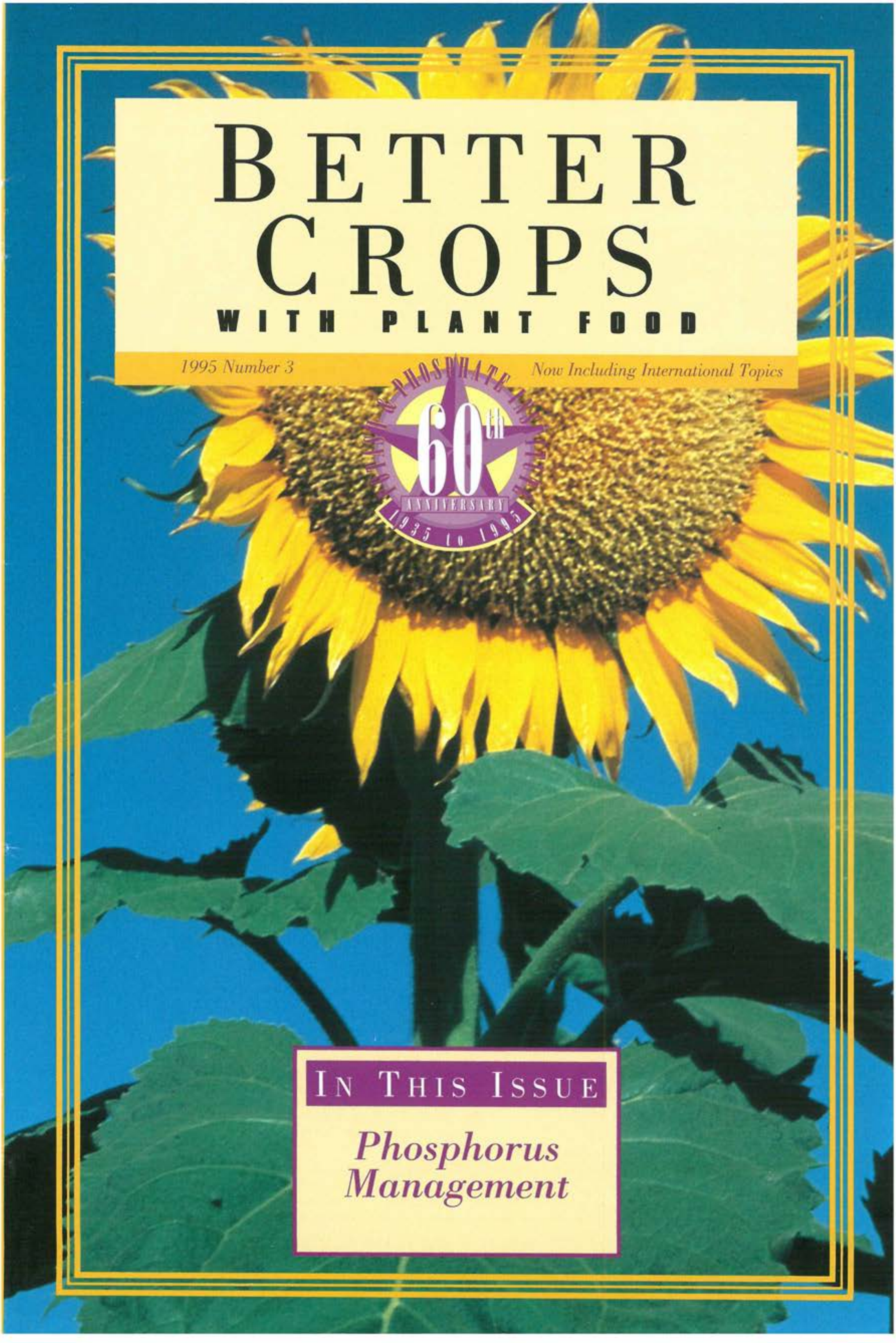

BETTER CROPS WITH PLANT FOOD

1995 Number 3

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IN THIS ISSUE

Phosphorus Management

BETTER CROPS
WITH PLANT FOOD

Vol. LXXIX (79) 1995, No. 3

Our Cover: Sunflower in Kearny County, Kansas.
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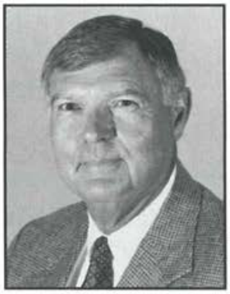

Dr. W.R. Thompson, Jr.

DR. W.R. (BOB) THOMPSON, JR. of Starkville, MS, is retiring effective November 1 from his position as Midsouth Director for PPI. The announcement came from Dr. David W. Dibb, President of PPI.

"Bob Thompson has devoted his professional life to service—service to the field of agronomy, to the fertilizer industry, to the farmers of the South, and to all of agriculture," Dr. Dibb stated.

As Midsouth Director, Dr. Thompson coordinated research and education programs for PPI in several states in the Southern U.S. Since joining the PPI staff in 1967, he has conducted numerous fertilizer dealer schools, workshops and training sessions throughout the South. Dr. Thompson has maintained a close professional relationship with researchers, Extension and agribusiness and has been a leader in several programs. He has served as Vice President of the Foundation for Agronomic Research (FAR) since 1990.

A native of Indianola, MS, Dr. Thompson earned his B.S. degree in agronomy, then later completed the M.S. and received his Ph.D. in 1966 from Mississippi State University. He served a two-year tour as a Lieutenant of Artillery with the U.S. Army during 1955-57 in Germany. On his return, he worked as an assistant county agent in Mississippi. From 1960 to 1967, he was Assistant Professor at Mississippi State.

Dr. Thompson has emphasized greater understanding of potassium nutrition for cotton in recent years. He was instrumental in developing the annual Southern Extension-Industry Agronomists Workshop and has worked closely with forage crop groups in several states. He received the Merit Certificate from the American Forage and Grassland Council and he is a Fellow of the American Society of Agronomy ■

PPI Announces Dr. C.S. Snyder as Director for Midsouth U.S.

Dr. Clifford S. Snyder

DR. CLIFFORD S. SNYDER is joining the staff of PPI as Midsouth U.S. Director, beginning October 1, 1995.

"Dr. Snyder has achieved an outstanding reputation for his involvement in soil fertility research and extension and PPI welcomes him to our organization," said Dr. David W. Dibb, President of PPI.

In 1978, Dr. Snyder received his B.S. in soil science from the University of Arkansas and completed his M.S. in 1980 in soil fertility. He studied and conducted research in soil microbiology/fertility at North Carolina State University and in 1983 completed the requirements for his Ph.D. Dr. Snyder has worked with the University of Arkansas Cooperative Extension Service as a soils specialist since the completion of his Ph.D. Over the past 11 years, Dr. Snyder has been extensively involved with applied crop production research and the preparation of fertilizer recommendations for Arkansas farmers.

In his new responsibility, Dr. Snyder will direct PPI programs in Arkansas, Kentucky, Louisiana, Missouri, Mississippi, Tennessee and eastern Texas. ■

Phosphorus and Sulfur Support Nitrogen in Intensified Cereal Production

By Paul E. Rasmussen

Studies on the Columbia Plateau near Pendleton, OR, emphasize the importance of providing adequate phosphorus (P) and sulfur (S) nutrition to supplement the traditional nitrogen (N) program in no-till and intensified dryland cereal production systems.

EFFICIENT FERTILIZER USE is a prerequisite for achieving optimum crop yield while avoiding adverse environmental impacts. Generally, nutrient deficiencies are greater under annual cropping than in cereal/fallow rotations because of the extra time in the latter for mineralization of available nutrients.

Nitrogen and S deficiencies are likely to be more severe in conservation tillage than in conventional tillage systems because these nutrients are derived primarily from the organic fraction of soil. It is the decomposition of this fraction that is most altered by a change in tillage. Phosphorus can be similarly affected. Nutrient deficiencies tend to be more severe in no-till because of cooler, wetter soil conditions that impair early crop growth and root development. This is especially significant relative to early season availability of P.

Six-Year Field Study

Cereal grain was grown over a 6-year period in an experiment with three rotation-tillage treatments and four levels of fertility on a Walla Walla silt loam. Crop rotation consisted of winter wheat/fallow and annual cropping (winter wheat/spring cereal). Tillage treatments, applied to annual cropping only, were no-till and conventional-till. Fertilizer treatments were (a) none, (b) N only, (c) N + S, and (d) N + P + S. Fertilizer amounts varied slightly with year, averaging 97 lb/A N, 22 lb/A P_2O_5, and 16 lb/A S. Soil tests prior to planting indicated that the soil (0-1 foot) was low in available S . . . 3 parts per million (ppm) . . . and medium in available P (11 ppm $NaHCO_3$ extractable) for dryland wheat production.

Table 1. Winter wheat grain yield and relative-yield ratio as affected by tillage and fertilization.

	-------- Yield, lb/A --------			
Fertilization	NT	CT	3-yr Avg.	NT/CT ratio
None	1,060	1,850	1,460	0.57
N	2,300	2,980	2,640	0.77
NS	3,260	3,680	3,470	0.89
NPS	3,550	4,200	3,880	0.85

NT = No-till, CT = Conventional-till.

Fertilizer Response

Rates of N, P and S were adjusted annually depending on soil water storage, cereal variety, seeding data, and previous experience. Cereals responded to each nutrient in all years at a statistical probability of 0.10. The marginal P responses (statistical probability between 0.05 and 0.10) tended to occur in years of low precipitation (years 3 and 6) while marginal S responses did not. Yields for all cereals,

Table 2. Spring cereal grain yield and relative-yield ratio as affected by tillage and fertilization.

	-------- Yield, lb/A --------			
Fertilization	NT	CT	3-yr Avg.	NT/CT ratio
None	1,380	2,220	1,800	0.62
N	2,200	3,010	2,610	0.73
NS	3,380	3,460	3,420	0.98
NPS	3,980	3,730	3,860	1.07

NT = No-till, CT = Conventional-till.
Barley planted in year 2 and year 4; spring wheat planted in year 6.

Dr. Rasmussen is Soil Scientist with USDA-ARS, Columbia Plateau Conservation Research Center, P.O. Box 370, Pendleton, OR 97801.

