BETTER CROPS with plant food

RESEARCH PPI EDUCATION

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BETTER CROPS
with plant food

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Soil and Water Management in Soybean Production Systems

By George J. Buntley

EROSION is a serious soil management problem in soybean production over much of the Southeast. For example, in 1979 in Tennessee we lost about **8.5 bu** of soil for every bushel of soybeans produced on our upland soils. On the more marginal of these upland soils we lost approximately **35 bu** of soil for every bushel of soybeans produced.

Soil loss of this magnitude is reducing the productivity potential of the soil and, in addition, the eroded sediment and the associated nutrients and pesticides are contributing to known water quality problems.

Soil erosion and water quality problems need to be seriously addressed. But some questions exist as to what management practices are most effective in reducing soil erosion and improving water quality. Many soil management specialists and professional soil conservationists are coming to the conclusion that it is much more practical, more effective, and less expensive to control soil erosion and sediment movement with conservation tillage and cropping systems than with the more soil-disruptive mechanical practices such as terracing.

Economics

For these and other reasons, some of which are economic, the trend in soil erosion control practices is moving rather rapidly in the direction of conservation tillage and cropping systems that emphasize keeping cover on the land as much of the year as possible.

Not the permanent, low income producing cover that was recommended in the early years of the soil conservation movement....but rather the combined or simultaneous use of cover and row crop that results in reduced levels of erosion, increased levels of available water, and that **maintains or increases farm income.**

Double-Cropping

Double-cropping of wheat and soybeans is an excellent soil and water conservation system because of the nearly year-round cover on the soil surface. The effectiveness of double-cropping as a soil and water conservation system is enhanced if the soybeans are no-till planted into the standing wheat stubble and the wheat aerially seeded into the soybeans prior to leaf drop.

Double-cropping systems in which conventional seedbeds are prepared prior to seeding of both wheat and beans are less effective as soil erosion control and moisture conservation practices. Soil moisture is lost as the result of the seedbed preparation operations and the soil surface is left without protective vegetative cover twice during the double-crop year.

Unfortunately, wheat-soybean double-cropping is not adapted to all soil situations. Double-cropping probably should be restricted to soils that are nearly level to gently sloping (0 to 5%), well or moderately well-drained, with high water-supplying

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capacities. Although double-cropping would be a good soil and water conservation practice on the more steeply sloping upland soils, it's doubtful whether these generally lower water-supplying soils can supply enough water for both crops most years. On the other hand, the more poorly-drained bottomland soils are not well adapted to wheat unless artificially drained and protected from flooding.

Systems in which single-crop soybeans are no-till planted into the mulch of a chemically-killed winter cover crop also are good soil and water conservation practices. This basic system is better adapted than double-cropping on the more steeply sloping upland soils.

Again, the effectiveness of this system as a soil and water conservation practice is increased when the winter cover crop is aerially seeded into the soybeans prior to leaf drop.

Planting Options

If wheat is used as the winter cover crop, this system can provide an early spring marketing decision option. If in early March wheat appears to have a price advantage over soybeans, the wheat can be top-dressed with nitrogen, left to mature, harvested for grain, and the stubble left for ground cover over the summer.

On the other hand, if it looks as though soybeans may have a price advantage over wheat, the nitrogen top-dressing would be skipped, the wheat chemically-killed in late April or early May, and the soybeans no-till planted into the mulch.

Innovative Strip-Cropping

Some innovative new approaches to the practice of strip-cropping and contour strip-cropping have become possible since the advent and improvement of no-till systems.

Systems of this kind can involve various combinations of strip-cropping or contour strip-cropping with conventional and no-till double-cropping or single-cropping.

One such system might alternate tillage systems between strips rather than crops. In a double-cropping system of this type, wheat would be sown over the entire field in the fall. After the wheat is harvested for grain, alternate strips would be prepared for conventionally-tilled soybeans leaving the standing stubble on the strips in between for no-till soybeans.

After a seedbed has been prepared on the strips to be planted conventionally, the entire field would be planted to soybeans using a no-till planter. The following year the no-till and conventionally-tilled strips would be rotated.

A system of this type would have several advantages over the traditional strip-cropping system in which a conventionally-tilled row crop is alternated with a hay crop:

- It would have about the same erosion control effectiveness as the contour strip-cropping of a conventionally-tilled row crop with a hay crop.
- It would make it possible to grow one row crop or a row crop and a small grain crop in one year over the entire field instead of one row crop over only half the field.
- In fields where weed pressure existed that might make it impossible to stay in a continuous no-till system, it would allow the use of preplant incorporated herbicides in each strip in alternate years.

Effective Conservation

Research data verify the effectiveness of double-cropping and other

Table 1. Average Annual Soil Losses Per Acre

Farming System	tons/A/yr
Farmed up and down the hill, residues left	52
Farmed on the contour, residues left	28
No-till planted on the contour in killed winter cover, residue disked before winter cover sown	5
No-till planted in prior year's crop residue	4

conservation tillage and cropping systems.

Table 1 shows soil losses under different soybean farming systems from a slightly eroded Grenada silt loam on a 100 ft-long, 8% slope in Gibson County, Tennessee. The soil losses were calculated using the Universal Soil Loss Prediction Equation as adapted to Tennessee by Jent, *et al.*

Research carried out in the Midwest indicates that under conventionally-tilled soybeans the evaporation from the soil surface during the growing season amounts to 25 to 30% of the growing season precipitation.

Reduce Moisture Loss

Research has shown that the mulches developed under conservation tillage and cropping systems not only reduce soil erosion but also significantly reduce the loss of soil moisture by evaporation.

TVA runoff data from the Beech River Watershed in West Tennessee indicate that about 20 inches of the 50 inches of annual precipitation runs off each year. Research shows that it would be less if all the cropland in the watershed were under conservation tillage and cropping systems.

For example, 10 years of research by Beale, *et al.* at Clemson University has shown that corn no-till planted in a vetch-rye mulch averaged 3.11 inches less runoff water per year than the conventionally-tilled check.

Research also has shown that it takes about 13,000 gallons of water to produce one bushel of soybeans in a 40 bu/A yield. This translates into the statistic that the soybean production potential can be increased by 2 bu for every inch of water that is not lost by runoff or evaporation.

If by using double-cropping and other conservation tillage and cropping systems it is possible to conserve 5 inches of water that would otherwise be lost during the growing season, that equates to 10 more bushels of soybeans.

Considering these benefits, it's difficult not to believe that conservation tillage and cropping systems, especially those involving no-till, are in themselves soil and water management at its best.■

Fertigation Supplements Base Fertilizer Program

By William I. Segars

UNDER THE INTENSIVE management of irrigated crop production there is growing interest in "fertigation" as part of a complete fertility program.

Fertigation can be defined as "the application of nutrients using an irrigation system by injection of the desired nutrients into the water flowing through the system."

While this article relates mostly to irrigated corn production in Georgia, some of the principles of fertigation included here may also apply to other areas.

Fertigation in Georgia is essentially limited to sprinkler irrigation, specifically center-pivot and lateral-move systems. The state has about one million acres under irrigation.

Fertigation is not intended to replace soil applied and incorporated fertilizers, but it can complement an overall fertility program if used wisely.

Apply Nutrients When Needed

The objective of a fertility program is to assure that plants have sufficient nutrients—in the right place and in an available form at the time they are needed. This can only be accomplished by understanding and incorporating information about the crop, the nutrient, the soil type and the expected weather.

When fertilizers are applied as needed, the result will be better crop growth, higher yields and better nutrient efficiency.

In Georgia, losses of nutrient efficiency are largely due to leaching. Since many Georgia soils are sandy with low cation exchange capacity, they have little ability to hold mobile nutrients from leaching.

Nitrogen (N) is the most important mobile nutrient, considering amounts needed and the cost and energy expended.

Likewise, boron (B) and sulfate-sulfur (SO_4) are fairly mobile. Potassium (K) can also be leached from sandy soils.

There are large differences among soils in their ability to hold nutrients. However, it's safe to say that all Georgia soils will lose these elements to some extent depending on rates applied, timing of application, the amounts and intensity of rainfall or irrigation, and crop removal.

