest yield was 197 bu/A. It received 235 lb N/A and had a K soil test of 312 lb/A. When more N was applied, yields declined.

The response surface clearly shows a sharp increase in yield at the lower levels of added N and soil test K. The response then flattens out as you approach the top of the surface.

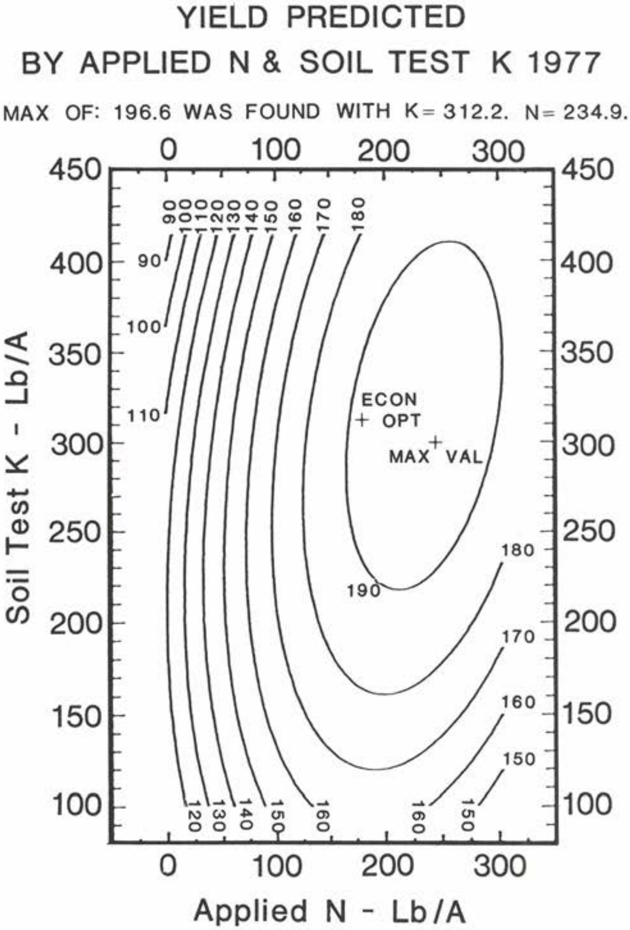


FIGURE 2

A YIELD CONTOUR MAP of the response surface was constructed to get a better look at the relationship between fertilizer and yield. It is shown in **Figure 2.**

Each line on this map connects points of equal yield. The yield lines (isoquants) are 10 bu/A apart.

Let's look at how applied N affected yield, while keeping soil test K constant. Draw a line connecting the 150 lb K/A rates on both sides of the map.

Now, going from left to right along that line, the rate of N applied increases from 0 to 300 lb/A. Note how the first 10 bu/A increase is obtained with a small application of N.

As you proceed along your line, note how the curved yield lines get further apart. This means it takes more and more N to get each additional 10 bu/A yield increase. Once you exceed about 200 lb N/A, yield actually declines at 150 lb K/A soil test.

On the other hand, you can get yield increases up to 235 lb N/A if soil test K is 300 lb/A. In this case, predicted yield would reach 196 bu/A compared with 177 bu/A at 150 lb K/A soil test.

The response surface in Figure 1 and the contour diagram in Figure 2 clearly show how important nutrient balance is to high corn yields.

ECONOMICAL MAXIMUM is what every grower shoots for. The highest yield is not necessarily the most profit-

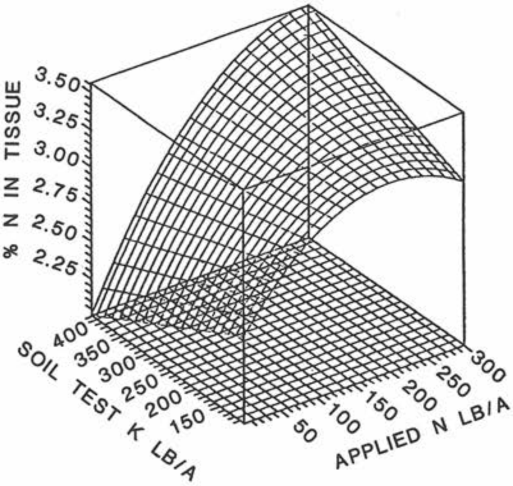


FIGURE 3

able yield.

At some point below the maximum rate of applied N and soil test K for maximum yield, the cost of each additional unit of N or K exceeds dollar return from the small yield increase.

This means the economical maximum will depend on value of the crop and fertilizer prices. Where does that economical maximum fall? Usually at about 90% of the rate required for maximum yield.

In any case, the equation from which the response surface is generated enables one to estimate the economic maximum fertilizer rates.

The economic N optimum calculates out to 182 lb N/A. The yield predicted for 182 lb N/A and 312 lb K/A soil test is 192 bu/A

The economic K optimum is less direct because the optimum rate is based on soil test K rather than amount of K added.

The amount of K that must be added to raise soil test enough for maximum yield depends on initial soil K and soil type. The Plano silt loam in this experiment requires about 5.16 lb K (6.2 lb K_2O) to raise the soil test by 1 lb/A. This means it would take 986 lb K_2O/A, applied over time, to increase K soil test 159 lb.

THIS POTASH should be regarded as a capital investment.

Adding 160 lb K_2O (133 lb K) each year for 4 years raised the soil test level from 153 to 252 lb/A. The soil test K held steady for the last 2 years.

Once the soil test level has been raised, it takes relatively small annual rates of K to maintain that level. It's a job of replacing losses from crop removal, erosion, and leaching.

With continuous corn on Plano silt loam, we found the maintenance application for 150 bu/A yield goal to be 60 lb K_2O/A.

A 200 bu/A yield would require about 85 lb K_2O/A (70 lb K) annual maintenance rates.

The cost of K_2O for 200 bu/A corn figured at $0.10/lb is $8.50 compared to $6.00 for 150 bu/A. The difference, $2.50, would be paid back by one bushel of added corn yield. Thus, at present potash prices, it is best to shoot for high yields rather than be "penny wise and pound foolish."

CROP QUALITY. In addition to increasing yields, proper fertilization improves crop quality. One measure of crop quality is crude protein content, estimated by total N. As with grain yield, there is an interaction between the concentration of N in plant tissue and applied N and soil test K.

Figure 3 shows this relationship for earleaf tissue and **Figure 4** for grain. The former is important when the corn is harvested for silage.

In the response surfaces of **Figures 3** and 4, the N and K dimensions are the same as in **Figure 1,** but the vertical dimension is %N in tissue **(Figure 3)** or %N in grain **(Figure 4).** The greatest effect on plant N is that due to applied N. Nevertheless, soil K is important in the utilization of that N by the plant.

Work by others has shown the percentage of total N in plants occurring as protein N increases as K levels are increased.

At low N rates, increased soil K actually decreases tissue N. This is probably a dilution effect due to dry matter response to K, shown in **Figure 3.**

At high N rates, increases in soil test K increased tissue N over the entire range of K.

TURN TO PAGE 22

THE RESEARCHERS seeking 300-bushel corn and 100-bushel soybeans at our land-grant universities will reach them—and soar far beyond one day. Maybe sooner than we think.