Table 3. Winter wheat yield in annual cropping and wheat/fallow rotation as affected by fertilization. (2-year average)

	------ Yield, lb/A ------		
Fertilization	Annual crop (AC)	Wheat-fallow (WF)	AC/WF ratio
None	1,630	3,170	0.52
N	2,260	3,380	0.67
NS	3,390	3,810	0.89
NPS	3,890	4,330	0.90

cropping systems, and tillage systems (**Tables 1-3**) were greatest for the NPS combination in which there was never any visual or analytical evidence that nutrients were deficient when applied at the rates indicated. Yields progressively increased from none<N<NS<NPS, indicating that the application of all three nutrients was necessary to maximize yields. Six-year yield averages were 1,620, 2,620, 3,450 and 3,870 lb/A, respectively, for these nutrient combinations.

Conventional-till (CT) vs. No-till (NT)

Winter and spring cereals responded about equally to N, P, and S in both no-till and conventional-till, with one distinction. Winter wheat yield (**Table 1**) in no-till was always less than conventional-till regardless of fertility, whereas spring cereal no-till yield (**Table 2**) equaled conventional-till when NS and NPS were applied.

The NT/CT yield ratio was lowest with no nutrient application and progressively improved when N and S were applied for both tillage systems. An increase towards unity in the NT/CT ratio with N and S addition indicates that the deficiency of these nutrients was more severe in no-till. The NT/CT yield ratio also increased for P addition in spring cereals, but not in winter wheat. This indicates P deficiency was similar in both no-till and conventional-till for winter wheat. The NT/CT ratio >1.0 for spring wheat reveals the importance of P for spring planting when cold, wet soil conditions limit P availability.

Annual Cropping vs. Wheat/Fallow

When grown without fertilizer, winter wheat in annual cropping yielded 52 percent of wheat following fallow (**Table 3**), reflecting the substantial contribution of a year of fallow to the nutrition of the following crop. When fertilized with N, P and S, annual crop winter wheat yielded 90 percent of wheat after fallow. Total production over two years would be up to 80 percent greater with annual cropping than with wheat/fallow, but with higher production costs to be considered in the final analysis.

SUPPLYING adequate P advances heading and maturity of spring grains by as much as 5 to 7 days. This can improve water use efficiency and avoid late-season drought stress. In the photo, barley plot at left received N and S, while plot at right received P in addition to N and S.

The AC/WF (annual crop/wheat-fallow) yield ratio increased with N and S application, indicating these nutrients were more deficient under annual cropping. The ratio did not increase with P addition, indicating that response was similar in both cropping systems.

Summary

Cereal grains responded strongly to application of N, P and S. Both N and S were more deficient in no-till than conventional-till. Deficiency was also greater when soils were cropped annually rather than in wheat/fallow rotation. These responses occur because the amount of N and S that native soil organic matter can supply decreases with less-intensive tillage and with less time between cropping. Phosphorus availability, which is governed to a greater degree by the mineral fraction of soil, was only minimally affected by either cropping intensity or type of tillage.

Adequate fertility is a prime prerequisite for efficient yield in all cropping systems, but more so in no-till systems and intensive cropping. ■

Research Tracks Phosphorus Dissipation Patterns in Rice Production

By Garry N. McCauley

Most Texas rice production is concentrated in areas near the Gulf Coast. It follows, then, that the crop . . . specifically flood water leaving rice fields . . . can impact on surrounding areas, including coastal waters. This study was established to evaluate the environmental impact of nitrogen (N), phosphorus (P) and potassium (K) fertilization of rice grown under flood management. Data presented in this article deal with P fertilization.

A RECENT REPORT published by the U.S. Department of Interior concluded that the Matagorda Bay of Texas is one of the most polluted areas in the U.S. The report was based on a simulated computer model. No sampling, analysis or field trials were done to support assumptions made by project leaders, who had no apparent knowledge of rice irrigation and management.

However, published information such as that included in the report can be successfully refuted only by good scientific data. Earlier small plot research conducted by Texas A&M University scientists showed that with proper pesticide and water management there is little potential for nonpoint source runoff from rice fields. Unfortunately, those studies are 20 years old and did not include P and K.

Extensive research has shown that natural or artificial vegetated wetlands are effective water purification systems. Small, contained vegetative wetlands have proven effective in the decomposition of all agricultural pesticides. A detailed design evaluation reveals that a rice field is a temporary vegetated wetland. One could assume that with sufficient water hold or flow through time, a rice field can purify the inflow water, dissipate all nutrients, and decompose all pesticides. Research is needed to verify these assumptions. This study was designed to define the degradation patterns and estimate nonpoint source runoff of P and K.

Twenty producers in a four-county area (Colorado, Jackson, Matagorda and Wharton) were recruited by county Extension agents to participate in the study. Producers took a water sample at the inlet and outlet of each test field following each rain and flush irrigation. After flood establishment, inlet and outlet samples were taken when the flood reached the bottom of the field and at three day intervals until four samples were taken or at least 12 days after flood establishment. It was assumed that P (and K) would be dissipated from flood water within 12 days after the flood had reached the bottom of the field.

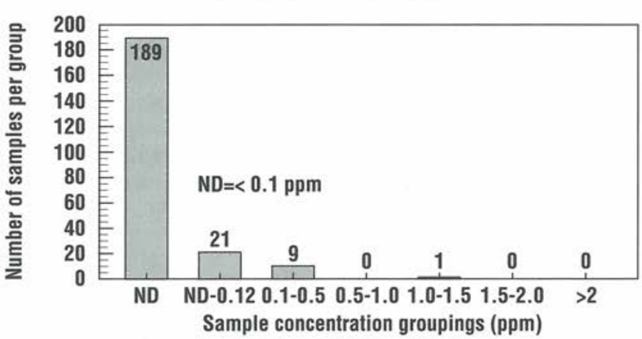

Figure 1. Phosphorus concentration distribution of 220 rice field water quality samples.

Dr. McCauley is Associate Professor, Texas A&M University System, Eagle Lake, TX.

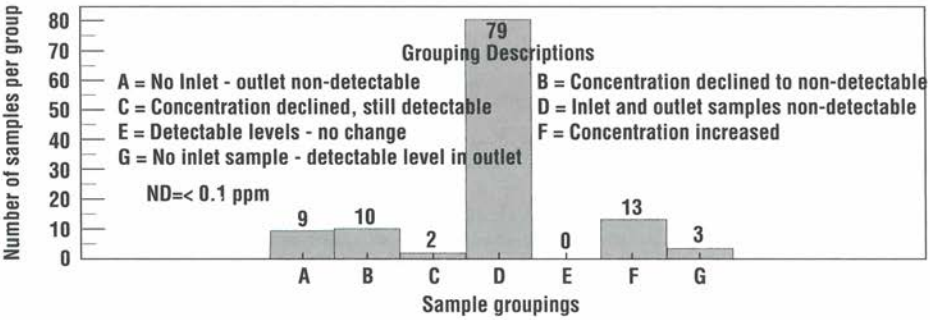

Figure 2. Distribution of inlet-outlet sample change in P concentration for 116 rice field water samples.

The 20 producers took a total of 220 samples at 116 different times. There were 104 matched inlet and outlet samples, with 12 outlet samples being taken when no inlet water was available. Phosphorus concentrations were very low, as shown in **Figure 1**. Only one sample exceeded 0.5 parts per million (ppm) P, while 189 (86 percent of all samples) contained no detectable P. To allow for detailed interpretation, samples were broken into seven groups.

A = No inlet – outlet non-detectable
B = Concentration declined to non-detectable
C = Concentration declined, still detectable
D = Inlet and outlet samples non-detectable
E = Detectable levels – no change
F = Concentration increased
G = No inlet sample – detectable level in outlet

Studying the seven groups reveals that A through E can only be interpreted to have a neutral or positive environmental impact. Group F would be a negative environmental factor, the magnitude depending on the amount of concentration increase. The impact of G group can not be determined because there was only one sample taken, but it is assumed to be negative (conservative interpretation).

Figure 2 shows that there were 13 F samples and 3 G samples (14 percent of the total) that could be considered detrimental to the environment.

Figure 3 illustrates how much those 16 samples increased. Ten samples increased less than 0.1 ppm and 5 samples increased by 0.1 and 0.2 ppm. The remaining sample appears to have increased by 1.1 ppm. In reality this was a single sample where there was no

(continued on page 9)

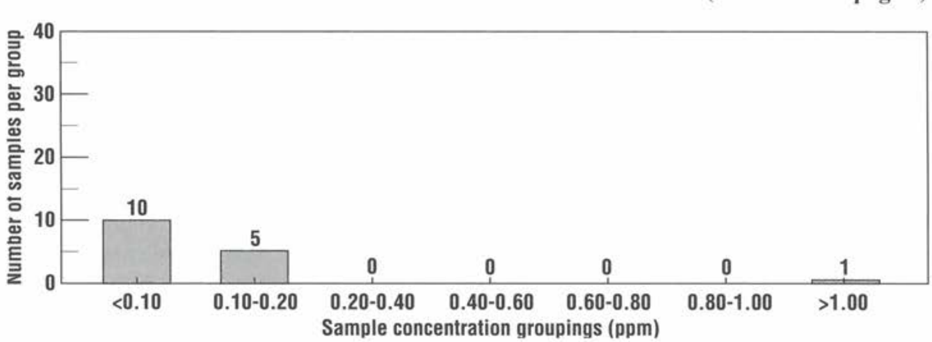

Figure 3. Distribution of P concentration increase from inlet to outlet for 16 rice field water samples that increased.

Alberta

Coating of Phosphorus Fertilizers with Polymers Increases Crop Yield and Fertilizer Efficiency

By M. Nyborg, E.D. Solberg and D.G. Pauly

Polymer-coated phosphorus (P) fertilizers produced greater yields and fertilizer efficiences than non-coated P fertilizers in greenhouse and field studies with Alberta soils.

RECOVERY of P fertilizer by small grains usually varies from 5 to 25 percent in the year of application. Low recovery of P results from its quick adsorption and precipitation in the soil. Generally, the better the P fertilizer is mixed into the soil, the poorer the recovery by the crop. Placing the fertilizer in narrow bands close to the seed usually produces the highest yield and greatest P recovery in cereal grains and oilseed crops. Nevertheless, first year P efficiency seldom exceeds 25 percent and is usually much less under field conditions.

We speculated that if exposure of P fertilizers to the soil is eliminated or minimized while exposure to plant roots is maximized, the recovery of P would be increased. We tested that idea with monoammonium phosphate (MAP) and diammonium phosphate (DAP) in two agricultural soils in a pot experiment, sown to barley. The fertilizers were dissolved in water and the solutions added through slender tubes in each pot. The tubes discharged the P solutions beside the barley seed. Phosphorus fertilizer was added at seeding or every other day.