Fertigation can be a tool to decrease these losses, increase nutrient uptake and thereby increase both yields and profits. The key is nutrient application as needed by the crop and at rates relative to the plants' requirements.

Nitrogen applications on corn are a good example: weekly fertigations of 30 to 40 lb/A from the time the

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corn is 18 inches tall until tasseling supply N when it is in greatest demand by the plant. These applications are normally made with needed irrigations.

Fertigations are also very useful when special applications are needed according to visual deficiency symptoms and/or according to plant analyses. A number of soluble nutrient compounds is available for applications of this type.

Fertigation can normally be applied even when other types of applications are not possible, such as when soils are wet or airplanes cannot fly due to bad weather.

Other Advantages

Fertigation, with some care, should result in very **uniform applications of nutrients.** Also, the extremely low amounts of micronutrients may be supplied evenly without the need to mix in other unneeded nutrients for bulk as is many times done in dry fertilizer applications.

Fertigation offers great **flexibility** in fertilizer application. Since the irrigation system is essentially dedicated to the land, there is no wait for equipment which may be committed to another farm task or for the availability of an aerial applicator. And consider flexibility in any scheduled application: attempt to fertigate with needed irrigations which in turn are dependent on rainfall.

Application of nutrients through the irrigation system will **reduce compaction** in most of our soils by elimination of trips over the soil. The highly detrimental effect of soil compaction on even the most sandy of our soils has been clearly demonstrated. Reducing the formation of traffic pans in the soil is a bonus — the small portion of soil affected by wheels of the system is negligible in comparison to other traffic.

Fertigation may reduce the amount of fertilizer needed to obtain equal yield or may result in higher yields for an equal amount of fertilizer. In other words, **fertigation has the potential of increasing the efficiency of nutrient utilization** in comparison to less frequent applications of high amounts of conventionally applied fertilizers. This potential is closely associated with the ability to apply the nutrients when and where they are needed for the growth of a given crop. By fertigating the mobile nutrients are less subject to leaching losses that are especially important in sandy Coastal Plain soils.

Recent studies show that **fertigation is economical.** This is largely due to the availability of irrigation equipment which is committed to a certain piece of land. Most economists assign the bulk or the total depreciation of that equipment to irrigation costs. The cost of an injector pump will generally be less than $500. The costs of the injection equipment can also be spread to chemigations used for pest control.

Cautions and Disadvantages

There are also some cautions needed and potential disadvantages with fertigation:

The fertilizer sources for fertigation are normally limited to those that are completely soluble. This is not an apparent problem for nitrogen, since solutions are widely available in Georgia and are generally used. Dry fertilizer nitrogen can be dissolved for fertigation under special circumstances.

Aqua and anhydrous ammonia can be injected but may result in special problems in volatilization losses and corrosion. Until these sources are investigated further, they are not recommended.

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Researchers Focus Attention on Maximum Wheat Yield Systems

WHEAT MIGHT BE the modern-day "Cinderella" crop. Over the past decade, wheat yields per acre haven't kept pace with developments in other crops. However, some recent research yields above 100 bushels per acre add a touch of glamour and a new look to the drab economic conditions that have faced wheat production.

Fifty-five wheat researchers from thirteen states and two Canadian provinces met in Denver recently to discuss methods of improving yields and lowering production costs per bushel. The "Maximum Wheat Yield Systems Workshop" was sponsored by the Potash & Phosphate Institute (PPI). Participants included: USDA and Agriculture Canada scientists; private wheat breeders; industry research personnel in fertilizers, pesticides and growth regulators; and extension personnel from throughout North America.

Yields have a direct bearing on overall profitability. It is the production cost per bushel, not production cost per acre, that determines profitability, PPI agronomists point out. As with corn, soybeans and other crops, the wheat production cost per bushel drops as yields per acre increase.

Highlights

Much of the discussion at the meeting centered on reports from maximum wheat yield projects funded by PPI and the Foundation for Agronomic Research (FAR), an affiliated organization.

Oregon researchers reported wheat yields up to 182 bushels per acre in the Willamette Valley. Michigan and New York researchers also reported yields above 100 bushels per acre in their investigations. The maximum yield systems feature high levels of soil fertility, excellent control of weeds, insects and diseases, and other good management practices coupled with favorable moisture.

Dr. Wayne Knapp of Cornell University reported ways in which European researchers and farmers routinely produce yields that would be considered exceedingly high in North America. For example, management practices often include very close rows, as narrow as 2.5 inches.

Dr. Bob Heiner of North American Plant Breeders discussed techniques which geneticists and plant breeders use to provide new, higher yielding wheat varieties. Stress-resistance and performance in high-yield environments are important considerations.

Dr. Neil Christensen of Oregon State University reported on successes in controlling crop diseases by providing plants with relatively large amounts of chloride. Although it is an essential element, chloride has received relatively little attention as a supplement in crop production until recently.

Lowell Burchett, secretary of the Kansas Crop Improvement Association, reviewed in detail the effects of seed quality on wheat production. He noted that the use of certified seed would have an immediate and profitable effect on wheat production throughout North America.

Future workshops are planned as a forum for researchers to discuss results of recent research, to implement production ideas from other areas, and to make new information available to growers.

Dr. Larry Murphy, Great Plains Regional Director, and Dr. Bob Darst, Southwest Regional Director of PPI, served as coordinators of the recent maximum wheat yield systems workshop. ■

(Fertigation — continued from page 7)

It's possible to use phosphorus (P) through irrigation systems. Procedures are available. However, phosphorus is immobile in soil; therefore, its application is generally recommended only one time each year according to the needs shown by the soil test. For early planted corn, a high phosphorus source is needed as a starter and should be band applied at 2 inches below and 2 inches to the side of the seed. **Fertigation is not a substitute for this band application.**

When **potassium** is fertigated, it also must be completely in solution. Therefore, the finely ground sources of muriate of potash are most commonly used but other soluble sources can be applied.

Soluble sources of **secondary and micronutrients** are available. Consult with your dealer for available sources.

Some Misconceptions About Fertigation

Fertigation is not foliar feeding. The amounts of water applied in fertigation can vary widely but are always enough to move the nutrients to and into the soil to some depth. Therefore, soil application rates of nutrients should be applied. Also, it is important to apply sources that are not inactivated by soil reactions. For example, a manganese chelate may not be effective due to its reaction with soil iron.

Fertigations can also be nonuniform. Uneven applications can result from poor irrigation patterns and are particularly apparent on the ends of center-pivot systems. End guns on the systems do not result in the uniformity of the areas under the towers. Another apparent problem is when fertilizers are injected into a system either already in operation or full of water. Depending on the length of the system, it may require considerable time before uniform application reaches the perimeter. Therefore, it's best to begin injection with the first water that passes the point of injection.

Fertigation is not a substitute for other needed fertility practices. There may be a strong tendency for growers to "over-use" a permanent system. Fertigation is supplementary and useful in a total fertility package approach. It is not a substitute for a good liming program, applications of immobile nutrients, or pre-plant and starter fertilizers.

The need for soil and tissue analyses is even greater when fertigating because in-crop corrections can be made quickly, based on these analyses.

Fertigation can be an excellent tool if used properly. But it cannot stand alone. It will be most useful and profitable where high levels of management are practiced for high yield goals. ■

Corn Response to Row Phosphate

By E. E. Schulte

AN EARLY GROWTH RESPONSE to band or row application of phosphate fertilizer is frequently observed under a variety of soil conditions. Yet, this early response does not always show up as increased yield at harvest time. **Under what conditions can an increase in corn yield be expected from row-applied phosphate?**

Research data from a wide range of soil conditions and locations indicate that the following situations favor yield response:

- Low phosphorus soil tests;
- Low levels of subsoil phosphorus;
- Cool soil temperatures;
- Soils that have a high P adsorption or fixation capacity;
- Shallow soil or restricted rooting depth;
- Acid or low pH soils;
- Soils with a high yield potential.

One or more of these conditions may be responsible for significant yield increases to row-applied phosphate.