You can't really get on paper — in words or pictures — the vigor and enthusiasm with which new knowledge is sought.

But they'll burst 300 bushels wide open not because the barrier is there, but because they are there — and because they have good reason to be seeking these high yields per acre of farmland.

An exhibit at a Chicago museum states the reason in 8 words: "There are 5 acres between you and starvation."

This is the message of a permanent exhibit at Chicago's Museum of Science and Industry describing the job of the American farmers.

The exhibit, presented by the USDA, reveals an average of 5 acres of farmland per person in this country. Just 75 years ago there were 11.5 acres per person.

The time is coming, maybe soon, when agronomic research will be considered the premium science to continue man's life on earth. It's that now. But how many consider it so?

In this issue, you will find a brief item on "Water and Its Uses."

When you read between the lines, the future role of agronomic research becomes gigantic.

This item reveals only 1% of the Earth's water is available for use—the rest being tied up in polar ice caps and sea waters not considered immediately usable.

It also reveals that the daily food requirements for one person need 4,533 gallons of water per day to grow. For one year this means 1,641,405 gallons or 5.08 acre feet for each person.

And this is **in addition** to each individual's average **daily** needs of 223 gallons.

What a future research in this area must have. Breeding plants that can utilize soil nutrients more fully to stretch the water further and further to get more and more yield.

It is going to require research on the interactions in plant growth. Not the influence of soil fertility alone. Not plant breeding or genetics alone. Not pest control or weed control alone. **But the whole team, hand-in-hand, bringing a top-yield package to the crop as a team.**

The new generation will perfect cooperation even more—**scientific teaming to make sure those dwindling farm acres produce enough to keep an increasing population going.**

What greater calling can our youth have than this work?

What a shame Justus von Liebig can't come back and see what has happened. He was the brilliant young German chemist out of whose laboratory came the first clear-cut analysis of soil-plant-atmosphere relationships. Liebig was the first to state the law that plants create organic matter out of purely inorganic substance, a thing that animals are incapable of doing.

Since that day, man has been intrigued with the idea that crop yields can be increased by adding some minerals to the soil on which the crops are to be grown.

Some of us may not be around when the young researchers hit 600 bushels of corn per acre. But they will be reached.

If this sounds like an irresponsible statement, just remember when 50 bushels was a big yield. Not many years ago.

And for those who say there is a limit to the moisture supply, that may be true.

But there's no limit to man's imagination. And that imagination may find a way to help plants utilize soil nutrients in such a way that what takes 1 gallon of water to grow today may take a half gallon tomorrow.

Some may think we have just about reached our limit. The young researcher should never think so. When or if he ever gets discouraged, that will be the day to start worrying.

An ancient author once said, "My son, you must store up a lot of absurd enthusiasms in your youth, else you reach old age with an empty heart, for you lose many of them by the way."

There's nothing absurd about 300 bushels of corn. Illinois master farmer Warsaw well exceeded it on his trial plot this year. Now, 600 bushels may seem slightly absurd at this time.

But experience has shown what seems impossible today may become very possible tomorrow.

To believe otherwise is to reach old age with an empty heart. And I don't want to do that, standing here on the brink of it.

BOYD R. WILLETT
KALIUM CHEMICALS

CHAIRMAN
BOARD OF DIRECTORS
POTASH & PHOSPHATE INSTITUTE

BOYD R. WILLETT, President of Kalium Chemicals Division of PPG industries Canada and Vice President of the Chemical Division-International Department of PPG Industries, has been elected Chairman of the Board of the Potash & Phosphate Institute, it was announced by outgoing Board Chairman John F. Frawley, Senior Vice President of AMAX Inc.

DAVID S. DOMBOWSKY, President of the Potash Corporation of Saskatchewan, has been elected Vice Chairman of the Institute board.

In welcoming the new board leaders, Dr. R. E. Wagner, Institute president, said, "For nearly 45 years, this Institute of agronomic scientists has supported hundreds of university research grants, participated in thousands of field demonstrations and cooperative projects, and distributed thousands of communication tools to find and tell agronomic needs for fertilization. This will continue to be our mission—done in a way that is sound and profitable for the farmer."

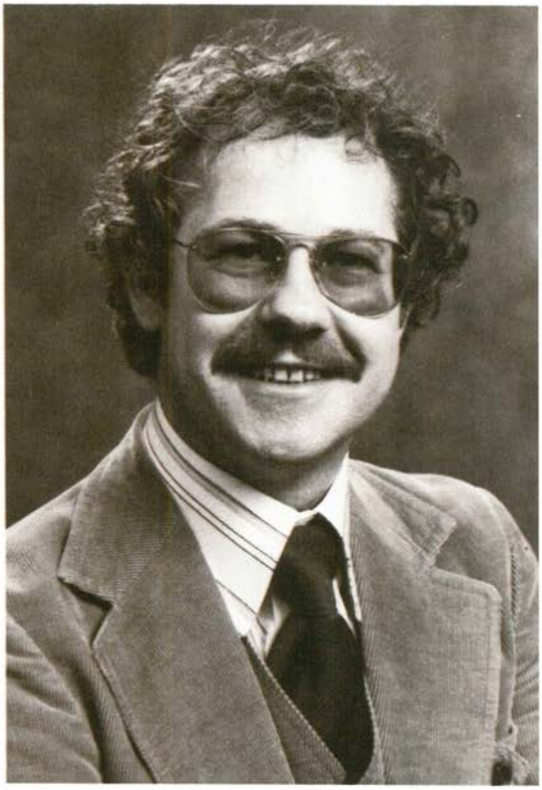
The Potash & Phosphate Institute is the research and education arm of the potash and phosphate industries. It was founded in 1935 as the American Potash Institute by U S. potash producers and became the Potash & Phosphate Institute when the phosphate industry started joining the Institute in 1977.

The Chairman and Vice Chairman are elected by a Board composed of major officials from the following Institute member companies: Agrico Chemical Company, AMAX Chemical Corporation, Borden Chemical, Borden, Inc., C-I-L Inc., Cominco American Incorporated, Duval Corporation, Estech General Chemicals Corporation, First Mississippi Corporation, Freeport Minerals Corporation, Great Salt Lake Minerals & Chemicals Corporation, International Minerals & Chemical Corporation, Kalium Chemicals, Mississippi Chemical Corporation, Occidental Chemical Company, Potash Company of America, Potash Corporation of Saskatchewan, Royster Company, Sherritt Gordon Mines Limited, Texasgulf Inc.

Chairman B. R. Willett, who became Vice President and General Manager of PPG's Chemical Division-International Department in 1973, is also Vice President and Director of PPG Industries Canada Ltd.

DAVID S. DOMBOWSKY
POTASH CORPORATION OF SASKATCHEWAN

VICE CHAIRMAN
BOARD OF DIRECTORS
POTASH & PHOSPHATE INSTITUTE



A native of Matador, Texas, Mr. Willett is a University of Texas graduate who joined PPG as a young development engineer in the Chemical Division's technical center at Corpus Christi in 1942.