Apparent recovery of P fertilizer was approximately twice as great when the P was applied in small doses every second day as compared to application of the full dose on the day of sowing (**Table 1**). That was true for both a Black Chernozem and a Gray Luvisolic soil, and for both MAP and DAP. Apparently, the frequent, dilute additions of P allowed the plant to take up more P before it was "fixed" by the soil.

We also tried wrapping single granules of MAP with thin, perforated kitchen film. There was more plant recovery of fertilizer P from the wrapped MAP than the non-wrapped MAP.

Table 1. Adding regular, small doses of fertilizer increases apparent P recovery in 45 day old barley grown in potted soils.

		Apparent P recovery, %	
Fertilizer	Time of Application	Black Chernozem	Gray Luvisol
MAP	All at seeding	13	18
MAP	Added every other day	24	36
DAP	All at seeding	8	14
DAP	Added every other day	17	39

Application rate: 18 lb P_2O_5/A

Coated Fertilizers

Phosphorus fertilizer with commercially coated polymer was also evaluated. Thin and thick coated MAP and DAP were used in an array of greenhouse experiments with barley grown in pots with a Gray Luvisolic soil. Results from one experiment are shown in **Table 2**. Fifty two days after P application, yield was substantially greater and apparent P recovery was 60 percent greater with the thin coated MAP compared to the non-coated MAP. This and other experiments indicated that polymer coating of P fertilizer granules resulted in a fairly slow, but steady supply of

Dr. Nyborg is Professor of Soil Fertility, University of Alberta, Edmonton; E.D. Solberg is Research Agronomist, Alberta Agriculture Food and Rural Development, Edmonton. D.G. Pauly was involved in this research as a graduate student at University of Alberta, but is now Research Agronomist, Sherritt Inc., Edmonton.

Table 2. Polymer-coating increased yields and P efficiency in a barley pot study.

Fertilizer	Plant yield, g/pot		Apparent P recovery, %	
	26 days	52 days	26 days	52 days
Check	1.2	7.8	–	–
MAP, not coated	5.3	19.0	26	27
MAP, thin coat	5.2	24.4	34	44
MAP, thick coat	3.6	18.6	20	32

Application rate: 28 lb P_2O_5/A

plant-available P as it diffused or leaked through the coating. This principle was much the same as that of using frequent small doses of P in solution.

In 1994 we set out two field experiments. The soils were near neutral Black Chernozems of silty loam texture. Monoammonium phosphate was commercially coated with two different kinds of polymer material. The yield was increased slightly by the thin coating of Polymer 1 but substantially by thin coating of Polymer 2 (**Table 3**). Polymer coating had a greater effect on P efficiency than on yield, with P recovery increasing from 26 percent for non-coated MAP to 54 percent for thin coating with Polymer 2.

Summary

Our results in the greenhouse and field have demonstrated that slowing the release of fertilizer P into the soil by coating fertilizer granules can markedly increase yield and P recovery by the crop. Apparently, different materials can form successful coatings. Increased P efficiency through coated fertilizers may improve the profitability of P fertilization, especially in areas with high P fixing soils. ■

Table 3. Polymer-coated P fertilizer increased barley dry matter and P efficiency in field grown barley.

Fertilizer	Dry matter yield, tons/A	Apparent P recovery, %
Check	1.07	–
MAP, not coated	1.60	26
MAP, thin coat of Polymer 1	1.77	36
MAP, thick coat of Polymer 1	1.56	30
MAP, thin coat of Polymer 2	2.10	54
MAP, thick coat of Polymer 2	1.30	28

Application rate: 16 lb P_2O_5/A

Phosphorus Dissipation . . . from page 7

inlet sample for comparison. The sample was taken as flush irrigation water reached the bottom of the field. The flush irrigation occurred immediately after a post-emerge application of 38 lb/A of P. Post-emerge application of P is an acceptable management practice, but may need to be reevaluated. Most of the other increases occurred early in the season shortly after preplant application of P. It should be pointed out that there were some concentration increases even when no P applications were made.

In this study, 98 percent of the test fields had total seasonal P losses of less than 0.5 lb/A. Two percent had losses ranging from 0.5 to 1.5 lb/A. The 20 fields studied received 0 to 60 lb P/A, the range that might be expected for Texas rice production. Data indicated that P lost from rice fields presents no problem to the environment. ■

North Dakota

Tillering Patterns in Spring Wheat and the Need for Phosphorus

By R.J. Goos

North Dakota studies show that phosphorus (P) fertilizer, preferably banded with or near the seed, is usually needed by spring wheat for complete initiation of critical T1 and T2 tillers, even on high P testing soils.

WINTER WHEAT differs in many ways from spring wheat. In the Great Plains it usually emerges in late September or October when conditions are cooling, days are getting shorter, and there is a long time for tiller initiation to occur before head differentiation. Thus, winter wheat normally produces many productive heads per plant.

Spring wheat differs in almost all of these aspects. It is normally planted in April or May, when the soil is warming and the days are getting longer. There isn't much time between emergence, tillering, and head differentiation. Therefore, the number of productive tillers per plant is usually much lower than winter wheat. Spring wheat farmers compensate for this fact with heavier seeding rates.

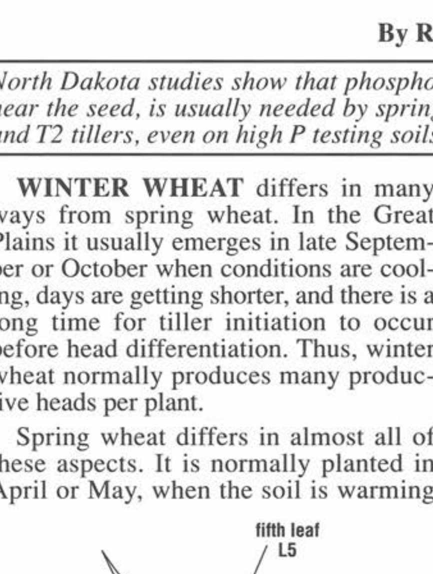

Figure 1. A young wheat plant, at the 4.4 leaf stage of the main stem.
Source: Klepper et al., *Agronomy Journal* 74:790.

Tillering in Spring Wheat

There are two types of stems (culms) in wheat. A wheat plant has a main stem and a variable number of tillers. Wheat tillers in an orderly way. At the seed piece there are three nodes. One node can form a tiller, termed the coleoptile or T0 tiller (**Figure 1**). The other two nodes can form adventitious roots. The plant decides whether or not to initiate this tiller when the main stem has about 2 to 2.5 leaves. Most varieties grown in North Dakota don't initiate a high percentage of T0 tillers.

At the base of the first leaf there are five nodes. One of these nodes can form a tiller, called the T1 tiller. The other four nodes can produce adventitious roots. This is a vigorous, productive, and important tiller. The plant decides whether or not to produce this tiller when the main stem has about 2.5 leaves.

There are also five nodes at the base of the second leaf. Again, one node can produce a tiller, the T2 tiller. The other four nodes can produce adventitious roots. The plant decides whether or not to initiate this tiller position at about the 3.5 leaf stage. This is the single most important tiller of spring wheat.

Dr. Goos is Associate Professor, Dept. of Soil Science, North Dakota State University, Fargo, ND 58105.

The initiation of important tiller positions like the T1 or T2 tillers is **not** automatic. If wheat is under stress between the 2 to 3.5 leaf stage of the main stem (only 2-3 weeks after emergence), these critical tillers and the adventitious roots associated with them may not be formed. There is no mechanism to initiate these tillers and roots later in the growing season. Stresses that reduce tiller initiation include seeding too deeply, inadequate fertility, soil compaction, heat or drought.

Many other tillers can be produced later in the growing season. Late appearing tillers include the T3 tiller, formed at the base of the third leaf, and the T10 tiller, formed at the base of the T1 tiller. However, these and other late-forming tillers are often too immature to form a head when the main stem gives the order to do so (about the late 4 or early 5 leaf stage). These late tillers either abort during hot weather in July or linger to form green, immature, nuisance heads at harvest. Late-forming tillers are no substitute for the critical T1 and T2 tillers in spring wheat.

Spring Wheat Tillering and Yield

The degree of tillering determines the number of heads per acre, an important yield component. An average spring wheat yield of 35 bu/A can be produced with about eight main stems per foot of row (assuming 6-inch row spacing) and the average of one vigorous tiller per plant.

However, for a high yield potential, a good stand of main stems and a high (>90 percent) initiation of the T1 and T2 tiller positions are needed. With a 6-inch row spacing, there should be about 12 plants per foot of row. A 90 percent initiation of T1 and T2 tillers is a practical goal.

The Role of Phosphorus in Spring Wheat Tillering

Phosphorus fertilization has long been known to "stimulate tillering" in spring wheat. Recently, though, we have learned more about the nature of this "stimulation."

Figures 2 and 3 show the effects of drill-applied P on T1 and T2 tiller initiation by two wheat varieties. "Marshall" is an old, late-maturing variety known for its relatively high production of tillers. "Butte 86" is typical of the early-maturing daylength-insensitive varieties popular today. **Figures 2 and 3** show the effects of P fertilization on T1 and T2 tiller production on low and high P testing soils, respectively. In both cases, drill-applied P promoted initiation of these two critical tillers. Both varieties responded to drill-applied P, but Marshall required less.

Figure 4 shows the relationship between soil test level (Olsen P) and T1 and T2 tiller initiation of wheat on six sites of differing soil test levels in North Dakota. The varieties were "Butte 86", "Grandin", or "Stoa". The P rate was 30 or 40 lb P_2O_5/A, drilled with the seed.

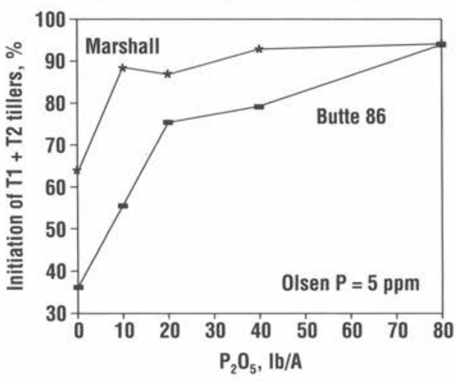

Figure 2. Effect of drill-applied P on T1 and T2 tiller initiation by spring wheat, low P soil. Dickinson, ND, 1992.