Effect of Soil Test Phosphorus on Response to Row Phosphate

Row-applied P appears to be most beneficial in cold climates or in cooler soils. Roots develop slowly in cold soil, so a high concentration of soluble phosphorus close to the roots will aid in increasing phosphorus uptake in such soils. Likewise, mineralization of organic phosphorus from soil organic matter proceeds slowly in cold soil.

The planting season in cooler climates is usually short. Although farmers recognize the benefits of row "starter" P, the need to attend to the fertilizer attachment slows the planting operation. Therefore, many farmers would prefer to broadcast enough phosphate to raise the available soil P to a level where row phosphate was no longer beneficial.

At what level of soil phosphorus or soil test P does corn no longer respond to row phosphate? This question cannot be answered with a single number, unfortunately, because of the influence of so many factors.

Test Results

At Marshfield, Wisconsin, P_2O_5 rates of 0, 137 and 687 lb/A were broadcast and disked-in to a depth of about three inches in 1980 in a Withee silt loam with an available P test of 60 lb/A. The objective was to establish test levels of 60, 70 and 160 lb/A of available P. Soil K was above 300 lb/A at the site; 225 lb/A of N was applied.

With corn planted on May 15, there was a 9 bu/A increase due to the broadcast, disked-in phosphate. The effect of row phosphate was insignificant. The broadcast phosphate, however, raised the soil test levels.

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The 137 lb/A rate resulted in a 65 lb/A level; the 687 lb/A rate gave a 160 lb/A level, four months after application.

These plots were plowed, incorporating the disked-in phosphate into the plow layer before the 1981 crop was planted. There was a significant yield response in 1981 to both soil test P and row phosphate rates up to 20 lb/A. See **Table 1.**

Table 1. Effect of soil test P and row P_2O_5 on corn yield.

Broadcast P_2O_5	Soil P		Row P_2O_5, lb/A			
April 1980	Sept. '80	Oct. '81	0	20	40	60
	lb/A			bu/A		
0	60	70	103	137	134	139
137	65	62	119	134	144	132
687	160	112	122	142	149	141

Withee silt loam soil (Marshfield, WI, 1981)

The biggest yield response (36 bu/A) from row-applied phosphate came where no broadcast P was applied. But even at a phosphorus soil test level of 112 lb/A, yield increases of 20 and 27 bu/A were obtained with row phosphate applications of 20 and 40 lb/A of P_2O_5, respectively.

By October of 1981, 17 months after application, the P soil tests had dropped to 62 and 112 lb/A, respectively. Crop removal would account for only a small decrease in soil P because only the corn grain was removed, and the phosphorus soil test in check plots to which only row phosphate was applied actually increased by 10 lb/A.

Corn response to the row phosphate was evident before and up to tasseling at all levels of soil test P, as shown in the photos.

Application of 40 lb/A of P_2O_5 in the row also decreased the time to 75% silking from 81 to 78 days.

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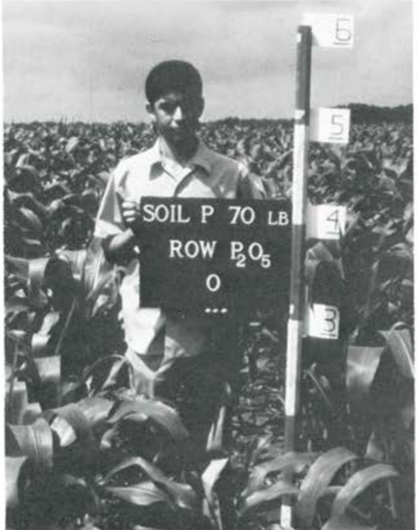

MIDSEASON RESPONSE of corn to 40 lb/A of row-applied P_2O_5 on a high testing soil is clear — corn in photo at left received no row application. This response also resulted in a 26 bu/A yield increase for corn with row phosphate.

Response Differences

The difference in response to row P at this site in 1980 and 1981 can be explained in part by the increased availability of freshly applied broadcast, disked-in P compared to that which was more thoroughly mixed into the plow layer and approached equilibrium with the soil by the second year.

More important, however, was the difference in early season growing conditions. In 1981, the corn was planted on May 2, very early for the area. The mean temperature for the month of May was 54.5° F, compared to 58.6° F in 1980, a difference of 4.1 degrees. This soil is imperfectly drained and soil moisture was excessive during the fall of 1980 and much of the 1981 growing season.

A similar experiment comparing row and broadcast applications of phosphate was conducted at Hancock, Wisconsin, on a Plainfield loamy sand under irrigation. Initial soil test P was 90 lb/A. In 1980, a broadcast application of 550 lb/A of P_2O_5 raised soil P level to 285. The broadcast phosphate increased corn yields by 19 bu/A in 1980, even though the initial soil P was high. Row-applied phosphate, on the other hand, did not increase yields significantly. In 1981, neither soil test P nor row P had any significant effect on yield. This is a well-drained soil which warms up readily in the spring.

Effect of Soil pH on Response to Row P

Lime was applied to a Plano silt loam soil at Arlington, Wisconsin, to raise the soil pH from 5.1 to 6.1. The initial soil test P level was 68 lb/A (high). Row P_2O_5 was applied at rates of 0, 35 and 70 lb/A at each pH level. Liming alone increased yields substantially, as **Figure 1** shows. There was further yield increase from the row P.

Application of 70 lb/A of P_2O_5 in the row at pH 5.1 resulted in a very profitable 20 bu/A yield increase. Even with the row P, however, the yield was lower than at pH 6.1 with the same rate of row P. It is important, therefore, that the liming program not be neglected when emphasizing soil fertility.

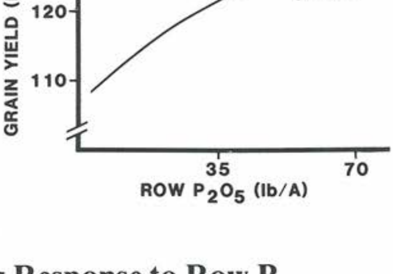

Figure 1

Other Factors Influencing Response to Row P

One of the principal reasons for applying P in the row in warm climates is to **minimize fixation** of P by reducing the amount of contact between added P and the soil. This approach is useful when one crop is grown continuously, where P fertilizer recommendations are tailored to the specific needs of the crop, and where P adsorption or fixation is a serious problem. Recovery of row-applied phosphate is more efficient than broadcast P in high P-fixing soils.

Also, soils differ in the **amount of P supplied by the subsoil** during the growing season. A soil with a high level of subsoil P might show good early growth response to row-applied phosphate, yet the response does not persist throughout the growing season and translate into an increased yield. As soon as the plant roots reach the subsoil, they begin to take up subsoil P, enabling plants to catch up with those supplied with row phosphate and showing the early response.

If a soil has a compacted layer, such as a plow sole or a hardpan that restricts root penetration or if the rooting depth is shallow, response to row phosphate is likely to be greater than in soils with a larger root volume. Higher concentrations of soluble P are needed to compensate for the reduced root volume.

Finally, **as yields increase, the need for all nutrients, including P, increases.** The higher the yield, the greater is the likelihood of response to row P. Very high yields may require both an increase in soil test P and row P to ensure an adequate supply of phosphorus during peak periods of uptake.

Summary

Responses of corn to row phosphate are likely to be greatest in soils that: are cool and wet or that warm up slowly in the spring; have low soil test P or subsoil P; are acid or low pH; have a high P adsorption or fixation capacity.

Shallow soils and soils with restricted rooting depths are also likely to give yield responses to row P. As yield levels increase, the chances of responses to row phosphate increase. A small amount of phosphate (10 lb/A of P_2O_5) is recommended for row crops grown in cool, wet soils, even if the phosphorus soil test is very high, to ensure good early season development. ■

Will Narrow Row Soybeans Increase Yields in the South?

By Donald J. Boquet

SOYBEAN PRODUCTION in narrow rows (less than 24 inches wide) has been gaining momentum each year in many areas. However, narrow rows generally have not been very successful in the South.

Poor weed control has been the most serious problem that producers encountered. And while research on narrow rows has produced varying results, it has been generally felt that soybean yields are about the same in narrow and wide rows in the South.