From there he became production superintendent of PPG's Lake Charles, Louisiana, chemical plant in 1946. Nine years later he became manager of operations for Stanchem Division of PPG Industries in Canada.

In 1961, he accepted the presidency of Kalium Chemicals Division of PPG Industries Canada, a Canadian operation producing potash near Regina, Saskatchewan. Twelve years later he accepted his present responsibility as Vice President and General Manager of PPG's Chemical Division-International Department

Mr. Willett has spent 37 years helping to build the PPG Company.

Vice Chairman D. S. Dombowsky was Managing Director of SEDCO when named President of the Potash Corporation of Saskatchewan in 1975.

Before SEDCO he served as Saskatchewan's Deputy Minister of Industry and Commerce, Deputy Provincial Treasurer, and Director of the Budget Bureau.

He started his career with the Budget Bureau of the Treasury Department in 1958. In 1964, he became Secretary to the Johnson Royal Commission for studying the efficiency and effectiveness of the Saskatchewan government.

He earned a degree in Commerce from the University of Saskatchewan, Saskatoon and a diploma in Public Administration from Carleton University.

Mr. Dombowsky is active on many boards and commissions, including the University of Saskatchewan, Saskatchewan Power Corporation Board, Western Development Museum, Saskatchewan Water Resources Commission, Saskatchewan Computer Users, Regina United Appeal Cabinet, and Saskatchewan Economic Development Corporation, which is the Province's Industrial Bank.

He has served as president of the Institute of Public Administration of Canada and is presently a member of the National Council of the Institute of Public Administration of Canada. And he represents the government on the board of the Interprovincial Steel and Pipe Corporation Ltd.

Farmers CAN Produce High Corn Yields ECONOMICALLY

R. D. MUNSON
St. Paul, Minnesota

DO RECORD high yield corn farmers actually make a profit on their crop? This question asked recently by some non-agricultural journalists prompted a study of past records to make economic comparisons.

Farm management results from test plots were compared with farmer averages in several states to find the answer. In each case, high corn yields were profitable. Let's look closer at the results.

HERMAN WARSAW had a top corn yield of 338 bushels per acre in 1975 on his dryland test area. His Saybrook, Illinois, farm was compared with 469 Illinois farmers who produced an average of 148 bushels per acre **(Table 1).** The state average was 116 bushels.

Table 1—Comparison of results from 469 Illinois farmers with Herman Warsaw's test area - 1975.

Farm mgt. corn production study (469 farmers)	Avg.	Herman Warsaw
Corn yield	148 bu/A	338 bu/A
Prod. cost	$254.00/A	$402.00/A (est.)*
Price corn	$2.79/bu	$2.79 (assumed - actually $2.85/bu)
Breakeven yield	91 bu/A	132.6 bu/A
Breakeven price	$1.72/bu	$1.19/bu
Profit per acre	$158.92/A	$541.02/A

*Additional production costs: nitrogen, phosphate and potash—$86.36/A; 20 ton manure application—$20/A; higher plant population—$8.29/A; harvesting an additional 190 bushels per acre at 18 cents per bushel—$34.20/A.

Warsaw's basic costs were assumed to be the same as those for the farmer study group. But, additional fertilizer, higher plant population and higher yield pushed production costs to $402 per acre or $148 higher than the group average. The bottom line shows a very economical $541.02 per acre profit for Warsaw compared to $158.92 per acre group average. That's a $382.10 advantage.

This top farmer has continued to achieve well above average corn yields since 1975 on the test plot. The test area produced 257 bushels per acre in 1978 and has an eight-year average yield of 254 bushels.

ROY LYNN, JR., set a U. S. record with his 352.6 bushel per acre corn yield in 1977. He grew the corn on a 10-acre irrigated test plot. His production costs were estimated at $347.91 per acre **(Table 2).**

The average Michigan farmer grew 85 bushels per acre at a cost of $225 per acre. The average farmer's breakeven yield was 112.5 bushels per acre while Lynn's was 174.

Lynn's profit was $357.29 per acre compared to a $55 per acre loss for the average farmer.

Table 2—An economic comparison of the average Michigan farmer's corn production with Roy Lynn, Jr.'s 10-acre test plot—1977.

	Avg. Mich. Farmer	Roy Lynn, Jr. Top U.S. Yield
Corn yield	85 bu/A	352.6 bu/A (irrig)
Prod. cost	$225.00/A	$347.91/A*
Breakeven price	$2.65/bu	$.99/bu
Breakeven yield at $2/bu	112.5 bu	174.0 bu
Profit or loss	-$55.00/A	$357.29/A

*Assumed added cost of $63.47 for harvest and drying.

In 1978, Lynn harvested a 298 bushel per acre yield from his test plot compared to a state average of 81 bushels.

WISCONSIN'S Hurlburt brothers were compared with that state's average corn farmer. The farm located near Durand produced 336.4 bushels per acre in 1978 compared with a state average of 100 bushels **(Table 3).** Production costs of $254 per acre were assumed. The average Wisconsin farmer lost $52 per acre with corn prices at $2.00 per bushel. The Hurlburt's 336.4 bushel yield returned a net profit of $215.66 per acre when production costs of $457.14 per acre were deducted.

Table 3—Comparison of the average Wisconsin farmer's corn production with the Hurlburt brothers' farm—1978.

	Avg. Wisconsin Farmer	Hurlburt Bros.
Yield	100 bu/A	336.4 bu/A
Prod. cost	$254.00/A	$457.14/A*
Gross return at $2.00/bu	$202.00/A	$672.80/A
Profit or loss	-$52.00/A	$215.66/A

*Basic cost of $254 plus additional manure and fertilizer, $93.80; irrigation, $66.95; and harvesting and drying $42.39.

McLEAN COUNTY, Illinois farmer Stanley Wilson grew 280 bushels of corn per acre on his non-irrigated test plot in 1978. That yield approached the physiological potential determined by Purdue University scientists using computer simulation models. Wilson could only grow 47 bushels per acre his first year in farming 28 years ago. His progress is excellent.

The average 1978 corn yield for Illinois was 111 bushels per acre. The average grower applied 136 pounds of N, 80 pounds of P_2O_5 and 90 pounds of K_2O. Wilson applied an additional 84.5 pounds of N, 23.5 pounds of P_2O_5 and 60 pounds of K_2O per acre. Additional fertilizer cost him $21.84 per acre using 15 cent per pound N, 16 cent P_2O_5 and 9 cent K_2O. Higher plant population cost him $2.38 more per acre (58 cents per 1,000 plants). He harvested 169 extra bushels per acre over state average adding another $30.42 per acre for harvesting and drying (18 cents per bushel). Drying costs were low because moisture at harvest was 16 percent.

When added to the $254 assumed basic production costs, Wilson's costs total $308.64 per acre. His 280 bushel crop sold at $2.00 per bushel would gross $560 per acre. This would leave a net return of $251.36 per acre. The average Illinois farmer lost $32 per acre. **(Table 4).**

Table 4—Economic comparison of the average Illinois farmer's corn production with the Stanley Wilson farm—1978.