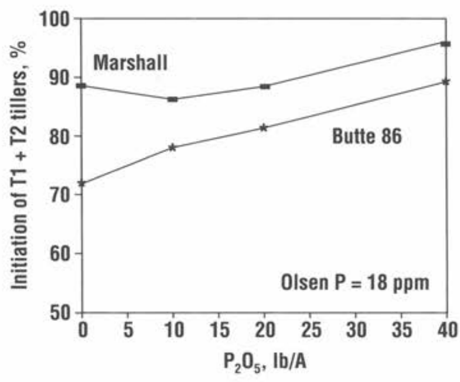

Figure 3. Effect of drill-applied P on T1 and T2 tiller initiation by spring wheat, high P soil. Dickinson, ND, 1991.

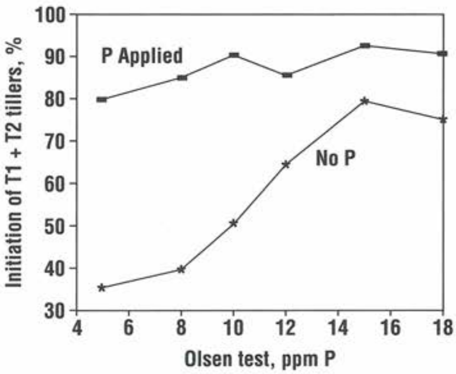

Figure 4. Effect of drill-applied P on T1 and T2 tiller initiation by spring wheat at six sites of differing soil test levels. North Dakota, 1990-1992.

The graph shows that at low soil test levels . . . less than 12 parts per million (ppm) . . . there was a great improvement in T1 and T2 initiation with drill-applied P. However, even at high soil test levels, there was still a 10 to 20 percent better initiation of T1 and T2 tillers with P fertilization.

The principle demonstrated in **Figure 4** agrees with the observation that there is a starter effect of P in spring wheat, even at high soil test levels. It was observed long ago that there can be early growth responses and modest yield increases to drill-applied P even with high soil test P levels. A modest improvement in T1 and T2 tillering with P fertilization at high soil test levels could account for much of this starter effect on grain yield.

Summary

Spring wheat grows for only a very short time between emergence and head differentiation. The main stem and only two tiller positions, the T1 and T2 tillers, account for virtually all of the grain yield of this crop. Phosphorus fertilizer, preferably banded with or near the seed, is usually needed for complete initiation of these critical tillers, even on high P testing soils. ■

Facts from Our Environment Revised Edition Available

THIS 60-PAGE BOOKLET presents a positive message on agriculture's concern for the environment. Emphasis in the publication is on understanding the roles of plant nutrition and fertilizer use. *Facts from Our Environment* was first published in the early 1970s, followed by an updated edition in 1991. The 1995 edition has added information on the role of fertilizers in improving the balance of greenhouse gases in the atmosphere.

The 6 x 9-inch booklet, printed on recycled paper with soy ink, features a question and answer format. Questions such as "Why are farmers using more fertilizer now than they were 25 years ago?" to "How have farmers been able to improve their fertilizer use efficiency?" provide the basis for explanations. (It does not contain all the answers, but simply identifies facts that are often ignored in the environmental rhetoric of the day – facts that seldom make the headlines.)

Order from Potash & Phosphate Institute, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2843. Phone (770) 447-0335 ext. 213 or 214; FAX (770) 448-0439. See page 31 for information on prices. ■

Arkansas

Phosphorus and Potassium Fertilization Improves Rice Growth and Yield

By C.E. Wilson, Jr., N.A. Slaton, R.J. Norman, B.R. Wells and P.A. Dickson

Arkansas research shows that frequency of phosphorus (P) and potassium (K) deficiencies in rice may be increasing and that P and K fertilization increase yields.

DEFICIENCIES OF P AND K in rice have been appearing more frequently across the rice-growing region of Arkansas. Symptoms commonly associated with K deficiency include brown leaf spot, reduced response to topdress nitrogen (N) application, and yellow older leaves.

Prior to 1992, the University of Arkansas did not recommend P fertilizer for rice except on recently leveled fields. Under flooded conditions, soil P availability increases and plants were believed to receive adequate P. Soil pH increases caused by lime deposition from irrigation water and neglected fertilizer application for soybeans in rotation have contributed to more frequent nutrition problems in rice.

The University of Arkansas currently recommends P and K for rice when soil test (Mehlich 3) values are below 25 and 175 lb/A, respectively. A 1993-94 summary of University of Arkansas soil test results indicated that 12 and 44 percent of the sampled rice acreage requires P and K based on these sufficiency levels. In addition, fields are not being sampled intensively enough to detect and manage soil fertility variability, with an average sample representing 44 acres.

Elevated soil salinity levels are also causing rice production difficulties. Many of the salt-affected soils are also low in P and K. Many growers are reluctant to apply potassium chloride (KCl), the most common K source, because of their concern that it may aggravate any existing soil salinity problem and result in partial or complete stand loss. Preliminary research in Arkansas has indicated that rice may suffer more from inadequate K than from a minor reduction in stand density following KCl application on soils with elevated salinity. Other work has indicated that the rice salinity damage may be eliminated or reduced if P has also been applied. Studies are underway to: 1) Evaluate current P and K recommendations, 2) evaluate the effects of KCl on soils low in K which also have a history of salinity problems, and 3) determine

Table 1. Soil test information for the 1994-95 P and K studies.

		0 to 6-inch Soil Test Levels (Mehlich 3), lb/A				
Location	pH	P	K	Ca	Mg	Cl[b]
Cross/1994	7.2	15	130	3540	555	–
Cross/1995	7.8	15	104	4057	494	16
Craighead/1995[a]	8.0	11	203	4458	455	116
Poinsett/1995	5.7	25	118	2052	316	14

[a] Soil sampled after application of 0-40-60-10 ($N-P_2O_5-K_2O-Zn$).
[b] Water-extractable.

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Table 2. Rice grain yields from a P and K study in Cross County, 1994.

$N-P_2O_5-K_2O$ lb/A	Grain yield, bu/A
0-0-0	172
0-0-60	182
0-0-80	192
0-0-120	181
0-40-60	198
0-40-80	192
0-40-120	197
Poultry litter, 1000 lb/A	182
Poultry litter, 2000 lb/A	179
$LSD_{.05}$	18

optimum nutrient concentrations in the plant tissue at various growth stages.

Field Studies

A preliminary test was conducted in 1994 in a producer's field that had soil test P and K levels below University of Arkansas sufficiency levels (**Table 1**), a history of rice seedling salinity damage, and a soil pH above 7.0

Treatments (**Table 2**) were broadcast on the soil surface after the field was planted. Salinity injury, maturity and grain yield were measured.

Experiments were initiated in 1995 at 15 locations on producer fields with various pH and soil fertility levels. Field information for three of the sites is reported in **Table 1** with treatments applied listed in **Table 3**. Plant samples were collected at each location by removing all the above-ground plant material in a portion of each plot at mid-tillering, mid-season (2-inch internode elongation), and three weeks after heading to measure dry matter production. Grain yields will be measured at all 15 locations.

Results

In 1994, elevated soil salinity caused stand reduction in the nonfertilized control (**Table 2**). Stand loss increased with increasing KCl rates, but no stand loss occurred when P was applied with KCl (data not shown). Stand density remained optimal in all treatments because a heavy seeding rate was used to counter stand reduction from salinity. The greatest yields were measured when both P and K were applied. Poultry litter was not an adequate substitute for inorganic P and K when applied to emerged rice since yields were only slightly higher than the nonfertilized control.

In 1995, only one of the 15 sites exhibited a significant stand reduction attributed to salinity. At that site in Craighead County, KCl alone caused moderate stand reductions where the grower had already

Table 3. Rice dry matter production at two growth stages with P and K fertilization (1995).

$N-P_2O_5-K_2O$ lb/A	Total dry matter production, lb/A					
	Mid-tillering			Mid-season (2-inch internode elongation)		
	Craighead[a]	Cross	Poinsett	Craighead[a]	Cross	Poinsett
0-0-0	527	1,875	982	6,295	5,741	6,607
0-40-0	589	2,500	1,152	8,357	5,571	7,036
0-80-0	768	3,125	1,214	8,500	7,134	6,250
0-0-60	—	2,116	1,250	—	6,241	6,946
0-0-90	420	2,071	982	6,196	6,170	6,946
0-0-120	—	2,571	1,339	—	6,411	7,250
0-40-60	—	2,839	1,496	—	6,804	7,714
0-40-90	679	3,384	1,643	8,741	7,304	7,661
0-40-120	—	3,241	1,438	—	7,884	6,536
0-80-90	973	3,170	1,223	8,482	8,000	6,464
Poultry litter, 2000 lb/A	607	—	—	7,250	—	—
Poultry litter +0-40-90	607	—	—	8,696	—	—
0-80-0 post flood	679	—	—	8,098	—	—
$LSD_{.05}$	232	1,125	438	2,723	1,911	1,607

[a] Treatments at this site were in addition to 0-40-60 preplant applied by cooperating grower.

preplant-applied 40 lb/A P_2O_5 and 60 lb/A K_2O plus 10 lb/A zinc (Zn). Bronzed lower leaves with yellow midribs were observed within 72 hours after flooding/ flushing. Treatments which included P continued to grow and tiller, while KCl alone treatments (and the control) had more bronzed leaves, remained erect, and produced few tillers. The photos illustrate the increased vegetative growth with P fertilization in 1995 in Cross County.

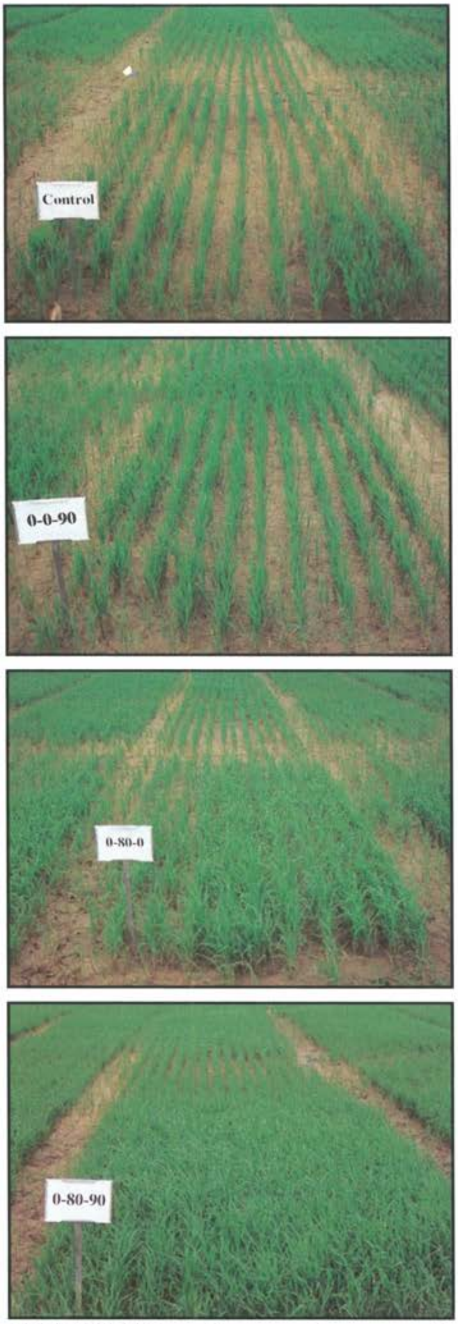
In 1995, treatments which included both P and K produced the greatest dry matter production at mid-tillering, which supports the visual observations. At mid-season, the P plus K treatments at Craighead and Cross counties produced the greatest dry matter, followed by the high P alone treatments. When KCl was applied without P, dry matter production increased at Cross and Poinsett counties, but tended to decrease in Craighead County.