Advances in weed control technology have greatly enhanced the feasibility of producing soybeans in rows too narrow for mechanical cultivation. Introduction of herbicides for postemergence grass and broadleaf weed

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control has helped the narrow row concept to become a viable production system.

Reasons for the continuing shift to narrow rows include attempts by farmers to reduce labor, equipment, and fuel costs. Also, the large increase in Southern wheat acreage means an increase in the acreage of double-crop soybeans. Because of the lateness of planting, double-crop soybeans usually yield better in narrow rows, compared with wide rows.

Will the increase in narrow row planting improve the overall productivity of soybeans for the South? Unfortunately, there's no simple answer. Although it's been conclusively proven that narrow rows are preferable for the northern indeterminate soybeans, results with the southern determinate soybean cultivars have varied from one experiment to the next.

Such variation should not be surprising considering the variability in agronomic performances of soybeans that is known and expected to occur with changes in environment. So it's quite possible that different results from seemingly similar row spacing experiments are a natural phenomena that can easily be explained.

To do so, let's examine the results of an experiment conducted at the Louisiana State University Northeast Experiment Station at St. Joseph. For a four-year period, row spacings of 10, 20, and 40-inches were evaluated for several planting dates and soybean cultivars.

Tables 1, 2, and 3 summarize the yield data. The yield response to row spacing varied with year, cultivar, and planting date. Each factor acted alone to influence response, but they also interacted with each other to affect response to row spacing.

Rainfall

Comparing response over years with rainfall amounts and distribution, the largest yield differences between narrow and wide rows was in 1979 when rainfall was highest. Conversely, the smallest differences among row spacings were in 1976 when total rainfall was lowest and extended periods of dry weather occurred. Intermediate amounts of rainfall in 1977 and 1978 with no extensive dry periods resulted in intermediate yield differences among row spacings.

From this we concluded that narrow rows would give the maximum yield advantage under optimum moisture conditions.

However, even under the driest conditions in this research, narrow row soybean yields were never lower than the yields in 40-inch rows.

Table 1. Year and Row Spacing Effect on Yield Response of Soybeans; Averaged Over Planting Dates and Cultivars.

Row Spacing	Year 1976	1977	1978	1979
Inches		Yield — Bu/A		
10	45	39	48	66
20	50	39	45	61
40	46	35	39	52

Cultivar Response

Cultivar influenced response to row spacings at least as much as climate did. Forrest and Lee 74 had **large yield increases (20% and 15%**, respectively) when row spacing was reduced from 40 to 20 or 10 inches. Centennial averaged a 15% yield increase, but its performance was less consistent than that of Lee 74. Yields of Davis increased 11% and Bragg increased 10% when rows were narrowed from 40 to 20 inches.

Table 2. Cultivar and Row Spacing Effect on Yield Response of Soybeans; Averaged Over Planting Dates and Years.

Row Spacing	Cultivars				
	Forrest	Lee 74	Davis	Centennial	Bragg
Inches	Yield — Bu/A				
10	38	39	45	43	45
20	36	39	43	41	45
40	29	33	40	35	40

Planting Date

Response to row spacing was not affected by planting date as much as expected. Yield increases obtained by narrowing row spacing were, however, smaller at optimum planting dates compared with later or earlier dates. When rows were narrowed from 40 to 20 inches at the May 15 planting date, yields increased an average of 10%; at the July 1 and July 15 dates the yield increases in narrow rows averaged 16% and 24%, respectively.

Table 3. Planting Date and Row Spacing Effect on Yield Response of Soybeans; Averaged Over Years and Cultivars.

Row Spacing	Planting Date						
	Apr. 15	May 1	May 15	June 1	June 15	July 1	July 15
Inches	Yield — Bu/A						
10	33	51	54	49	45	35	28
20	33	50	52	49	43	35	24
40	28	44	47	43	38	30	18

From the information in **Tables 1, 2, and 3,** it's obvious that narrow rows have the potential to be higher yielding than wide rows. But whether or not they actually are depends upon cultivar, moisture availability, planting date, soil type and perhaps other factors. Thus, it's likely that yield results with row spacings will differ from farm to farm, and perhaps on the same farm from year to year depending on the growing conditions. ■

Six Winners Selected for 1982 PPI Fellowship Awards

SIX OUTSTANDING graduate students in soil and plant science have been chosen to receive fellowship awards from the Potash & Phosphate Institute (PPI). The fellowships of $2,000 each are granted to deserving candidates for either the M.S. or Ph.D. degree.

The winners are: Craig Beyrouty, a native of California, now at Purdue University; Stephen A. Ebelhar, a native of Kentucky, now at North Carolina State University; Don Flaten, a native of Saskatchewan, now at the University of Manitoba, Canada; Philip M. Jardine, a native of Pennsylvania, now at the University of Delaware; Michael A. Schmitt, a native of Wisconsin, now at the University of Illinois; and Jimmy Don Stein, a native of Oklahoma, now at Oklahoma State University.

"We received applications from a large number of highly qualified entrants for the awards," noted Dr. R. E. Wagner, President of PPI. "The fellowships are to be used for continuation of study and research. There is a real need to encourage excellence among bright, young researchers in soil fertility and related areas."

Each of the six winners will receive a certificate and a check for $2,000 from the Potash & Phosphate Institute.

Craig Beyrouty graduated with honors from California Polytechnic State University in 1977 before moving to Purdue University in West Lafayette, Indiana. He received a M.S. degree in soil fertility and soil chemistry in 1981 and has served as a full-time instructor involved in soils teaching and undergraduate counseling. His Ph.D. research will study uptake of heavy metals by several vegetable crops.

Stephen A. Ebelhar holds B.S. and M.S. degrees from the University of Kentucky. In 1981, he began advanced study at North Carolina State University in Raleigh. His Ph.D. program involves research on potassium requirement and utilization by corn genotypes as influenced by ear number and nitrogen rate.

Don Flaten earned a Bachelor of Agriculture degree from the University of Saskatchewan in 1978 and now pursues a Ph.D. program at the University of Manitoba in Winnipeg. His thesis deals with the efficiency of preplant banding of phosphate with nitrogen, particularly deep dual banding of nitrogen and phosphorus.

Craig A. Beyrouty

Stephen A. Ebelhar

Donald N. Flaten

Philip M. Jardine

Michael A. Schmitt

Jimmy Don Stein

Philip M. Jardine received the American Society of Agronomy outstanding senior award for the 1981 academic year. He graduated with distinction and cum laude from the University of Delaware in Newark. He is now continuing work there toward a Ph.D. in soil chemistry. His research program seeks better understanding of potassium exchange in heterogeneous soil systems.

Michael A. Schmitt earned numerous honors as an undergraduate at the University of Minnesota before beginning his advanced study at the University of Illinois in Urbana. His proposed research program involves the effects of temperature, nitrogen stabilizers and soil type on nitrification rate of ammonia under field conditions.

Jimmy Don Stein achieved an outstanding academic record as an undergraduate at Oklahoma State University. After graduating with a B.S. degree in 1981, he is now a candidate for a M.S. degree in soil fertility. His proposed thesis research will investigate the effect of phosphate sources, methods, and rates of application on forage yield and chemical composition of established alfalfa.

The fellowship recipients were chosen by a committee of five members: two from the PPI staff and three from the PPI advisory council.

Scholastic record, excellence in original research, and leadership were among the qualifications evaluated. ■

By-Product Gypsum Improves Sugarcane Stubble Crop Yield

By Laron E. Golden

MANUFACTURING of phosphoric acid from mined Florida phosphate rock produces by-product gypsum which can be used as fertilizer for sugarcane.

A four-year field experiment in Louisiana showed positive residual benefits through increased sugarcane yields in the three stubble crops after the first year (plant cane). Small amounts of radioactivity in by-product gypsum had no measurable effect on radioactivity in the soil or in sugarcane juice.

Uranium (U-238) and radium (Ra-226) in Florida phosphate rock are generally separated during production of phosphoric acid. The U-238 follows the phosphoric acid and is usually recovered at the plant site. The Ra-226 stays with the by-product gypsum.