	Avg. Illinois Farmer	Stanley Wilson
Yield	111 bu/A	280 bu/A
Prod. cost	$254.00/A	$308.64/A
Gross return at $2.00/bu	$222.00/A	$560.00/A
Profit or loss	-$32.00/A	$251.36/A

HILDUS WOLD produced 247.6 bushels per acre on his Houston County farm in southeastern Minnesota. That was much higher than the 100 bushel state average for 1977.

The average Minnesota farmer applied 101 pounds of N, 58 pounds of P_2O_5 and 64 pounds of K_2O per acre. According to the soils area and Wold's reported data, let's assume that he applied an additional 117 pounds of N, 84 pounds of P_2O_5 and 116 pounds of K_2O. At the assumed basic production costs of $254, adding the extra nutrients would cost $43.43 per acre. Add $4.52 per acre for extra seed and $26.57 for harvesting the higher yield. Production costs now total $326.52 per acre **(Table 5).** Minnesota's average farmer lost $54 per acre while Wold enjoyed a profit of $168.68 per acre.

Table 5. Economic comparison of the average Minnesota farmer's corn production with Hildus Wold—1977.

	Avg. Minnesota Farmer	Hildus Wold
Yield	100 bu/A	247.6 bu/A
Prod. cost	$254.00/A	$326.52/A
Gross return at $2.00/bu	$200.00/A	$495.20/A
Profit or loss	-$54.00/A	$168.68/A

TWENTY-NINE Georgia farmers grew over 200 bushels of corn per acre in 1978. All but two of the farmers irrigated in this drought year. The group

Table 6—Economic value of the extra yield to 29 Georgia farmers growing 200+ bushel corn as compared to the U. S. average yield—1978.

	U. S.	Georgia 200+ Bushel Farmers
1978 average corn yield	101 bu/A	212 bu/A
$N+P_2O_5+K_2O$, lb/A	120+60+65	270+105+152
Extra fertilizer, lb/A		150+45+87
Extra yield		111 bu/A
Value of extra yield, $2.00/bu		$222.00/A
Cost of extra fertilizer*		$37.52/A
Cost of irrigation**		$66.95/A
Cost of extra harvesting and drying***		$19.98/A
Cost per added bushel		$1.12/bu
Profit per added bushel with $2.00 corn		$.88/bu
Extra net return		$97.68/A

*Prices: 15 cents per lb N, 16 cents per lb P_2O_5, and 9 cents per lb K_2O.
**Added for two farmers not irrigating. Average cost of irrigation based on Nebraska results.
***Harvesting and drying costs at 18 cents per bushel.

averaged 212 bushels per acre, considerably higher than the U. S. average of 101 bushels **(Table 6).** The extra 111 bushels cost $124.46 per acre or $1.12 per bushel, but their added net return was $97.68 per acre (88 cents per bushel).

IN SUMMARY, this study leaves little question that high yields and profits go together. It is probably the only way the farmer can stay in business in the long run. Farmers getting lower yields are probably losing money unless they are doing a super job through animal feed conversion. There is still some doubt that low yields are even profitable.

Fertilizers will play an interesting role as yields are pushed higher because the nutrients must be available for plant use. This means an even greater proportion of high yields will be attributed to fertilizers. Extremely high yields may show as much as 80 percent due to fertilizers. It will require a complete management package to take advantage of the interaction of nutrients, climate and cultural practices. **The End.**

Do record high yield corn farmers actually make a profit on their crops? This question prompted a study of past records to make economic comparisons. Farm management results from test plots were compared with farmer averages in several states to find the answer. In each case, high corn yields were profitable.

Forage Fertilization: A Neglected Practice

BOB DARST
Stillwater, Oklahoma

IS FERTILIZATION the most neglected forage management input? Some think so.

Yet, forage fertilization is recognized by agronomists, economists, and animal scientists as an essential management input in forage production.

Why doesn't the grower see it as such? To help answer this question, the Potash & Phosphate Institute surveyed 25 research and extension agronomists. This article deals partly with their responses.

WHY DOES THE GROWER neglect fertilization? He has little confidence in fertilization as an income producer.

He can't easily see the benefits, so considers it a poor risk. So, when operating capital gets tight, fertilization expenses are usually the first to be cut.

The grower places low priority on expected income from forage production. He considers forages as a secondary crop—if a crop at all. In many cases, the beef producer is only part-time and doesn't have to depend on his cattle operation for a living. His full-time job is off the farm.

Low cattle prices are often cited as the cause of poor fertilization. What about when prices are high? Does the grower adjust fertilization—and other inputs—to take advantage of higher prices? No. Why not?

He keeps poor records. So he can't identify what is profitable and what is not. His stocking rate may be so poor he doesn't need the extra forage. He may not have time to manage for more intensive production. His present standard of living is all right to him.

WHERE DOES THE GROWER get production information? More often than not he seeks answers from his fertilizer, seed, and chemical dealer.

He also relies on his county agent for production information. He attends farmer meetings and demonstration tours. He talks with neighbors, industry, and university agronomists and reads farm magazines.

He is—or has the opportunity to be—exposed to the latest production techniques. Why haven't we sold him on the importance of good fertilization practices?

WE MUST DO A BETTER JOB of reaching the grower. We know the dealer and county agent are keys to the success of our efforts. That is, they are his most important sources of production information.

But in many cases they are poorly equipped to handle the task of providing good information.

The dealer's basic motivation is profit—as it should be. But he must be convinced that his profits and his knowledge of the economical benefits (to the producer) of his products go hand in hand.

Most dealers are not trained agronomists. Few have sufficient background in product knowledge, nor can they predict expected dollar returns from dollars invested in fertilizer and lime. They need more training.

The county agent is becoming an administrator—more and more. He has less time to keep up with production information. And his college training may have been in animal science, economics, or plant pathology. He may be weak in crop production knowledge. He needs more training.

The dealer and county agent should be involved together in more training programs. They should be encouraged to communicate with each other, to know what each other is doing. This "we-they" attitude in the field should be changed. It does exist, unfortunately. A united front must be shown the farm producer if we expect him to accept our programs.

WHERE DO WE GO FROM HERE? There is plenty of research information in many cases, if put to use—facts to double or triple per-acre forage production and to do it economically. I'm not advocating we terminate forage fertility research.

The best tool available to convince the producer to use this information is the forage demonstration. We are making use of it but not as efficiently as we should. And here are some reasons why:

1. **Our design is too intricate and management level too intensive for many producers to relate to them.**
2. **We demonstrate only one phase—fertilization, for example — and don't tie it to other required management inputs.**
3. **We fail to demonstrate economic benefits.**
4. **We set up too many demonstrations and fail to do any of them well.**
5. **We select poor cooperators.**

If demonstrations are to be effective, they must be aimed at the right audience. They should answer production questions that exist in that particular area. They must be well managed. One poorly managed demonstration can offset the benefits of five good ones. People tend to remember failures.

A continued emphasis must be placed on the use of printed materials. They are an effective communications tool. The state extension services do an excellent job of putting them together.

Farm magazines will continue to serve a vast farm reading audience. We should utilize them more fully.

