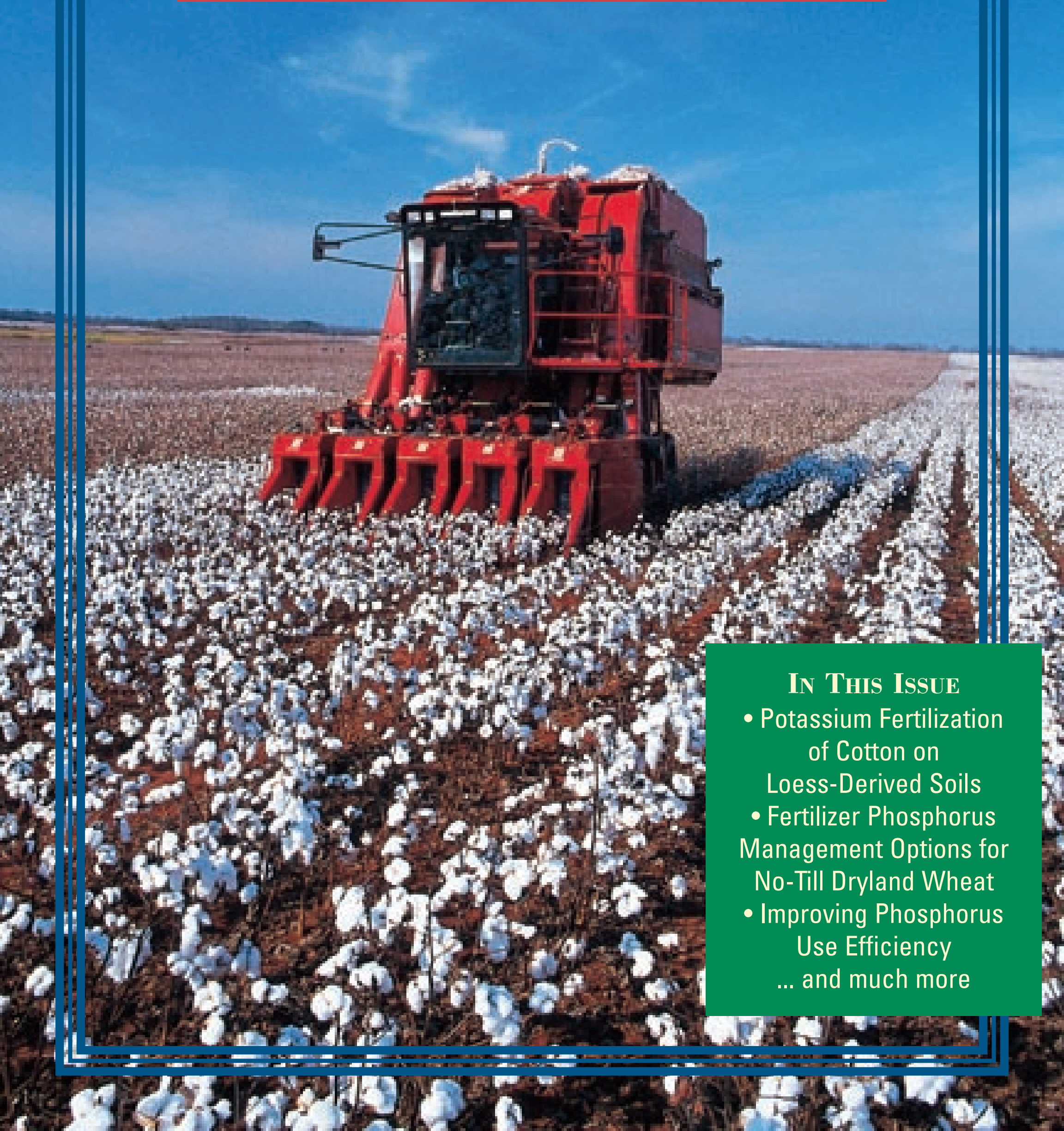
BETTER CROPS

WITH PLANT FOOD

2002 Number 4



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- Potassium Fertilization of Cotton on Loess-Derived Soils
- Fertilizer Phosphorus Management Options for No-Till Dryland Wheat
- Improving Phosphorus Use Efficiency