The Poinsett County site had a lower pH and a higher soil P level than the other sites (**Table 1**). At mid-tillering, all treatments had dry matter production greater than or equal to the nonfertilized control, but treatments which included both P and K tended to be greatest. In contrast to the other sites which had higher soil pH levels, the highest rate of P alone tended to reduce dry matter production at mid-season.

Summary

These preliminary results indicate that P may need to be applied with K to increase rice yields, especially on soils with a pH greater than 7.0. Reduced plant populations and dry matter production tend to indicate that KCl alone may be detrimental on high pH soils. However, grain yield increases with KCl application suggest that the need for K is greater than the potential aggravation of soil salinity from KCl applications.

Further work is being conducted to measure plant nutrient concentrations and uptake at various growth stages. Grain yields will also be measured. Evaluations of P sources and P and K application timing are also planned. ■



PHOSPHORUS enhances rice growth response to K on soils testing low in P and K in Arkansas. Shown from top are plots with these treatments: control (no fertilizer); K_2O only, 90 lb/A; P_2O_5 only, 80 lb/A; and at bottom 80 lb/A P_2O_5 plus 90 lb/A K_2O.

Starter Fertilizer/Hybrid Interactions in No-Till Corn and Grain Sorghum

By R.E. Lamond, W.B. Gordon and D.L. Fjell

Kansas studies show that no-till corn and grain sorghum hybrids differ in response to nitrogen (N) and phosphorus (P)-containing starter fertilizers. However, a majority of hybrids show increased yield even with high P soil tests.

CONSERVATION TILLAGE production systems are being used by an ever-increasing number of farmers across the United States. Conservation tillage is really a general phrase that includes any production system designed to leave a protective residue cover on the soil surface. Examples include no-till, ridge-till, reduced till, and others. The value of residue in protecting the topsoil from wind and water erosion has been well documented. Residue cover can impact nutrient management significantly. The efficiency of surface applied N, for example, can be affected by heavy residue cover. The potential for N immobilization in decomposing residue and N volatilization is increased.

Production systems that leave a heavy residue cover on the soil result in cooler and wetter soils, particularly early in the growing season. These conditions increase the importance of using P-containing starter fertilizers. Recent work in other states has suggested that hybrids may react differently with respect to nutrient uptake under certain conditions. This article summarizes recent research in Kansas that evaluated the use of starter fertilizers on corn and grain sorghum hybrids grown under no-till conditions.

Corn

A dryland corn production system that has gained considerable popularity in Kansas over the past several years

Table 1. Hybrid and starter fertilizer effects on dryland, no-till corn, North-Central Experiment Field, Republic County, KS.

Hybrid	Starter	Days to mid-silk 1993	Days to mid-silk 1994	Grain Yield, bu/A 1993	Grain Yield, bu/A 1994
ICI 8599	With	63	58	164	203
	Without	65	60	163	199
Pioneer 3563	With	63	57	192	217
	Without	67	62	190	212
Pioneer 3346	With	65	58	225	209
	Without	69	64	213	190
Dekalb 636	With	66	60	196	196
	Without	72	64	183	178
Dekalb 591	With	64	58	191	202
	Without	67	63	185	193
Pioneer 3394	With	–	58	–	222
	Without	–	63	–	207

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involves early planting, from mid-March in southern Kansas to early to mid-April in the north, of early maturing (85-105 days) corn hybrids. The concept is to get the corn crop through pollination before the extremely hot and dry part of the growing season. When this production scheme is employed in no-till systems, there is a high risk of cool, wet soils interfering with N and P uptake. Low soil temperatures limit plant growth due to slow root growth and reduced nutrient availability, even though the soil may have high residual fertility levels.

Table 1 summarizes results of two years of work evaluating the effects of starter fertilizer on six corn hybrids grown in an environment ranging from 2,530 to 2,850 growing degree units under dryland, no-till conditions. The soil was a Crete silt loam that had a Bray-1 P level of 85 lb/A (high range). The corn hybrids were grown without or with liquid starter fertilizer (30 lb N/A and 30 lb P_2O_5/A) as urea ammonium nitrate (UAN) solution and ammonium polyphosphate (10-34-0). The starter was applied 2 inches to the side and 2 inches below the seed at planting. Nitrogen was balanced at 180 lb/A on all treatments as knifed UAN just after planting. Corn was planted on April 26 in 1993 and April 19 in 1994.

Results show that the use of starter fertilizer reduced the number of days to midsilk for all hybrids both years. Grain yields of some hybrids were dramatically increased by starter fertilizer, while other hybrids showed little response to starter.

STARTER FERTILIZER is an important input in conservation tillage production systems. Corn on the left received N-P starter, resulting in faster plant development and increased grain yields.

Grain Sorghum

With the dramatic differences observed on some corn hybrids, we decided to examine effects on grain sorghum hybrids. The experiment was also conducted on a Crete silt loam soil with a high Bray P-1 soil test (62 lb/A). The grain sorghum hybrids Pioneer 8699 (medium-early maturity), Pioneer 8505 (medium maturity), Pioneer 8310 (late maturity), Dekalb 40Y (medium-early maturity), and Dekalb 48 (medium maturity) were grown in a no-tillage system with and without starter fertilizer. Starter fertilizer (30 lb N and 30 lb P_2O_5/A) was

(continued on page 20)

Table 2. Hybrid and starter fertilizer effects on dryland, no-till grain sorghum, North-Central Experiment Field, Republic County, KS.

Hybrid	Starter	Yield, bu/A	Days to Mid-Bloom	6-Leaf Dry matter	6-Leaf P_2O_5 Uptake	Total P_2O_5 Uptake
				----------lb/A----------		
Pioneer 8699	With	136	61	662	2.3	35
	Without	120	67	517	1.7	26
Pioneer 8505	With	152	63	655	2.5	38
	Without	142	68	513	1.9	31
Pioneer 8310	With	151	68	644	2.6	37
	Without	151	74	529	2.1	37
Dekalb 40Y	With	151	63	575	2.5	37
	Without	131	72	492	2	30
Dekalb 48	With	147	64	648	2.6	36
	Without	147	69	520	2.1	36

Total includes uptake in grain and stover at maturity.

Alberta

Wheat, Barley and Canola Response to Phosphate Fertilizer

By R.H. McKenzie, L. Kryzanowski, K. Cannon, E. Solberg, D. Penney, G. Coy, D. Heaney, J. Harapiak and N. Flore

Extensive phosphorus (P) fertilizer calibration trials with wheat, barley and canola suggest almost 75 percent of Alberta's soils are marginally to highly responsive to P fertilization.

CANADIAN PRAIRIE SOILS tend to be naturally low in plant available P. The benefits of seed-placing phosphate fertilizer with wheat grown on fallow soils were first observed in western Canada in the mid 1940s. However, use of phosphate fertilizer did not become common until the 1950s and dramatically increased from the 1960s to 1980s. Phosphate fertilizer purchases in the three prairie provinces now exceed 300 million dollars annually.

In the 1980s, agronomists began noting that crops did not always respond to added phosphate on soils that tested low in plant available P. Some agronomists felt that residual phosphate build-up over a period of years resulted in reduced crop response to phosphate fertilizer. This led to questioning of the accuracy of P soil tests used by laboratories as well as questioning the need for phosphate fertilizer.

A research project to assess crop responsiveness to P fertilizer on a wide range of soil types across Alberta was conducted from 1991 to 1993. Replicated field trials with spring wheat, barley and canola evaluated P response using four application rates (0, 13, 27, and 40 lb P_2O_5/A) in six major soil zones across the province. Banded and seed-placed P were compared at several locations. During the three-year study, 450 sites were established, of which 427 sites were taken to completion and harvested.

Table 1 shows the numbers of sites that statistically responded to applied P. In summary, 50 percent of wheat sites, 55 percent of barley sites and 34 percent of canola sites significantly responded to added phosphate fertilizer at the 427 research sites. However, statistical analysis likely underestimated the real response to phosphate fertilizer.

Table 1. Sites showing a statistically significant response to P fertilization (1991-1993).

		Soil Zones						
Crop	Response	Brown	Dark Brown	Thin Black	Black	Gray Wooded (Central)	Gray Wooded (Peace R.)	Total Sites
Wheat	Response	9	14	12	22	9	8	72
	No Response	7	14	14	13	10	13	73
Barley	Response	8	14	19	27	10	10	88
	No response	8	12	18	12	9	12	71
Canola	Response	6	5	5	12	5	9	42
	No response	10	20	13	17	10	11	81

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Table 2. Sites showing at least a two bushel yield response to P fertilization (1991-1993).

		Soil Zones						
Crop	Response, bu/A	Brown	Dark Brown	Thin Black	Black	Gray Wooded (Central)	Gray Wooded (Peace R.)	Total Sites
Wheat	>5	9	10	14	21	10	10	74
	2-5	1	10	9	8	6	9	43
	<2	6	8	3	6	3	2	28
Barley	>5	9	14	19	32	14	13	101
	2-5	5	12	14	3	2	6	42
	<2	2	0	4	4	3	3	16
Canola	>5	3	2	1	9	6	8	29
	2-5	8	14	11	12	8	7	60
	<2	5	9	6	8	1	5	34

Table 2 summarizes the numbers of responsive and unresponsive sites based on a yield increase of at least 2 bu/A. Yield increases of 2 to 5 bu/A occurred at 145 sites and increases greater than 5 bu/A occurred at 204 sites. This suggests about 82 percent of all sites responded to applied P. By crop, P fertilization increased yields in 81 percent of wheat trials, 90 percent of barley trials and 72 percent of canola trials.