More emphasis must be placed on forage research. Fertilization-utilization studies are needed. Grazing studies, pasture and hay management, species evaluation, fitting legumes into forage systems, methods of harvesting, winter grazing, and weed control—all these and other areas need additional attention.

We must recognize many growers are not interested in doing a better job. There is probably little to be done to help them. But many others do want and need help. Through improved cooperation among industry, research and extension, we can do a better job than has been done in the past. **The End**

FROM PAGE 4

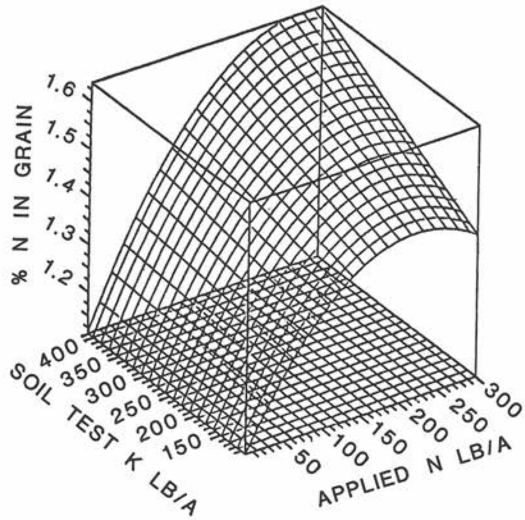


FIGURE 4

Figure 4 shows N content of grain increases with higher N rates, but much more when soil K is also high.

For example, with 250 lb N/A maximum grain N content is 1.48% (9.25% protein) at 150 lb soil K, but 1.57% (9.81% protein) at 300 lb soil K.

The corresponding yields would be 173 bu/A at 150 lb soil K, 195 bu/A at 300 lb soil K receiving the 250 lb N/A.

This means the grower could increase his grain crude protein 148 lb/A by increasing soil test K by 150 lb/A—or about 1 lb of protein for each 1 lb increase in soil K.

IN SUMMARY, nutrient balance is vital to high yielding quality corn. The results reported here are for a particular soil at one location.

Other soils may behave like this, but the optimum soil test levels and N rates may be different. Follow appropriate soil test recommendations geared to high management levels. **The End**

ALFALFA
10 Tons/A Possible In Western Canada

L. D. BAILEY
Agriculture Canada
Brandon, Manitoba

ALL LEGUMES will improve soil structure but, contrary to popular belief, do not add large quantities of nitrogen to the soil or provide nitrogen for grasses grown in association with the legume.

The legumes themselves do not "fix" atmospheric nitrogen but rather support bacteria which are capable of fixing nitrogen in nodules on the roots.

The bacteria take energy from the plant and, under ideal conditions, provide sufficient nitrogen to meet the plants' needs. If this "fixed" nitrogen is to be utilized by other crops, the legume must be plowed down at the early bud stage, for at this stage it will contribute the largest amount of nitrogen to the soil, shown in **Figure 1.**

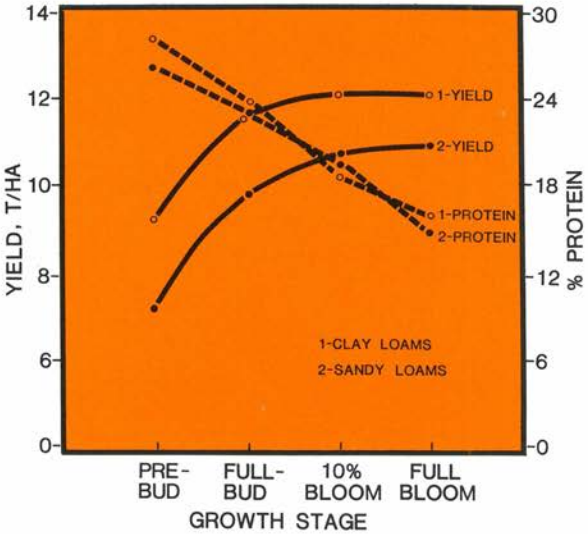
It is estimated alfalfa is grown on approximately 4 to 5 million hectares of land in Canada. The crop is used essentially as on farm feed. But in recent years, a substantial portion of the crop is processed by the dehydration industry.

Alfalfa can be stored as hay, silage, haylage, and as dehydrated pellets without significantly altering its feed value. Because of its ability to symbiotically fix atmospheric nitrogen, the crop is used in grass rotation as a green manure.

Alfalfa can help soil structure. It can give superior yields of protein and net energy. It tastes better to animals than other legumes. It can bring superior returns on money invested.

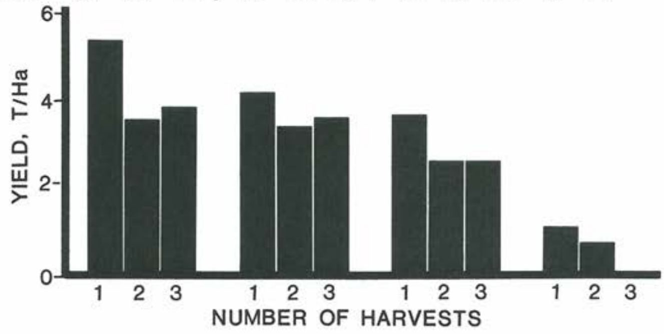
But to do all these, it must be managed correctly. A fertilizer program for legumes must therefore have two goals: (1) To provide an adequate environment in which bacteria can fix nitrogen. (2) To provide optimum levels of all nutrients that are necessary for plant growth.

FIGURE 1



Soil:	CLAY LOAM			SANDY LOAM			CLAY LOAM			SANDY LOAM		
	P_2O_5	K_2O	S	P_2O_5	K_2O	S	P_2O_5	K_2O	S	P_2O_5	K_2O	S
Fert. Kg/Ha	60	30	30	60	120	30	0	0	0	0	0	0
Yield T/Ha	5.0	3.3	3.6	4.0	3.2	3.4	3.6	2.6	2.6	1.0	0.8	0.0
% Protein	23	22	21	24	22	22	19	16	16	11	10	

FIGURE 2



YIELD POTENTIAL. The producer should aim for three cuts with a goal of 8 to 12 tons per hectare of herbage with a crude protein content of 18% or greater, shown in **Figure 2.**

In areas where moisture is generally very low, a two-cut system may be desirable. In this system, yields of up to 10 tons per hectare of forage with protein content of 18% or greater are obtainable.

Irrespective of the program, harvesting should commence at the "full bud" stage and not later than 5% bloom, shown in Figure 1. At this growth stage, yields of herbage and protein are maximized.

Delaying harvest beyond this time will result in minimum increase in forage yield but a significant reduction in protein. Alfalfa should not be harvested in September, since during this month it prepares for over-wintering by accumulating and storing carbohydrates in its roots.

The remaining forage (3rd cut in the 3-cut system) is harvested in October after the first killing frost. Under irrigation, with good fertility management four or more harvests can be taken. Producers who want to operate at this level of management should consult a knowledgeable forage agronomist.

SOIL TYPE. Alfalfa can be grown on all soils except those that are poorly drained or too coarse textured to retain moisture. Coarse textured soils associated with high water table conditions can be as productive as fine textured soils if fertility and moisture levels are adequate, shown in Figure 2.