This study measured the effects of Ra-226 in gypsum on a Baldwin silty clay loam soil. Gypsum rates of zero, 1000 lb/A and 2000 lb/A (one ton) were applied in the summer of 1975 before the original sugarcane crop was planted in the fall.

The gypsum contained 13% sulfur (S), moist basis. Analysis of the gypsum, dry weight basis, showed this content: 31.3% CaO; 42.3% SO_3; 20% H_2O; 2.8% SO_2; 1.4% P_2O_5; 0.1% Na_2O; 1.0% F; 0.5% Al_2O_3; 0.2% Fe_2O_3 and 0.4% other substances.

The sugarcane variety CP65-357 was fertilized with 160 lb/A of N, 40 lb/A P_2O_5, and 80 lb/A K_2O at a constant rate over the experimental site each crop year. The sugarcane, planted in 1975, was harvested as plant cane in 1976 and as stubble crops in 1977, 1978 and 1979.

The radioactivity was analyzed on topsoil and sugarcane juice samples from the check and treated areas. Topsoil and juice samples were also taken from two additional sites where by-product gypsum had been used in a similar study planted later; the two sites were on a Mhoon silty clay loam and a Sharkey clay soil.

There was no significant difference in plant cane (first year) yields due to gypsum application. However, in succeeding years yields from stubble cane crops which received one ton of gypsum were significantly higher than check plot yields. **Table 1** summarizes four-year yield data.

The four-year total yield increase from one ton of gypsum was 14.58 standard tons/A of cane more than the check (zero rate). Assuming a value of $20 per ton for the increased yield, the total added value for the four-year period would be $291.60. Total cost of commercially applied by-product gypsum at the rate of one ton per acre would probably be $25 to $30 per acre for areas 100 to 125 miles from the source.

Analyses showed that the gypsum application increased the level of extractable sulfur in the topsoil, primarily during the plant and first stubble crop years, but S concentrations were increased in leaf blades throughout the four crop years.

Dr. Golden is an Agronomist with the Louisiana Agricultural Experiment Station at Baton Rouge. References and more detailed information on this study are available on request.

Table 1. Effect of by-product gypsum on yield of sugarcane and sugar.

Gypsum treatment	Yield 4-year period: Total	Yield 4-year period: Increase over check
Tons/A		
	Net tons of cane per acre	
0	96.14	—
0.5	104.29	8.15
1	107.14	11.00
	Sugar per acre, lb	
0	21,206	—
0.5	22,723	1,517
1	23,614	2,408
	Standard tons of cane per acre	
0	128.53	—
0.5	137.72	9.19
1	143.11	14.58

Radioactivity

Radioactivity levels were determined for three sources of by-product gypsum.

The net counts per minute per gram (cpm/g) of by-product gypsum varied from 24 to 31 — this indicates that there was very little variation among the three sources of by-product gypsum.

Averages of radioactivity in samples of topsoil from check plots and from plots treated with one ton/A of by-product gypsum were statistically higher than background radioactivity. However, differences in averages between check and treated areas at the sites were not significant.

Failure to find a topsoil difference due to by-product gypsum treatment was a result of the small amount of radioactivity in the gypsum and to its dilution by a factor of approximately 1,000. That is, 2,000 lb of gypsum was mixed with approximately 2 million lb of topsoil. The positive, but very small, amount of radioactivity in the topsoil was apparently due to natural radioactivity existing in the soil and/or fallout from the atmosphere.

Radioactivity determinations in sugarcane juice showed no counts that differed significantly from background nor that differed significantly when check and treated areas were compared.

Summary

Among treatments in this study, no significant yield differences were obtained in plant cane. Application of one ton/A of by-product gypsum increased first stubble sugar yield 12.6%, second stubble yield 17.9%, and third stubble yield 20.9%

The progression of increases in yield during the stubble crop years suggests that residual benefits from the treatment tended to be cumulative and/or that the need for treatment became more acute when no sulfur was added. Similar trends have been noted with P and K nutrition of sugarcane in Louisiana.

The yield increases were apparently due primarily to better S nutrition of the crops. The increases were larger than those which were generally obtained in tests with mined agricultural gypsum applied at annual maintenance rates of 24 lb/A of S. Positive effects of gypsum treatments on silicon uptake may have also had a small positive influence on yields. Better general soil conditions for sugarcane growth may have developed as a result of treatments with gypsum. ■

Yolo County, California

Demonstration Trials Bring Rapid Change in Fertilization and Seeding Methods

By T. E. Kearney

GROWERS WILL adopt new practices and change production systems rapidly when they see the economic advantages of higher yields.

A dramatic shift in fertilization and seeding methods for wheat and barley in Yolo County, California, illustrates the influence of practical demonstration trials.

In less than 10 years, wheat yields in the county increased more than 70%—from 30 cwt/A (50 bu/A) in 1970 to 52 cwt/A (87 bu/A) in 1980.

In the past, most growers broadcast the seed and applied only nitrogen (N). Now, most grain growers in the area use a drill with a fertilizer attachment and apply both N and phosphorus (P) with the seed.

Wheat and barley are major crops in Yolo County, with more than 100,000 acres grown annually.

We had suspected that drilled phosphorus would be more efficient. But it wasn't commonly recognized that phosphorus fertilization would economically increase yields in the area. Good demonstration trials hadn't been accomplished earlier, mainly due to lack of a drill with a fertilizer attachment.

The broadcast method of planting was well entrenched in the county, particularly in dryland, hilly areas where growers weren't convinced that a grain drill would operate properly on steep hills. This was true for some of the older drills.

In the early 1970's, the California fertilizer industry donated a drill with a fertilizer attachment to Cooperative Extension. The first trials in 1972 were large replicated studies harvested with the grower's combine. They turned out to be very effective demonstrations of the improved efficiency of drilled phosphorus.

Message Spreads

After one year of trials, the first cooperator was so convinced of the advantages that he changed most of his operation to the drilled method. In the following years, we expanded demonstration trials to other key growers in the county. All of them subsequently changed from broadcast plantings with little or no phosphorus to drilled plantings using nitrogen and phosphorus with the seed.

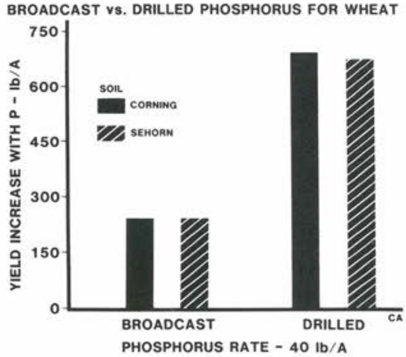
The improved fertilization and seeding practices swept the county as the message spread from grower to grower that this method of fertilization and planting would substantially improve the economic return from these crops.

Today a majority of the grain growers in Yolo County use drills with a fertilizer attachment, and apply an N-P fertilizer combination at seeding. Most of the N for the crop is supplied by spring topdressing or preplant applications.

Mr. Kearney is Farm Advisor with Cooperative Extension in Yolo County, California.

Figure 1 shows the average of three years of trials on two soil series. Drilling phosphorus with the seed produced three times the yield increase as did broadcasting. No wonder the growers changed so rapidly. ■

Figure 1



Forage Fertilization in the South Still Has a Long Way to Go

By Stanley L. Chapman

THE SUNBELT has been touted as having tremendous potential for forage production. However, most southern soils used for forages are either too infertile or have other limitations that keep production levels low.

Interest in forage fertilization traditionally rises and falls with cattle prices. There is a less direct relationship between forage fertilization and fertilizer prices.

J. D. Beaton and Josef Berger in "Forage Fertilization," a 1974 American Society of Agronomy report, estimated the average per-acre rate of plant food applied to forages in the southern U.S. to be 8 lb of nitrogen (N), 6 lb of phosphate, and 4 lb of potash.

They estimated the potential plant food use at 1.5 to 3 times higher than the amount being used, as **Table 1** shows.