Seed-placed P was compared to banded P at 55 sites in central and southern Alberta. Placing the phosphate in the seedrow produced a better yield than banding in 33 of the 55 responsive sites. Banding was superior to seed-placed P in only 8 trials. **Figure 1** shows a typical yield response for wheat and barley. Whether seed-placed or banded, P fertilization is essential to optimize crop production in prairie soils.

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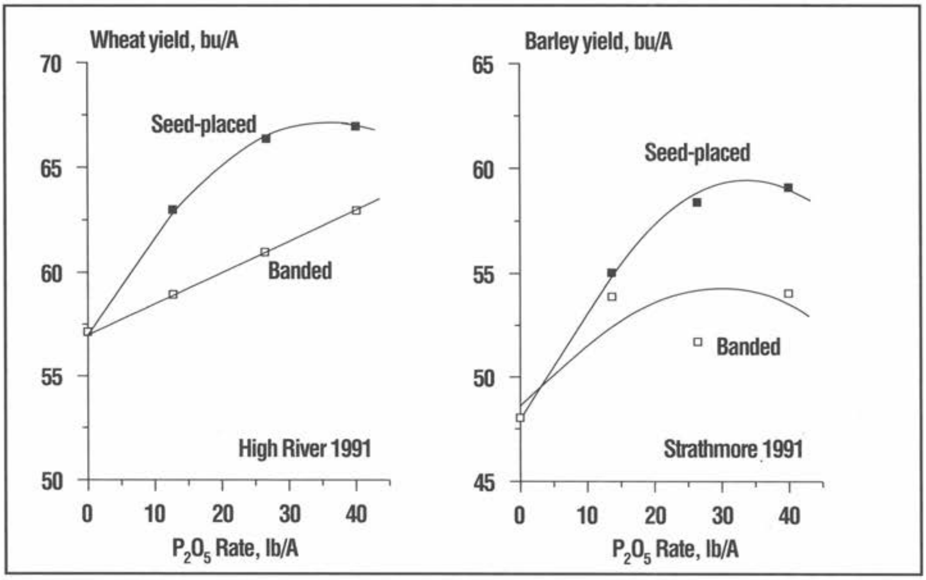


Figure 1. Response of wheat and barley to seed-placed and banded P in Alberta.

WHEAT GROWTH RESPONSE to P fertilization is demonstrated here. Plot at right received 40 lb/A P_2O_5, while plot at left received none (gray wooded soil near Grand Prairie, AB).

Summary

Alberta soils are deficient in available P and will respond to P fertilization. From 1991 to 1993, P fertilization of spring wheat, barley and canola was evaluated in 427 field trials scattered across six different soil zones in the province. Yield responses of at least 2 bu/A occurred in about 75 percent of the trials.

The crop response data generated in this study are currently being correlated with various P soil test methods in use in the prairies. This extensive data base will improve soil testing laboratory recommendations for prairie farmers and should increase farmer confidence in profitability of P fertilization. ■

Starter Fertilizer . . . from page 17

applied 2 inches to the side and 2 inches below the seed at planting. Liquid ammonium polyphosphate (10-34-0) and UAN were used as the starter fertilizer sources. Nitrogen was knife applied as UAN immediately after planting in order to supply a total of 160 lb N/A to all plots. Grain sorghum was planted no-till on May 18 at the rate of 50,000 seed/A into residue from a previous corn crop.

Results of this 1994 study are summarized in **Table 2**. Starter fertilizer improved dry matter production and P uptake at the 6-leaf stage in all hybrids. When averaged over hybrids, 6-leaf dry matter production was 20 percent greater with starter than without. Hybrids differed in the amounts of dry matter and P uptake at the 6-leaf stage. When averaged over all hybrids, starter fertilizer decreased the time from emergence to mid-bloom by 6 days. Starter fertilizer hastened maturity in Dekalb 40Y by 9 days and in Dekalb 48 and Pioneer 8505 by 5 days. Starter fertilizer improved total P uptake (grain plus stover) in three of the five hybrids. Grain yields also were improved by starter fertilizer in three of the five hybrids, one response being 20 bu/A. Yields of Dekalb 40Y were 20 bu/A greater with starter than without. However, yields of Pioneer 8310 and Dekalb 48 were not improved with starter fertilizer.

Summary

Results show that some corn and grain sorghum hybrids respond dramatically to N-P starter fertilizer while others do not. This work suggests that responses to starter fertilizer can be very economical even on high P soils—at least with some hybrids, particularly when corn or grain sorghum is planted early in high residue production system. Other aspects of this work emphasize the importance of high $N:P_2O_5$ ratios (1:1) in the starter fertilizer. The impact of starter fertilizer in conservation tillage systems for corn and grain sorghum suggests that starter use should be considered regardless of the soil test value for P. ■

Phosphorus Fertility and Placement Enhance Wheat Forage Yields

By Travis D. Miller and Brent Bean

Texas research has emphasized the importance of adequate phosphorus (P) and P management for wheat forage and grain yields. Greatest benefit from deep banding of P has been associated with surface moisture shortages.

MOST OF THE WHEAT CROP in west Texas is grazed by lightweight stocker cattle. The amount and intensity of the wheat crop utilized for forage vary with the price of wheat grain and that of feeder cattle, but estimates project that more than 70 percent of the Texas wheat crop is grazed in any given year. The duration of this grazing increases with increasing cattle prices and with decreasing value of the wheat grain crop. In most years, over 40 percent of the Texas wheat crop is grazed out, with no grain harvested. This extrapolates into about 4.5 million acres of wheat grazed in a given year, with at least 2.4 million acres utilized entirely as forage.

Grain yield response to P fertilization in low to medium P testing soils is widely documented, particularly in higher yield environments. In west Texas, P use has been poorly accepted by wheat farmers due to sporadic responses associated with prolonged periods of dry weather in the fall, which limits root development and activity in the surface soil zones where P is concentrated with conventional broadcast P applications. Several site years of P placement studies in west and west-central Texas have revealed that deep (approximately 8 inches) banding of P prior to seeding results in greatly superior forage yields in winter wheat when moisture limits root activity near the soil surface. Forage response to deep banded P has not necessarily equated to a greater grain yield response compared to broadcast P.

Texas Studies

Plots were established at several locations representing conditions typical for wheat planted as a dual purpose crop for forage and grain. Phosphorus placement comparisons in these studies used a fluid P source (10-34-0). Conventional surface-incorporated treatments were compared to deep banded treatments applied with a chisel. In most studies, the spacing between chisels was 10 inches, although in two studies with irrigated wheat at Etter, the spacing was 15 inches. Depth of

Table 1. Dryland wheat forage response to P fertilization.

	Total forage yield, lb dry matter/A					
Fertilizer placement	Runnels '87-88	Baylor '93-94	Baylor '94-95	Wichita '94-95	Abilene '94-95	Average 5 sites
P deep banded	2,583	2,552	4,295	2,357	3,898	3,137
P surface incorporated	1,595	1,248	3,757	1,238	4,770	2,521
0 P check	1,482	1,568	3,615	1,257	2,200	2,024
0 N & P check	–	–	3,607	1,199	–	–
Soil test range	Low	High	High	Med.	Med.	–

Texas

Dr. Miller is Professor and Extension Agronomist-Small Grains, and Dr. Bean is Associate Professor and Extension Agronomist, Texas A&M University, College Station and Amarillo, respectively.

LIGHTWEIGHT CALVES on wheat pasture in Wichita County, TX.

WHEAT FORAGE response to deep banded P and NH_3 is shown at right. Adjoining area at left received only NH_3 (Abilene, TX).

these bands was approximately 8 inches, although depth varied slightly with soil conditions. Forage was hand clipped, oven dried and reported on a dry weight basis. Grain yields were harvested by plot combine.

Forage Yields

Weather during the early growing season was of great importance relative to the response of wheat forage to P placement. In the dryland wheat study, 3 of 5 trials (Runnels, Baylor '94 and Wichita) were conducted with very dry fall weather (**Table 1**). In these three trials, deep banded P produced 84 percent more dry weight forage than wheat which received broadcast, surface incorporated P. Broadcast P produced the same yields as the no P check.

The Baylor '95 and Abilene plots received unusually high rainfall during the fall and early winter. Forage response to deep placed P was better than broadcast P, but the advantage was only about half of the response measured at the Baylor site in 1994. At the Abilene site, the surface broadcast P treatment was significantly better than deep banded P and both placement techniques caused very large forage responses compared to no P. The 5-site year average indicated forage grown with deep banded P was 24 percent greater than surface incorporated P and 55 percent greater than no P checks.

In the Northern High Plains, irrigated wheat forage response to P placement was much the same as in dryland

Table 2. Irrigated wheat forage response to P fertilization.

Fertilizer placement	Total forage yield, lb dry matter/A			
	1992	1993	1994	Average
P deep banded	4,137	5,475	5,502	5,038
P surface incorporated	4,957	3,759	4,590	4,435
0 P check	2,317	3,294	1,999	2,537

Soil test P: Medium — Etter, TX

Table 3. Early wheat forage responses to P fertilization.

Fertilizer placement	Early forage[1] yield, lb dry matter/A					
	Runnels '87-88	Wichita '94-95	Etter '91-92	Etter '92-93	Etter '93-94	Average
P deep banded	1,516	2,086	1,267	844	4,006	1,944
P surface incorporated	848	1,002	1,768	361	3,128	1,421
0 P check	967	999	531	500	1,272	854
0 N & P check	–	920	–	–	–	–
Soil test range	Low	Med.	Med.	Med.	Med.	–

[1] Early forage refers to clipping taken at or before normal livestock removal dates. — Texas

WHEAT MATURITY and grain yield response to deep banded P. Check strip in center of photo received no P.

wheat (**Table 2**). In the 1992-93 and 1993-94 crops, forage yield response to deep banded P was 46 and 20 percent, respectively, greater than surface incorporated P. In a high rainfall year (1991-92), forage yield on the deep banded P treatment was 17 percent less than surface incorporated P. Over the 3 year study, deep banded P averaged 15 percent greater forage yield than surface incorporated P treatments and 99 percent greater yield than no P check plots.

Total forage yield doesn't tell the entire story. Most wheat farmers use the crop for overwintering stocker cattle on high quality forage; removing livestock near growing point differentiation, and managing the crop for the remainder of the season as a grain crop. In this scenario, early forage yield is a more important number. Early season forage yield response summarized for five of these studies showed that deep banded P was more effective than surface broadcast P in four cases, averaging 37 percent greater forage yield than broadcast P and 128 percent more than the no P check (**Table 3**).