Alfalfa tolerates moderate salinity and can be established on soils with a conductivity of 4 millimhos/cm. But an established stand will tolerate salt levels of 8 millimhos/cm if its fertility needs are met.

Alfalfa should not be grown on acid soils because acidity interferes with the fixation of nitrogen. Consequently, soils with a pH of 6.5 or lower should be limed. Most prairie soils have a pH of 7.0 or higher and are suitable for alfalfa production.

VARIETIES AND SEEDING. Producers should seed only those varieties recommended for their region and for the intended use. Lists of recommended varieties and uses are obtainable from Provincial Extension Centers. Always choose a high yielding, fast regrowth variety.

Alfalfa seeds should be placed not more than 2.5 cm deep in a firm seedbed. Row width varies, depending on moisture availabillty.

In Manitoba, the recommended row width is 30 cm. In drier regions this width is increased. Alfalfa should not be seeded with a companion crop.

Early seeding (May1-30) gives a better stand than late seeding (August 15-30). In most years, the May seed crop can be harvested in August.

Table 1. Average annual removal of nutrients from soils by alfalfa under a three harvest system.

Soil Type	Cut#	Fertilized				Check			
		N	P	K	S	N	P	K	S
					kg/ha				
Clay loam soils	1	185	13	175	12	108	7	86	8
	2	116	8	100	8	83	5	52	6
	3	122	9	90	8	65	5	42	6
Total	3	423	30	365	28	256	17	180	20
Sandy loam soils	1	152	10	104	10	18	2	11	2
	2	112	7	74	8	13	1	6	2
	3	119	8	68	8	No harvest taken			
Total		383	25	246	26	31	3	17	4

PLANT NUTRITION. Before seeding alfalfa, the soil should be tested and the recommended levels of plant nutrient should be applied and worked into the soil.

High rates of fertilizer material placed with the seed will result in damage to the germinating seed. No potassium, nitrogen, or sulphur should be placed with the seed.

Small amounts of phosphate fertilizer (not more than 20 kg P_2O_5/ha) can be safely placed with the seed. If more P_2O_5 is required, it should be sidebanded or broadcast.

Established alfalfa stands require annual fertilizer applications if they are to produce high yields of quality forage. A soil test and/or chemical analysis of the forage is used to determine the quantity of the various nutrients to be applied.

The crop responds to spring and fall broadcast applications of phosphorus, potassium, and sulphur when the levels of these nutrients in the soil are less than 19 kg P/ha and 690 kg K/ha in the 0-30 cm depth, and 17 kg SO_4-S/ha in the 0-15 cm depth.

Since alfalfa uses as much sulphur as phosphorus (Table 1), any soil test or plant analysis program should include a check for sulphur levels.

Alfalfa requires no fertilizer nitrogen since, under proper management, it derives its nitrogen from the nitrogen-fixing bacteria associated with its roots. Therefore, plants should be checked periodically for the presence of nodules. Large nodules, bright pink when cut open, are good indications that nitrogen is being fixed and the plant is being supplied with nitrogen.

When grown on nutrient deficient soils, alfalfa will respond to annual broadcast applications of fertilizer. Table 2 shows the yield response of alfalfa to broadcast applications of P_2O_5, K_2O, and S fertilizer.

Table 2. The effect of P_2O_5, K_2O and S on the yield and chemical composition of alfalfa forages grown on soil deficient in these nutrients.

A. The effect of P_2O_5, 5 year average.

Rate P_2O_5/ha	Yield T/ha	% P	% N
0	4.98	0.08	1.8
23	6.12	0.15	2.0
46	10.25	0.20	3.0
69	12.50	0.22	3.2
115	11.17	0.25	3.0

B. The effect of K_2O, 5 year average.

Rate K_2O/ha	Yield T/ha	% K	% N
0	3.30	0.8	1.5
56	6.42	1.2	2.0
84	8.25	1.8	2.8
112	10.55	2.5	3.2
224	10.00	3.2	3.4

C. The effect of S, 5 year average.

Rate S/ha	Yield T/ha	% S	% N
0	3.62	0.10	1.4
17	6.20	0.16	1.8
34	9.60	0.21	3.0
51	11.98	0.23	3.3
68	11.65	0.23	3.4

In general, as the rate of fertilizer material increased, the yield and chemical composition of the forage increased. The addition of the fertilizers appeared to

TURN TO PAGE 30

Crop Respons
25 Years of Rotatio

STANLEY A. BARBER
Purdue University

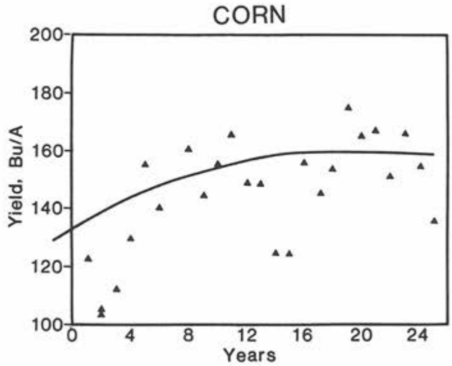


Figure 1. Corn yield where N, P, and K were not yield limiting in a long term fertility rotation experiment at the Purdue University Agronomy Farm.

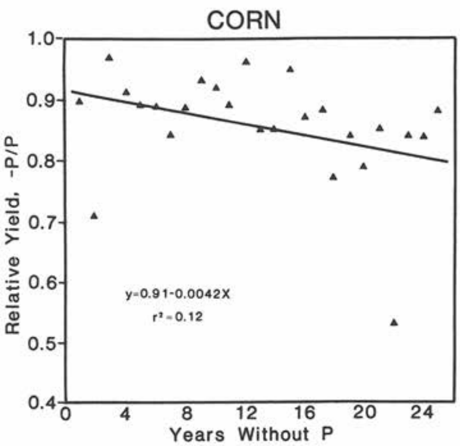


Figure 2. Corn yield of plots not receiving P since the start of the experiment as a fraction of corn yield with adequate P.

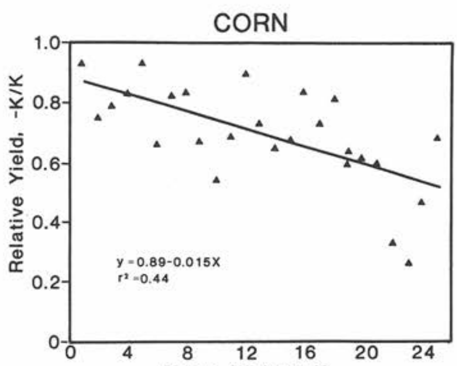


Figure 3. Corn yield of plots not receiving K since the start of the experiment as a fraction of corn yield with adequate K.

A ROTATION-FERTILITY experiment completed 25 years of continuous measurement in 1977, with only a few modifications of the original design at the Purdue University Agronomy Farm.