Table 1. Estimated average and potential rates of plant nutrients applied to forage crops in the Southcentral United States

States	Estimated Rates (lb/A)					
	1973			Potential		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Texas, Oklahoma, Arkansas, Louisiana	6	4	3	25	15	11
Kentucky, Mississippi, Alabama, Tennessee	19	13	14	54	49	53
Weighted Average	**8**	**6**	**4**	**30**	**21**	**17**

(Continued on page 22)

Dr. Chapman is Extension Soils Specialist at the University of Arkansas.

Taking N use estimates of Beaton and Berger and assuming an average soil release of 50 lb/A of N per year, fertilizer and soil N would provide nutrition for slightly less than 1.5 tons/A of forage.

That translates into a stocking rate of one animal unit per four acres, near the actual average for the South. To increase carrying capacity to one animal unit per acre would require additional N fertilizer rates of 180 lb/A (assuming 40 lb of N per ton of grass forage). Phosphate and potash rates would have to be increased significantly also.

Actually, an annual N release rate of 50 lb/A may be higher than for many southern soils, at least according to a 1981 Arkansas soil test summary. The summary showed that 73% of the forage acreage had organic matter levels of less than 1%. One percent organic matter will normally release about 40 lb/A of N per year. Based on this assumption, most Arkansas soils do not release enough N from the organic matter each year to produce more than a ton of dry forage per acre. That's equivalent to a stocking rate of one animal unit per six acres.

The 1981 soil test summary showed that average fertilizer recommendations have increased significantly since the 1961-1964 period, especially potash rates. Following are some additional facts reflected in the summary.

- Approximately 80% of the acreage tested was for maintenance purposes. In general, a higher rate of N and K was recommended for maintenance than for establishment; higher P was recommended for establishment.

- Over 40% of all soil samples tested were for forage crops. These represented over 23% of the total acreage tested. Each sample from the forage crop area represented an average of 16 acres.

- Nearly half of the soil samples from the upland forage crop area had a pH below 5.9 and should be limed for efficient production. Legumes needed about 2 tons/A of lime to bring the soil pH up to an acceptable range. Grasses required about a half ton less.

- Phosphorus was very low on 40% of the forage crop acreage and low on an additional 23% as shown in **Table 2.**

Table 2. University of Arkansas soil test summary for upland soils. (January-October, 1981)

Plant food	Soil test value (lb/A)	Percent of acreage	Recommended rate (lb/A)
Phosphate	0-23	40	90
Phosphate	23-44	23	60
Phosphate	45-89	20	30
Potash	0-76	12	120
Potash	76-160	36	80
Potash	161-250	36	40

- Potash was low or very low on 48% of the acreage. At least 40% of the acreage required a minimum of 80 lb/A each of phosphate and potash for a medium level of forage production. Up to 120 lb/A of potash is needed for most forage crops on the 12% of soils testing very low in K **(Table 2).**

- Only 17% of the forage acres did not require P_2O_5; 16% did not need K_2O.

Using Arkansas as the example, how does fertilizer use compare to fertilizer recommended? **Table 3** shows average forage recommendations in Arkansas during the period, 1961-1964, **more than 10 years prior to** the Beaton and Berger report.

The data reveal that about six times the N, 12 times the P_2O_5 and 10 times the K_2O were recommended than were actually used. Further, these recommendations were for moderate production levels and did not include extra top-dressed N for production.

Table 3. Average plant food recommended on forages in Arkansas during 1961-1964

Crop	Percent of forage acreage	Recommended plant food N	P_2O_5	K_2O
			lb/A	
All pastures	28	50	49	26
All legumes	19	12	51	31
All grass-legumes	53	40	48	29
All forages	**100**	**37**	**49**	**29**

Fertilizer use on forages is not limited by the rate recommended. Rather, it is the small number of acres that are actually fertilized each year that keep the total fertilizer use down.

For example, it is estimated that there are over 3 million acres of improved pastures in Arkansas. If all of this acreage were fertilized annually with the average soil test recommendation, it would require more than 500,000 tons of mixed fertilizer alone. This is 25% more than was used on all crops in the state in 1981 and approximately five times the amount that was used on forage crops.

If this 3 million acres were fertilized annually with the average recommended rate, it is capable of supporting at least an animal unit per two acres, or a total of 1.5 million cattle. With additional nitrogen, the same acreage could easily feed the 2.5 million head of cattle currently in the state. More than 8 million acres are required to feed them now.

Reports from other southern states indicate similar situations. Some have progressed further than others. There is a tremendous opportunity to expand forage production with fertilization in the South. We still have a long way to go! ■

Bio-cycling of Phosphorus in the Soil

By D. W. L. Read

WE HAVE LEARNED much about phosphate fertilizer. But there has been little information on the movement of phosphorus (P) in the soil by "bio-cycling" through plants. This concept may present a whole new angle to P fertilization.

We know that P adheres firmly to soil particles, so it does not leach through the soil. On most prairie soils, P remains available for plant use many years after application. Phosphorus can be applied by different methods. But the relative efficiency of each method is still open to question.

In 1966, Dr. Wilf Ferguson laid-out plots to study the residual effects of phosphate fertilizer at Swift Current, Saskatchewan. He applied three rates in the form of superphosphate: 90, 180, and 360 lb/A of P. Control plots received no application.

Fertilizer was broadcast and rototilled into the top 4 inches of soil. There were adjacent blocks of stubble and fallow. Each treatment was replicated four times as both stubble and fallow.

The residual P studies continued for eight years. Soil samples were taken at various depths to 48 inches in the fall each year. The blocks were cropped in a fallow-wheat rotation. **This study showed that the method worked; the P remained available for plant use for the eight years.**

The soils were sampled before the P was applied. They had a fairly uniform amount of extractable P over the entire area at each depth.

When the P was applied, the extractable P in the top 6 inches of soil increased in relation to the amount of fertilizer applied, as expected. Each area of the plots received one application of fertilizer, ranging from 0 to 45 lb/A of P with the seed during the eight years of the test.

Since 1974 the area has been handled as one field and cropped in a fallow-wheat rotation with no fertilizer applied.

In the fall of 1967, 1974 and 1979 (one, 8 and 13 years after the original application) each plot was sampled at a depth of 48 inches.

Figure 1 illustrates the changes that have taken place. It shows the increased amount of sodium bicarbonate extractable P for each application rate, in excess of that from the zero rate.

Mr. Read recently retired from the Research Branch, Agriculture Canada, Swift Current, Saskatchewan.

The 360 lb/A rate showed a significant increase from 1967 to 1979 in the amount of P found at all depths from 6 to 48 inches. The amount present in 1979 was somewhat more than in 1974 for all depths below 12 inches.

Even for the 90 and 180 lb/A rates of P, there was some increase at all depths. **This indicates a gradual downward movement of P. The movement is related to the application rate and time since application.**

How was the P transported from the surface to the lower depths? A possible way was by "bio-cycling".

Plants grown with adequate fertility tend to have a higher P content in all of the plant tissue. If the roots of the plants contain more P, this will be released into the soil at the depths they are growing when they die. This increases the P content of the soil.

If this is the explanation, it presents a whole new angle to phosphorus fertilization. Maybe we can gradually build up the soil P content at depths where plants are active, rather than just the surface soil.