Grain Yields

Grain yield response to P application method was less consistent than effects on forage yields. Under unusually dry weather in Wichita County, grain yield was significantly improved (more than 11 bu/A) by deep P placement, while the reverse was true at Abilene where surface incorporated P yielded more (14.5 bu/A) than deep banded P (**Table 4**). Little difference was noted at three other sites. Either method of P application increased grain yields about 10 bu/A over the no P checks.

In the 3-year irrigated study at Etter, grain yield with deep banded P was superior (8 bu/A) to surface incorporated P in only one year with no difference between P placement methods in the other years. Either P application method increased grain yields an average 13 bu/A over the no P checks.

Summary

On low P soils in a dry climate typical of west Texas where forage production represents a significant part of the value of a crop, preplant deep banding of P fertilizer can give substantial yield advantages. In years with wet fall weather, the advantage of deep banding P is lost. Grain yield responses are not so closely associated with P placement overall. This research shows that P fertilization is a key in both dryland and irrigated wheat forage and grain production, and that placement technique should be adjusted to reflect available soil moisture. ■

Table 4. Wheat grain yield responses to P fertilization.

	Yield, bu/A					
Fertilizer placement	Runnels '87-88	Baylor '93-94	Baylor '94-95	Wichita '94-95	Abilene '94-95	Average
P deep banded	31	46	41	16	34	34
P surface incorporated	26	47	39	5	49	33
0 P check	21	35	39	5	20	24
0 N & P check	–	–	28	4	–	–
Soil test range	Low	High	High	Med.	Med.	–

Texas

Understanding Crop Response to Phosphorus

By Paul E. Fixen

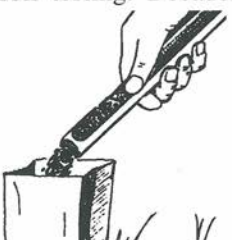
For profitable crop production, it is crucial to assure that phosphorus (P) nutrition is not limiting yield. In the U.S. and Canada, P is second only to nitrogen (N) as a nutrient limiting crop yield potential.

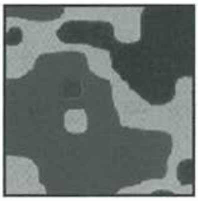
IN THE FALL of 1985, a 370 bu/A grain yield was harvested by a master corn grower, Herman Warsaw of Saybrook, IL. Field average corn yields frequently soared to over 250 bu/A in several regions of the U.S. in 1994. When yield limiting factors are removed by management, weather, or both, modern hybrids and varieties have remarkable yielding ability.

Predicting crop response to P is a critical step in designing a management plan to eliminate P as a limiting factor in crop production. Many interacting factors influence the crop response to fertilizer P, requiring an evaluation of the specific conditions of each site. Consider the following points.

Factors That Influence Phosphorus Responses

Predicting P response starts with soil testing. There is no substitute for accurate soil testing. Decades of soil test calibration research go to work for us once soil test levels are known. A very low soil test level means that an economical response will occur more than 80 percent of the time. A very high level means that no response will occur more than 80 percent of the time. Many other factors influence response between the extremes and help determine whether a specific field will go "against the odds" and regularly respond to fertilizer P at a very high soil test level . . . or not respond at a low soil test level.





Recognize potential within-field soil P variability. Don't assume that a single sample collected to represent the average level of a field tells the whole story. Recent summaries of data from detailed soil sampling have shown tremendous variability in P. Many fields that average high or very high have substantial areas within the field that test low or even very low.

Is soil drainage impaired? Crops on poorly drained soils, such as those in a Minnesota study summarized in **Figure 1**, often show P response even at high soil test levels. Low oxygen availability in poorly drained soils reduces root growth rates and the ability of roots to absorb and translocate P. The higher soil moisture content also tends to keep these soils cooler in the spring, further reducing P uptake. Combine yield monitors show that tiled (drained) fields often have significant areas where yields are reduced due to failing tile lines or laterals spaced too far apart.

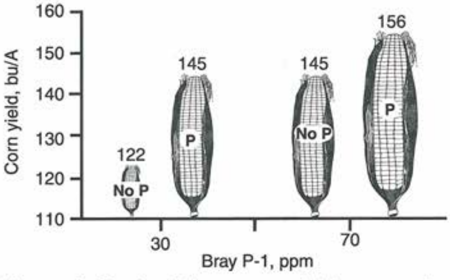
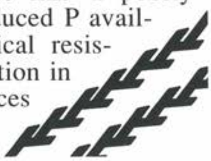


Figure 1. Starter P increases yields on poorly drained soils even at very high soil test levels. (Minnesota)

Dr. Fixen is Northcentral Director, Potash & Phosphate Institute, P.O. Box 682, Brookings, SD 57006.

Compaction can reduce P availability. Many fields were worked and planted wet last spring. That caused soil compaction which can make a normally well-drained soil act like a poorly drained soil with reduced P availability. Added physical resistance to root penetration in compacted soils reduces the crop's ability to obtain soil P.



Phosphorus placement can influence P response. Band placement will usually outperform broadcast P applications at modest rates and low soil test levels. As soil test level or rate increases, differences generally decrease and often disappear. However, response to starter P banded in or near the seed row can occur even at extremely high soil test P levels.

Areas of fields that were flooded the year before often have reduced P availability for the following crop. A combination of soil chemical changes and a reduction in beneficial mychorrizal (fungal) colonization of crop roots contribute to frequent P deficiency in these areas, even at very high soil test levels.

Varieties and hybrids often differ in P response. Many studies have shown that crop varieties or hybrids can differ substantially in P response, especially response to banded P. This means that specific crop varieties being grown may not respond the same as those used when P management guidelines were developed. General guidelines require local fine tuning because of potential varietal differences.

Tillage systems with large amounts of surface residue usually result in greater response to starter P. Cool, wet spring soil conditions are at least a part of the cause of the increased starter need. Root development is slowed and generation of energy necessary for nutrient uptake is diminished.

Salt-affected areas of fields typically show more P response than normal areas. Plant P uptake and concentrations are often reduced as soil salinity increases. Salts carried in water concentrate in field areas where water tends to flow or wick to the surface and evaporate. Greater P response and higher P needs can be expected in these parts of the field.

High aluminum (Al) levels in acid soils increase wheat response to P. Phosphorus banded with the seed lowers the toxicity of Al even when P tests are very high. Lime if you can . . . and be sure plant P needs are met.

Balanced nutrition is a must for full P response. Insufficient levels of other nutrients substantially reduce response to P. For example, in one Kansas study on irrigated corn, 10-year average response to annual P applications of 40 lb P_2O_5/A varied from 5 to over 50 bu/A depending on N rate applied.

Conserving the yield potential of the seeds that are planted is a season-long process. Phosphorus deficiency prior to the 5-leaf stage of corn reduces the potential number of kernels per ear. In high yielding environments, this translates into lower grain yields.

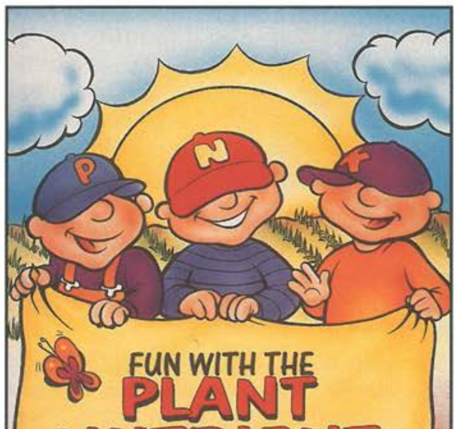
Summing Up

Understanding P response can help in the development of a site-specific P management plan that allows harvest of a higher percentage of the crop's genetic potential, leading to greater profitability. The plan should focus on soil testing, but consider the multitude of factors that influence P response. A P management plan should be dynamic, evolving each year as more is learned about the unique requirements of the specific soils, crops, and cultural practices employed. ■

AN EDUCATIONAL activity book for use in kindergarten through third grade is now available. The book, a project of PPI and FAR, encompasses information about the importance of plant nutrients and basic concepts of food and fiber production.

"Because so many children today don't grow up on farms, they may not realize how plants grow and where food and fiber products originate," said Dr. David W. Dibb, President of PPI. "Our challenge was to produce an activity book that will be entertaining but also educational for young children. We believe we have met the challenge with *Fun with the Plant Nutrient Team*."

The 24-page book features nitrogen (N), phosphorus (P) and potassium (K) as characters in a variety of activities such as dot-to-dot, word puzzles, coloring, mazes, matching pictures and experiments. Principles such as soil conservation and science as part of modern agriculture are included.



Fun with the Plant Nutrient Team can be purchased for $1.00 per copy, plus shipping/handling. A teacher's guide with additional information, experiments, facts and resources is also available on request.

See page 31 for more details on ordering. Contact: PPI, Circulation Manager, 655 Engineering Drive, Suite 110, Norcross, GA 30092-2843. Phone 770-447-0335. Fax 770-448-0439. ■

Conversion Factors for Metric and U.S. Units

To convert column 1 into column 2, multiply by	Column 1	Column 2	To convert column 2 into column 1, multiply by
		Length	
0.621	kilometer, km	mile, mi	1.609
1.094	meter, m	yard, yd	0.914
0.394	centimeter, cm	inch, in	2.54
		Area	
0.386	kilometer^2, km^2	mile^2, mi^2	2.590
247.1	kilometer^2, km^2	acre, acre	0.00405
2.471	hectare, ha	acre, acre	0.405
		Volume	
0.00973	cubic meter, m^3	acre-inch	102.8
3.532	hectoliter, hl	cubic foot, ft^3	0.2832
2.838	hectoliter, hl	bushel, bu	0.352
0.0284	liter, l	bushel, bu	35.24
1.057	liter, l	quart (liquid), qt.	0.946
		Mass	
1.102	tonne (metric)	ton (short)	0.9072
2.205	quintal, q	hundredweight, cwt (short)	0.454
2.205	kilogram, kg	pound, lb	0.454
0.035	gram, g	ounce (avdp), oz	28.35
		Yield or Rate	
0.446	tonne (metric)/hectare	ton (short)/acre	2.240
0.891	kg/ha	lb/acre	1.12
0.891	quintal/hectare	hundredweight/acre	1.12
1.15	hectoliter/hectare, hl/ha	bu/acre	0.87
		Temperature	
(1.8 x C) + 32	Celsius, C	Fahrenheit, F	0.56 x (F-32)
	-17.8°	0°F	
	0°C	32°F	
	20°C	68°F	
	100°C	212°F	

Metric Prefix Definitions

mega	1,000,000	deca	10	centi	0.01
kilo	1,000	basic metric unit	1	milli	0.001
hecto	100	deci	0.1	micro	0.000001

To convert U.S. crop yields from bushels per acre (bu/A) to metrics:

Corn — bu/A x 0.063 = tonnes/ha
Soybeans — bu/A x 0.067 = tonnes/ha
Wheat — bu/A x 0.067 = tonnes/ha
Grain Sorghum — bu/A x 0.056 = tonnes/ha

Nutrient Balance in a Long-Term Fertilizer Trial in a Red Soil of Yunnan

By Dai Rongshu and Hong Lifang

A 14-year (1978-91) experiment conducted on a low yielding, red, acid soil in Yunnan Province, China, clearly demonstrates the role of balanced fertilization in manure-based fertilizer systems. Nitrogen (N), phosphorus (P), potassium (K) and farm manure were applied in various treatments to compare response.