There were 22 P and K treatments superimposed on a 4-year rotation of corn-soybean-wheat-hay. After ten years, the hay crop in the rotation was dropped and corn added to give a corn-soybeans-wheat-corn rotation. This experiment is on Raub silt loam, a prairie soil. Samples taken in 1952 and analyzed in 1977 gave a Bray P_1 test of 35 lbs/acre and an exchangeable K level of 135 lbs/acre. The fertility treatments consisted of different rates and placements of P and K fertilizers.

This report describes (1) the change in yield level with time and (2) the change in crop response to added P & K with time.

The yields without added P and K show what would happen on this soil if we stopped using phosphate and potash fertilizers.

CROP VARIETIES were changed when a new variety promised better yields. Herbicides were used for weed control. The soils were fall-plowed for the next year's corn and soybeans.

Highest fertilizer rates reached 125 lbs P_2O_5/A/yr and 150 lbs K_2O/A/yr. All high fertility plot yields were averaged to give the yield where neither P nor K was limiting.

FIGURE 1 plots corn yield on these plots by years.

It appears that yield increases with additional years that occurred in the early years have become smaller so that only year to year variation due to weather can be detected from a visual inspection of the data.

to P & K During -Fertility Experiment

FIGURE 2 plots average corn yield without P as a fraction of the yield with adequate P.

While differences in weather conditions apparently caused wide variations there was a gradual decrease in yield with time on the plot receiving no P since 1951.

The slope of the line fit to the data indicates that response to P was increasing with additional cropping so that after 25 years the relative yield had decreased to 0.81.

In 1977, the soil on the plots that had not received P had a Bray P_1 test of 14 lbs/acre. This compares with the initial level of 35 lbs/acre.

Crop removal of P was much greater than this difference so this soil had an ability to release initially unavalable P to an available form for crop uptake.

FIGURE 3 plots relative yields without K against year of cropping.

Yields declined much more from omitting K than from omitting P.

After 25 years of continuous cropping, corn yields were 50% less on plots receiving no potash.

The decrease in yield with time appeared to be linear over the 25 year time period. The level of exchangeable K in 1977 averaged 93 lbs/acre. The decrease from the original 135 lbs/acre level is small considering the amount removed in crops.

Hence, a large amount of K moved from the unavailable to the available form and into the plant on this soil when crops were grown under a K stress situation.

How declining fertility might affect soybeans following corn was also studied in this rotation experiment.

FIGURE 4 plots average soybean yields on the highest fertility plots by years.

Yield climbed steadily during the 25 years, though climate caused wide fluctuations.

FIGURE 5 plots no-P yield at a fraction of the high-P yields.

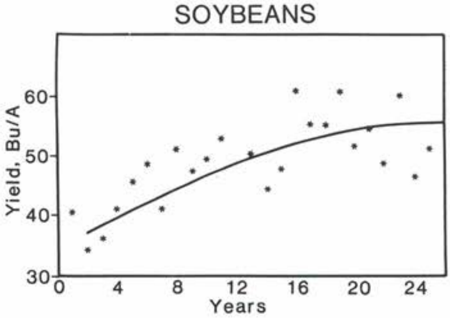


Figure 4. Soybean yield where P and K were not yield limiting in a fertility-rotation experiment at the Purdue University Agronomy Farm.

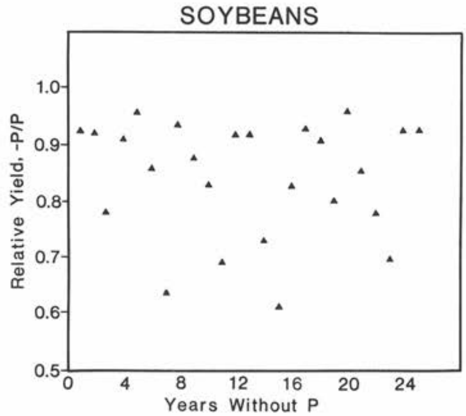


Figure 5. Soybean yield of plots not receiving P since the start of the experiment as a fraction of soybean yield with adequate P.

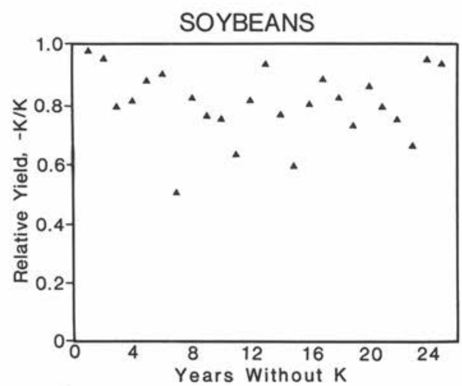


Figure 6. Soybean yield of plots not receiving K since the start of the experiment as a fraction of soybean yield with adequate K.

The results are in contrast with those for corn. There was much more variation between years than there was due to a gradual decrease in the P fertility level. The average response of soybeans to P was similar to that for corn but it did not show the increase with time that was observed for corn.

FIGURE 6 shows the relative soybean yields without K.

As with P, response varied much more from weather than from declining soil fertility.

THESE EXPERIMENTS show how corn and soybeans differ in their response to P and K.

Corn response to P & K fertilizer increased with additional years. This was expected where continued P & K removal was not replaced by fertilizer.

We would expect soybeans to give the same pattern of response, but they did not.

Why not? Possibly because the much greater year-to-year variation in response overshadowed yield reduction from P-K removal on plots receiving no P-K fertilizer.

And our studies showed much more soybean roots present in the surface soil than corn roots. This may have caused weather conditions to affect P-K uptake by soybeans much more than by corn. **The End**

Response of Cotton to

HORACE C. SMITH and TOM McCUTCHEN
University of Tennessee

EXPERIMENTS INDICATE cotton on some soils may respond to higher P_2O_5 and K_2O levels than the presently recommended 60 lbs of P_2O_5 for low P testing soils and 60 lbs of K_2O for medium K testing soils.

The trend in fertilization for cotton has been away from localized placements to broadcast applications. But some experiments have shown that small applications of fertilizer for a "pop up" or "starter" effect may be profitable.

This article reports on a 5-year study of the effects of broadcast and band applications of fertilizer on cotton yields.

TWO EXPERIMENTS were conducted at the Miland Field Station on a Grenada silt loam, 0-2% slope. In 1969 and 70, cotton was fertilized in an unreplicated test with 0, 50, and 100 lbs of 15-15-15 fertilizer per acre applied in a band.

The area was uniformly fertilized with 80 lbs of nitrogen and 40 lbs each of P_2O_5 and K_2O per acre broadcast and disked into the soil. The area harvested consisted of two rows 690 feet long with 40 inches between rows. The variety was Hancock.

In 1971 through 1973, cotton was fertilized with 0, 60, or 120 lbs each of P_2O_5 and K_2O per acre broadcast and disked during early April. In addition, 50 lbs of a 15-15-15 fertilizer was applied as a band application to some of the broadcast-fertilized plots.

The band of fertilizer was applied about 3 inches deep in a furrow opened with a double disk. The cotton seed were planted about 1 inch over the fertilizer band. The entire experimental area received a broadcast application of the 80 lbs N/A.