There may still be a few things to learn about phosphate fertilizer. ■

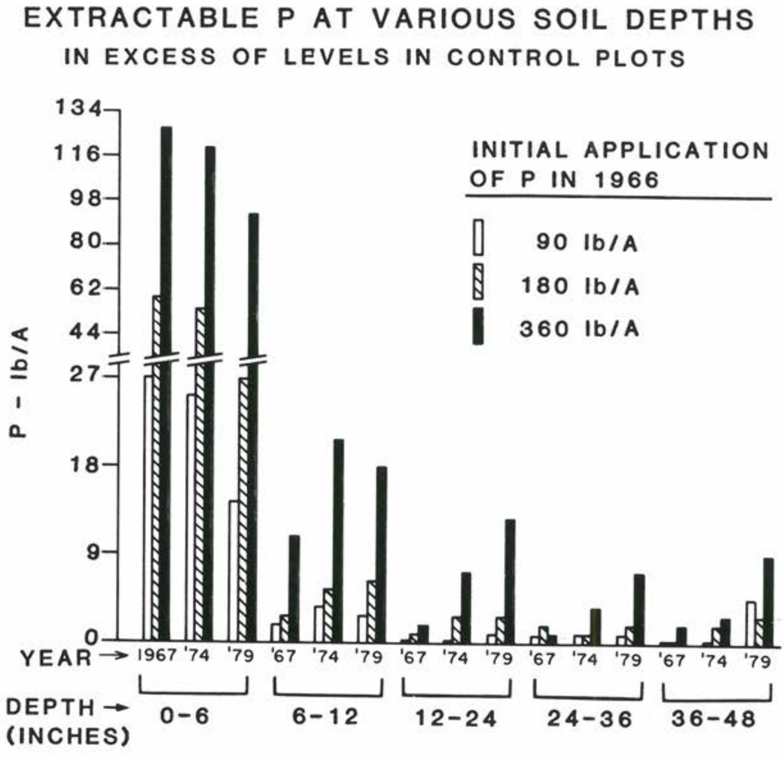


Figure 1

How Rapidly Do Potassium, Sulfate and Chloride Move through the Soil?

By Dale Smith and L. A. Peterson

POTASSIUM (K) FERTILIZERS can be topdressed on alfalfa in the form of muriate of potash (KCl) and sulfate of potash (K_2SO_4). Potassium and phosphorus (P) are relatively immobile in mineral soils and generally remain close to the point of application unless redistributed by tillage.

On a Plano silt loam soil in Wisconsin, we tested for residual K that had been topdressed as KCl during the first 2 years of a 3-year study at rates of 100 to 1,000 lb/A. The K was virtually all in the top 6 inches of the soil profile after 3 years of normal rainfall.

In Minnesota, K also moved very little even in loamy sand after fertilization with 415 lb/A of K and irrigation with 46 inches of water during 55 days (reported in *Better Crops with Plant Food* LIX (3): 25, 1975).

Trial Established

Since K can be applied as KCl or K_2SO_4, we wanted to know how rapidly the chloride (Cl) and sulfate (SO_4) moved in the soil, as well as the K. At the same time, we studied the movement of P and nitrate (NO_3) in the soil.

In Wisconsin research, potassium was topdressed on a 4-year-old stand of Ranger alfalfa in triplicate plots at the rate of 500 lb/A of K as KCl and as 1,000 lb/A of K as K_2SO_4. Application date was May 11, 1973. P was also applied as concentrated superphosphate at 500 lb/A of P. Nitrogen was applied as ammonium nitrate at 450 lb/A of N.

The fertilizers were applied when plant foliage was dry and the surface soil was very dry; no plant damage was noted.

Soil cores were removed at intervals to a depth of 60 inches before the fertilizers were applied (May 1973) and again in July and October 1973. More soil cores were taken in May and October of 1974 and during May 1975. **Table 1** shows the results.

Potassium and Phosphorus

The residual of K and P applied on May 11, 1973 was found entirely in the top 6 inches of the Plano silt loam soil. Two years after their application (May 1975), the largest proportion of both the residual K and P was still located in the 0 to 3-inch soil layer. From the time of application to the last sampling, a total of 64.9 inches of precipitation was measured.

During the 1973 experimental period, precipitation was 24.06 inches. In 1974, it totaled 33.46 inches and through April of 1975, 7.39 inches.

Dr. Smith, a former University of Wisconsin Agronomist, is now in the Department of Plant Sciences, University of Arizona at Tucson. Dr. Peterson is in the Horticulture Department, University of Wisconsin.

Table 1. The nitrate (NO_3^-), sulfate (SO_4-$S^=$), and chloride (Cl^-) concentrations of Plano silt loam soil after their application by topdressing at high rates.

Soil sample depth (Inches)	Sample dates May 11 1973	July 11 '73	Oct. 11 '73	May 3 '74	Oct. 15 '74	May 15 '75
			NO_3, ppm			
0-3	1	**134**	7	3	2	4
3-6	0	**51**	8	1	1	4
6-9	0	**29**	**12**	1	1	4
9-12	0	**12**	**20**	1	0	2
12-18	0	3	**25**	4	1	1
18-24	0	1	**12**	**14**	0	1
24-30	0	1	3	**21**	0	1
30-36	0	0	1	**24**	0	0
36-42	0	–	0	**12**	1	1
42-48	0	–	1	3	0	0
48-54	0	–	1	2	0	0
54-60	1	–	1	1	0	0
			SO_4-S, ppm			
0-3	7	**296**	59	14	14	7
3-6	5	**128**	**136**	15	14	4
6-9	5	**69**	**186**	18	14	8
9-12	4	24	**198**	**60**	18	8
12-18	3	11	**74**	**104**	**23**	**24**
18-24	6	12	16	**83**	**41**	**31**
24-30	12	17	15	14	**21**	**37**
30-36	15	30	15	13	11	**24**
36-42	15	–	16	14	13	14
42-48	16	–	17	15	17	15
48-54	15	–	16	14	16	11
54-60	15	–	15	14	11	10
			Cl, ppm			
0-3	0	**327**	3	0	0	0
3-6	0	**165**	3	0	0	0
6-9	0	**112**	**51**	0	0	0
9-12	0	**52**	**94**	0	0	0
12-18	0	6	**98**	2	0	0
18-24	0	0	**61**	**20**	0	0
24-30	3	0	5	**57**	**23**	0
30-36	0	0	0	**60**	**54**	5
36-42	0	–	0	**23**	**39**	**33**
42-48	0	–	2	3	**18**	**45**
48-54	0	–	0	0	3	**29**
54-60	0	–	3	0	0	**22**

(Numbers in bold type indicate movement of nutrient concentrations through the soil.)

Nitrate, Chloride and Sulfate

The NO_3 and Cl moved similarly and quite rapidly through the soil, as **Table 1** illustrates. One year after their application (May 1974), most of the

(Continued on page 28)

residual NO_3 and Cl was in the 18 to 42-inch soil layer, and 2 years later (May 1975), the Cl was mostly in the 36 to 60-inch soil layer; a movement of about 18 inches each year.

No NO_3 was found after May 1974, probably because the alfalfa had absorbed most of it from the soil. A portion could have been lost by denitrification.

Table 1 also shows that both the NO_3 and Cl moved more rapidly through the soil during the winter period than during the growing season.

The residual SO_4-S moved less rapidly than the NO_3 and Cl. The residual SO_4-S was located mostly in the 9 to 24-inch soil layer by May 1974, and in the 12 to 36-inch soil layer by May 1975. The rate of movement was about the same during the winter and the growing season, in contrast to the NO_3 and Cl.

Summary

These data show that NO_3 and Cl moved rapidly through the soil, while SO_4-S was intermediate in its speed of movement through the soil. K and P remained close to the point of application. ■

Check Fields for Nutrient Shortages

A COMBINATION of conditions could result in nutrient deficiencies in many crop fields this season. Frequent field examination will help uncover soil fertility problems and other shortcomings in management practices.

A new folder from the Potash & Phosphate Institute (PPI) points out the reasons why it's so important to check fields this year and lists guidelines on how to do it.

Titled **"Check Fields for Nutrient Shortages"**, the publication is available from PPI at the address shown below.

The cost: 15¢ per copy. (Cost is 10¢ per copy for members of PPI, contributors to FAR, to university and government agencies). For more information, contact:

Potash & Phosphate Institute
2801 Buford Hwy., N.E.
Atlanta, GA 30329

Batch and Annual Phosphorus Fertilizer Application for Wheat in Western Canada

By H. D. Jose and Linden Nilsen

FOR SOME WHEAT producing areas of western Canada, a large "batch" application of phosphorus (P) fertilizer once in several years may be more economical than small annual applications.

Soil scientists have observed that fertilizer P can be effective for long periods of time in the calcium dominated soils of western Canada and the U.S. If P remains available to plants for a number of years from one application, annual applications could be avoided. Also, application could be at a convenient time rather than during the critical period of spring planting when labor demands are high.