SPRING GROWN CORN rotated to fallow or a green manure crop was fertilized with either 1) 30 t/ha farm manure and 135 to 150 kg P_2O_5 (MP), 2) 135 kg P_2O_5 (P), 3) 30 t/ha farm manure (M), or 4) no nutrients, check (CK). The manure and P fertilizer (single superphosphate) were applied as basal dressings at the time when corn seedlings were planted. All plots received 200 kg N/ha. During years 7 through 14, each treatment was split with one-half receiving 150 to 210 kg K_2O/ha as K_2SO_4 and the other half receiving no potash.

Phosphorus data in **Table 1** show that a significant P deficiency existed in this red, acid soil. Statistical analysis of the data indicate that the order of P availability for the four treatments was P>MP>M>CK. The data also indicate that with continual use of P fertilizers soil-P levels were improved. When only manure or no fertilizer was applied, levels of soil-P remained low.

Table 1. Soil nutrient status after 14 years of treatment based on nutrient input/output studies.

Treatment	Soil nutrient status at year 14, kg/ha N	P_2O_5	K_2O
MP	-	surplus	-70
P	-	1,416	-279
M	surplus	-123	surplus
CK[1]	surplus	-22	surplus

[1]Few grain produced on the ears.

Potassium data in **Table 1** reveal the dynamic interaction of P fertilizers on the availability of soil K. The availability of soil K was found to be lowest in the MP and P treatment plots, less than half the soil K content in the CK treatment. However, soil-K levels were highest in the manure treatment. In general, the availability of soil-K among the treatments is ranked as M>CK>MP>P. The reasons relate to nutrient input and nutrient export from the field according to the yield achieved.

The important finding is that after eight successive years of applying P fertilizers, K became very limiting. Long-term, large (30 t/ha) applications of farm manure

Table 2. Average P and K content of corn plants during the final six-year period.

Nutrient	Plant part	Farm manure and P fertilizer	P fertilizer only	Farm manure only
P,%	Grain	0.216	0.235	0.187
	Stem	0.033	0.049	0.025
	Leaf	0.087	0.107	0.088
K,%	Grain	0.33	0.35	0.32
	Stem	1.01	0.42	1.43
	Leaf	1.09	0.48	1.65

Note: Growth in the CK treatment was poor, resulting in abnormal P and K contents. Thus this treatment was eliminated from the comparison.

Dai Rongshu is with the Soil & Fertilizer Station, Qujing Prefecture, Yunnan, People's Republic of China. Hong Lifang is with the Soil & Fertilizer Institute, Yunnan Academy of Agricultural Sciences, Yunnan, People's Republic of China

could only partially alleviate the K deficiency. Balanced fertilization practice through the application of both P and K fertilizers is essential for maintaining productive soils, even when farm manures are applied.

The P and K content of grain, stem and leaf tissue determinations during the final five-year period of the study are shown in **Table 2.**

The data indicate adequate P supply and availability to corn only when P fertilizers or P-enriched manures were applied. Data support the findings in **Table 1** and as indicated by the amount of growth the corn achieved under the various fertility treatments.

In the last year of the trial, leaf and stem tissue K contents of PK-fertilized corn were 1.11 percent and 0.59 percent, respectively. When P fertilizers were applied without K, the K content of leaves and stems declined dramatically to 0.19 percent and 0.21 percent, respectively.

Long-term effects of unbalanced fertilization practices on corn yields are depicted in **Figure 1** for the MP, P and M treatments. Corn receiving annual applications of 30 t/ha farm manure produced low but slightly increasing grain yields because both P and K supply were insufficient. The addition of P fertilizers initially increased yields between the years 1978-1985, but from 1986-1991 yield gradually decreased because of K deficiency resulting from the earlier high yields depleting soil K levels. The MP treatment produced significantly superior yields that became increasingly higher with time. To further explain the need for balanced fertilization, the CK plots which received only N

THE CHECK treatment (foreground) had poor growth of corn. While manure plus P plots were better, balanced fertilization including K produced the best results.

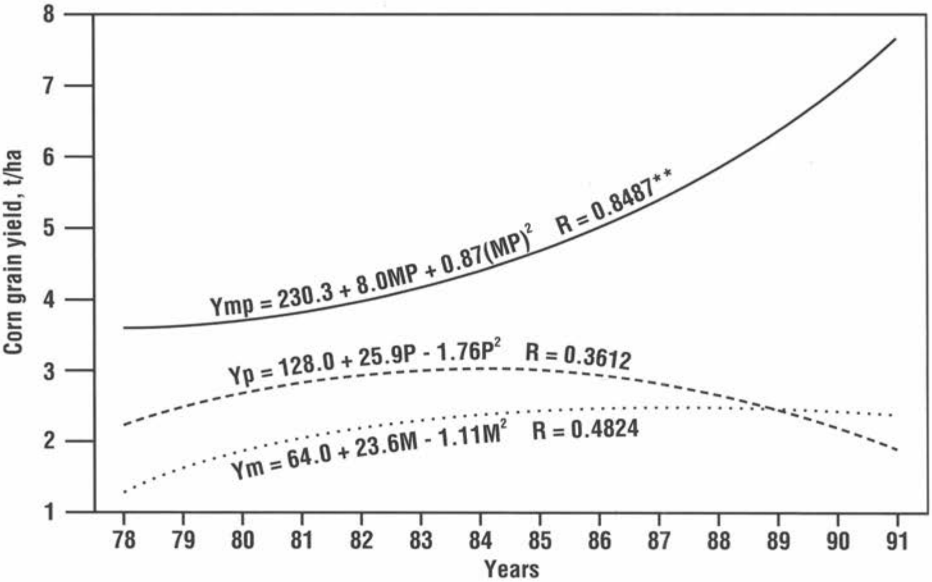


Figure 1. Dynamic curves of corn yield at a long-term location experiment in red soil.

fertilizer produced yields ranging from 60 to 435 kg/ha until 1984, with no yields in the subsequent years.

Potash additions to the long-term P treatments increased yields by an average of 189 kg/ha. Although yield response was not large, statistical analysis of the yield trend shows that with potash additions, the slope of the yield curve was positive (+31.4) compared to a negative slope (-19.4) when no potash was applied. The addition of potash resulted in progressively higher yields.

CORN in both plots shown here had P applied. The difference is that the plot at right received K while the one on the left received none.

Similarly, M only for corn did not supply sufficient P, resulting in low and declining yields. The addition of P to the manure increased yields by 2,505 kg/ha and approximately doubled the grain yield.

This long-term experiment has shown that soil fertility and the productive capacity of red, acid soils can be improved by a balanced fertilization program using P and K fertilizers with farm manures. ■

Central America

Regional Corn Grain Yield Response to Applied Phosphorus in Central America

YIELD RESPONSE to phosphorus (P) source, rate and method of application was measured at 33 Central America locations and on three soil orders (Andisols, Inceptisols and Ultisols). Phosphate rock (PR) was applied broadcast preplant without incorporation at rates of 13 and 26 kg/ha. Triple superphosphate (TSP) was band-applied at planting at rates of 13 and 26 kg/ha and broadcast preplant at 26 kg/ha. The previous three treatments were compared to plots where no P was applied.

Averaged over locations, corn grain yield responses to TSP were 380 and 740 kg/ha at application rates of 13 and 26 kg P/ha, respectively. Responses to broadcast PR were 210 and 160 kg/ha at the same rates.

Researchers concluded that the consistent response to P shows that soil P is a yield-limiting factor across a wide range of environments in Central America. The probability of an economic response to applied P is high. ■

Source: William R. Raun and Hector J. Barreto. 1995. Agronomy Journal 87:208-213.

Dr. W.K. Griffith Receives MGPA "Man of the Year" Award


Dr. W.K. Griffith

THE Maryland Grain Producers Association (MGPA) recently presented Dr. William (Bill) K. Griffith their prestigious "Man of the Year" award for 1995. The recognition was given during the 18th annual meeting of the Association on July 27, 1995. Dr. Griffith was cited for his contributions to the development of intensive small grain production systems and their increasing use on farms.

Dr. Griffith recently retired after 34 years as the Eastern U.S. Director for the Potash & Phosphate Institute (PPI). As Eastern Director, Dr. Griffith coordinated research and education programs for PPI.■

Information Materials from PPI

Listed here are several recent releases from the Potash & Phosphate Institute (PPI).

	Quantity	Cost
Preparing for the 1996 National CCA Exam This manual provides information on each performance objective of the CCA exam. Item #50-1000 Cost $25.00 each	______	$______
Facts from Our Environment Revised Edition Emphasis in this publication is on understanding the roles of plant nutrition and fertilizer use. Item #04-1460 Cost $3.00 (MC*50¢)	______	$______
Fun with the Plant Nutrient Team This 24-page activity book features nitrogen, phosphorus and potassium. Recommended for kindergarten through third grade. Item #30-3080 Cost $1.00	______	$______

*The MC symbol indicates Member Cost: For members of PPI and contributors to FAR and for educational institutions.

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Notice: Effective August 1, 1995, our area code has been changed by the telephone company–now 770 instead of 404.

Phos-For Us

Phosphorus is present in every living cell. Without it there would be no life—human, animal or plant.

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Most of the Earth's soils cannot naturally supply enough phosphorus to produce our food needs. Even with the best conserving practices, crops remove more phosphorus than we add back.

For centuries, farmers have added phosphorus to the land through manures and organic residues. Even so, it is impossible to feed the world's burgeoning population without the phosphorus fertilizer industry.

The industry mines phosphate rock in areas where deposits occur and converts it into forms usable by plants.

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