Broadcast And Band Placement of Fertilizer

From Tennessee Farm & Home Science Progress Report 96

Seed cotton was harvested twice each year from the four center rows of eight row plots. The rows were 60 feet long. The varieties were Hancock in 1971 and 72 and Stoneville 603 in 1973.

The soil test values for samples taken in November 1970 were as follows: pH 6.8; phosphorus low, 7 lbs/A; potassium medium, 140 lbs/A.

YIELDS OBTAINED from band fertilization are shown in **Table 1.** A response to band fertilizer was obtained both years of this test, with 50 lbs of 15-15-15 giving slightly higher yield than the 100 lbs.

The favorable results of this test prompted the conducting of the replicated, more detailed second experiment.

Table 2 shows the results of the second experiment. Fertilizing with the low rate of P and K without a supplementary band application increased the seed cotton yield 128 to 194 lbs, giving an average yearly increase of 170 lbs, a 7% increase.

The high rate of P and K without a band application increased yield 243 to 309 lbs of an annual increase of 278 lbs or 12%.

Adding a band of fertilizer at planting to the cotton receiving the low rate of broadcast fertilizer gave an additional increase in yield of 44 to 295 lbs for an average yearly increase of 142 lbs or 6%.

Adding a starter fertilizer to the high rate of broadcast fertilizer gave an additional increase of 61 to 386 lbs of cotton for an average annual increase of 259 lbs or 10%. The starter fertilizer was almost as effective in increasing yields as the much larger broadcast applications of P and K.

Table 1. Yields of seed cotton from two rates of band fertilization, Milan Field Station, 1969-70.

Fertilizer						Seed cotton per acre			Increase from banded fertilizer	
Broadcast[1]			Band[2]							
N	P_2O_5	K_2O	N	P_2O_5	K_2O	1969	1970	2-yr. avg.	Lb.	%
Pounds per acre						Pounds				
80	40	40	0	0	0	1310	2090	1700	—	—
80	40	40	7.5	7.5	7.5	1414	2597	2005	305	18
80	40	40	15.0	15.0	15.0	1380	2586	1983	283	17

[1] Applied as ammonium nitrate and 0-20-20.
[2] Applied as 50 or 100 pounds of 15-15-15.

Table 2. Cotton yields obtained from broadcast and banded fertilization, Milan Field Station, 1971-73.

Fertilizer						Seed cotton per acre				Increase from fertilizer			
Broadcast[1]			Band[2]							Broadcast		Band	
N	P_2O_5	K_2O	N	P_2O_5	K_2O	1971	1972	1973	3-yr. avg.	Lb.	%	Lb.	%
Pounds per acre						Pounds							
80	0	0	0	0	0	2694	2474	1974	2380	—	—	—	—
80	60	60	0	0	0	2888	2659	2102	2550	170	7	—	—
80	60	60	7.5	7.5	7.5	2977	2703	2397	2692	—	—	142	6
80	120	120	0	0	0	2975	2783	2217	2658	278	12	—	—
80	120	120	7.5	7.5	7.5	3036	3110	2603	2917	—	—	259	10
L.S.D.		.05				175	182	210					
		.01				234	251	285					

[1] Applied as ammonium nitrate and 0-20-20.

[2] Applied as 50 pounds of 15-15-15.

Table 3 gives the percentage of total seed cotton harvested in the first picking. In 1971 all fertilizer treatments gave a slight decrease in the amount of cotton in the first picking. In 1973, all fertilizer treatments gave an increase in early cotton. There was no effect in 1972.

Although there was a noticeable early vegetative response from the starter fertilizer in all years of the study, there was no significant effect of this placement on the amount of cotton in the first picking.

THE AVERAGE SOIL TEST values for P and K for samples taken after harvest each year are given in **Table 4.**

The soil tests for both P and K increased with the rate of broadcast fertilizer. But the P values remained near the low level and the K values stayed in the medium range.

The band applications gave very small increases in both available P and K when applied to plots receiving the low rate of broadcast fertilizer, but had no effect on the test values of plots receiving the high rate of broadcast fertilizer.

IN SUMMARY, the soil test values show higher than recommended rates of P and K may be needed to raise the soil test levels of these elements significantly.

The data also suggest that a band

FROM PAGE 25

have increased the nitrogen content (crude protein) of the forage. This is especially true for forage grown on the K_2O and S treated soils.

Figure 2 shows the effect of proper fertilization on the yield and protein composition of alfalfa grown on clay and sandy loam soils. Adding fertilizer increased the yield of herbage by 39%, 27%, 38% for the 1st, 2nd, and 3rd cuts respectively, on clay loam soils.

On sandy loam soils, the increases were 300% for the 1st and 2nd cuts. Without fertilizer, there was no 3rd cut. Protein content increased by 4 to 5% on the clay loam soils and by 12 to 13% on the sandy loam soils with the addition of fertilizer.

Table 1 shows the tremendous drain 10 to 12 tons of alfalfa forage per hectare can exert on the soil. The large amount of

Table 3. Percentage of total seed cotton harvested in first picking, Milan Field Station, 1971-73.

Fertilizer						Seed cotton in first picking		
Broadcast			Band					
N	P_2O_5	K_2O	N	P_2O_5	K_2O	1971	1972	1973
Pounds per acre						Percent		
80	0	0	0	.0	0	71	87	78
80	60	60	0	0	0	65	88	82
80	60	60	7.5	7.5	7.5	65	84	86
80	120	120	0	0	0	62	85	84
80	120	120	7.5	7.5	7.5	64	85	87

Table 4. Soil test values for cotton experiment, Milan Field Station, 1971-73.

Fertilizer						Soil test[1]					
Broadcast			Band			1971		1972		1973	
N	P_2O_5	K_2O	N	P_2O_5	K_2O	P	K	P	K	P	K
Pounds per acre						Pounds per acre					
80	0	0	0	0	0	8	130	8	120	6	130
80	60	60	0	0	0	10	150	12	138	10	150
80	60	60	7.5	7.5	7.5	10	170	13	165	11	170
80	120	120	0	0	0	11	190	16	167	16	190
80	120	120	7.5	7.5	7.5	12	190	15	160	16	190

[1] P test: low = less than 15: K test: medium = 120-190. Values are average of 4 replications.

placement, in addition to a broadcast application, may be important for maximizing yields. The rate of starter fertilizer used in these expeeriments would require very little time to stop to refill the fertilizer box on the planter. **The End**

nutrient removed must be returned to the soil in order to maintain high yields of quality forage.

Although spray or soil applications of micronutrients (molybdenum and copper) did not boost yield significantly, they did increase nitrogen fixation and utilization of nitrogen by the plants.

STAND LIFE. Alfalfa stand life depends on management of the crop from seeding through harvest. Soil fertility plays a major role in sward maintenance and longevity.

Plants grown without fertilizer on soil with less than 292 kg K/ha, 10 kg P/ha, and 6 kg S/ha, or plants having 1.0% K, 0.15% P, and S or lower levels of these nutrients suffered from winterkill and stand life was 3 to 4 years.

To guarantee top yield, quality, and stand life of 15 years or more, the crop should be managed and fertilized to maintain 3.0% N, 0.20% P, 2.5% K, and 0.20% S or greater in the forage. The End

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