In one experiment, it took approximately 8 years for available soil P to be reduced to 10 ppm after an application of 90 lb/A. It took 14 years for a 180 lb/A application and 19 years for a 360 lb/A application to reach the same equilibrium with the same initial available concentration. In the same experiment, the soil P content in check plots remained relatively constant for the full 19 years with no crops being grown. This indicates the residual phosphorus is not lost during summer fallow years on western Canadian soils.

Another experiment compared the yields from large broadcast applications of P with the yields from annual applications with the seed. The broadcast rates applied to two Saskatchewan and two Manitoba soils were 90, 180, and 360 lb/A. Available P status and pH of these soils are given in **Table 1.**

Table 1. Available P and pH status of soils.

Soil	Available P - lb/A	pH
Cabri	4.5	7.64
Swift Current	15.0	6.69
Griswold	8.0	7.39
Goodlands	6.0	7.20

The annual P applications studied were 0, 4.5, 9, 18, 27, 36, and 45 lb/A. Results of this experiment are shown in **Table 2.** To find P_2O_5 rate, multiply P rate by 2.3.

Crops were grown on the two Saskatchewan soils (Cabri and Swift Current locations) on alternate years to represent a typical rotation with one crop in two years. On the Manitoba soils (Griswold and Goodlands locations) crops were grown continuously for 8 years.

(Continued on page 30)

Dr. Jose was a member of the Department of Agriculture Economics, University of Saskatchewan, when this work was completed. He is now Extension Farm Management Specialist, University of Nebraska. Linden Nilsen is a former student at the University of Saskatchewan.

Table 2. Wheat yield from check and percent increase in yield.

a) Yield increase from single broadcast application of P, no application with seed.

	Yield - lb/A unfertilized check		percent yield increase over check Phosphorus rate - lb/A					
			90		180		360	
Location	8-yr mean	8th yr	8-yr mean	8th yr	8-yr mean	8th yr	8-yr mean	8th yr
Cabri	1421	2158	33%	25%	43%	29%	44%	39%
Swift Current	1072	1305	12	11	12	15	18	33
Gwiswold	1294	628	66	60	71	78	74	111
Goodlands	1704	1296	30	58	33	65	40	91

b) Percent increase in yield from P applied with seed (8-year mean); no initial application of P.

	Check yield lb/A	Rate of application with seed (P - lb/A)					
		4.5	9	18	27	36	45
Location		Yield Increase					
Cabri	1421	12%	15%	21%	28%	25%	32%
Swift Current	1072	5	9	10	16	18	21
Griswold	1294	24	45	49	63	68	73
Goodlands	1704	9	22	37	35	41	40

The basic economic concept in adding successive units of a variable input to a fixed factor, such as adding fertilizer to land, is to continue to add the input until the marginal revenue becomes equal to marginal cost.

The theoretical optimum is reached when the ratio of the marginal return (MR) to the marginal costs (MC) reaches 1.0. To allow for uncontrollable risk and the variability of weather and expected fertilizer response, a ratio of 1.5 is often used rather than 1.0 as the decision-making criterion or cutoff point in the addition of fertilizer.

For example, the Saskatchewan Soil Testing Laboratory uses the 1.5 criterion in making fertilizer recommendations. This means that, on the average, a return of $1.50 is expected for each additional $1.00 of expense. The criterion assumes a risk-averse behavior on the part of the decision maker. The economic criterion used in this analysis was the MR:MC ratio must be at least equal to 1.5 in determining the economic optimum application of phosphorus.

There are two steps in determining the economic feasibility of batch applications. First, determine the optimum annual application. Second, compare this with the batch applications to determine which application strategy is economically superior.

Optimum Annual Applications

Using the MR:MC ratio of 1.5 criterion discussed above, the optimum applications for the base price situation are as follows:

Cabri	9 lb/A
Swift Current	4.5 lb/A
Griswold	18 lb/A
Goodlands	18 lb/A

If the price of wheat increased relative to the price of phosphorus, the impact on the optimum annual application would be as follows:

Cabri — The optimum would still be between 9 and 18 lb/A.

Swift Current — The optimum would increase to 9 lb/A.

Griswold — The optimum would increase to 27 lb/A.

Goodlands — The optimum would increase to 27 lb/A.

If the price of fertilizer increased relative to the base price of wheat, the optimum applications would stay about the same as the base situation for Swift Current, Griswold, and Goodlands. For Cabri, the optimum would decline to 4.5 lb/A.

Comparing Batch and Annual Applications

The returns above fertilizer costs for the 90 lb/A batch application are shown in **Table 3.**

Table 3. Annual returns above P fertilizer costs for 90 lb/A batch applications.

Location	8-yr mean yield - lb/A	Annual returns per acre for 3 price situations* P_w=\$133 P_f=\$257	P_w=\$181 P_f=\$257	P_w=\$133 P_f=\$349
Cabri	1890	\$112	\$157	\$107
Swift Current	1200	66	95	61
Griswold	2148	136	188	134
Goodlands	2215	140	194	138

*P_w=price of wheat/ton P_f=price of fertilizer/ton

The average annual returns above fertilizer costs for the optimum annual applications are presented in **Table 4.**

Table 4. Annual returns above fertilizer costs for optimum annual applications.

Location	Price Situation* P_w=\$133 P_f=\$257	P_w=\$181 P_f=\$257	P_w=\$133 P_f=\$349
Cabri	\$105 (9 lb)**	\$144 (9 lb)	\$101 (4.5 lb)
Swift Current	72 (4.5 lb)	100 (9 lb)	71 (4.5 lb)
Griswold	121 (8 lb)	173 (27 lb)	117 (18 lb)
Goodlands	137 (18 lb)	194 (27 lb)	133 (18 lb)

*P_w=price of wheat/ton P_f=price of fertilizer/ton

**The numbers in parentheses are the optimum annual applications per acre, using the criterion that the MR:MC ratio must be at least 1.5.

In this experiment, the batch application had an economic advantage for all price situations considered for all locations except Swift Current. At the latter location the annual applications are economically preferred, particularly when the price of fertilizer is high relative to the price of wheat.

These results lead to the conclusion that there is a potential economic advantage for batch application in the higher rainfall areas of the Prairies where wheat can be grown continuously or with limited summer-fallowing.

More detailed information and references for this study are available on request. ■

Dow Chemical Adds Support to Foundation for Agronomic Research

WITH A $50,000 contribution, the Agricultural Products Department of Dow Chemical U.S.A. has added its support to the Foundation for Agronomic Research (FAR).

FAR is a tax-free organization which sponsors research in total crop management for maximum economic yields. It is affiliated with the Potash & Phosphate Institute (PPI), with headquarters in Atlanta, Georgia.

The grant from Dow stems from the company's growing interest in and dedication to overall plant nutrition research. The contribution will help to further set the importance of fertility in feeding an ever increasing world population, notes Keith R. McKennon, recently appointed Vice President for Dow Agricultural Chemicals globally.

Nitrogen stabilizers are among the important agricultural products of Dow. Research has shown enhanced uptake of potassium and phosphorus through optimum nitrogen utilization.

"Agricultural chemicals represent one of our most exciting growth opportunities," observes Paul Oreffice, President and Chief Executive Officer of The Dow Chemical Company.

FAR now sponsors 61 different research projects in the U.S. and other nations. It was established in 1980 to offer all segments of the fertilizer, seed, pesticide, farm equipment, and other industries the opportunity to invest in well integrated crop production research.

"We encourage the quest for maximum crop yields in research and maximum economic yields for the farmer," says Dr. R. E. Wagner, President of FAR and PPI. "The object is teamwork from all disciplines—to show growers and their suppliers how their different inputs can *interact* to break those yield barriers that hold down production and profits."

Other organizations supporting FAR's program of continued crop research include: Agrico Chemical Company; Amoco Foundation, Inc.; Chemical Enterprises, Inc.; DeKalb AgResearch, Inc.; Frit Industries, Inc.; International Minerals & Chemical Corporation; Kalium Chemicals; Potash Corporation of Saskatchewan; The Sulphur Institute, and Texasgulf Inc.■

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