... and much more

BETTER CROPS
WITH PLANT FOOD

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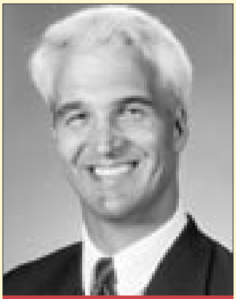
Dr. R.L. Mikkelsen Joins PPI Staff as Western Region Director

Dr. Robert L. Mikkelsen has joined the staff of the Potash & Phosphate Institute (PPI) as Western Region Director. He is based in Davis, California, with responsibility for PPI agronomic research and education programs in the states of Arizona, California, Idaho, Montana, Nevada, Oregon, Utah, Washington, and Wyoming.


Dr. R.L. Mikkelsen

"We are understandably very happy to have Rob as part of the organization. He is a highly respected scientist and educator who also has tremendous knowledge of agriculture in California and the western region," said Dr. David W. Dibb, PPI President. Dr. Mikkelsen assumes responsibility for the region following the recent retirement of Dr. Al Ludwick, who had served as Western Director since 1980.

Dr. Mikkelsen was previously Associate Professor of Soil Science at North Carolina State University (NCSU) in Raleigh. A native of California, Dr. Mikkelsen earned his B.S. degree in Agronomy/Soils at Brigham Young University in 1981, then received his Ph.D. in Soil Science at University of California, Riverside, in 1985. He was a postdoctoral research scientist and assistant research soil scientist there before joining the National Fertilizer Development Center at Muscle Shoals, Alabama, in 1987 as Soil Chemist/ Project Leader. In 1991, Dr. Mikkelsen became Assistant Professor of Soil Science at NCSU and was promoted to Associate Professor in 1997.

At NCSU, Dr. Mikkelsen was honored as Outstanding Graduate Instructor of the Year in the College of Agriculture and Life Sciences. He has served as chairman of Soil Science Society of America (SSSA) Division S-4 (Soil Fertility and Plant Nutrition) and on the editorial boards of *Soil Science Society of America Journal*, *Fertilizer Research*, *Nutrient Cycling in Agroecosystems*, *Agronomy Journal*, and *Journal of Environmental Quality*.

Widely known for his research and expertise in nutrient management, Dr. Mikkelsen has authored or co-authored numerous research publications and book chapters in recent years. In addition to basic agronomic and fertilizer technology, his research has included nutrient interactions with the environment, animal waste management, and nutrient budgets. He is a Licensed Soil Scientist and is listed in the North Carolina Registry of Certified Professionals in Soils.

Dr. Mikkelsen is involved in several professional societies, including the American Society of Agronomy. BC

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COLORADO

Fertilizer Phosphorus Management Options for No-Till Dryland Winter Wheat

By Ardell D. Halvorson, John L. Havlin, and Curtis A. Reule

The effects of four phosphorus (P) fertilizer placement methods and five P rates on winter wheat yields were evaluated in a no-till wheat-fallow system in eastern Colorado. Winter wheat grain yields, averaged over four crops, were increased significantly with P fertilization. Additionally, differences in total wheat yields after four crops were observed among P placement methods. The results of this study have demonstrated the need for relatively high rates of fertilizer P to optimize winter wheat yields in the Central Great Plains.

Adoption of no-till (NT) wheat-fallow farming systems in the Central Great Plains raised the question of how to best manage fertilizer P to optimize yields when tillage would not be an option to incorporate added P. Research in the Northern Great Plains had shown that a one-time, high rate application of P would satisfy the P needs of dryland crops for several years under conventional tillage practices. Would a high rate of fertilizer P be effective in a NT wheat-fallow system in the Central Great Plains? This research was undertaken to determine effects of fertilizer P placement method and P rate on winter wheat yields in a wheat-fallow cropping system under NT management.

Four placement methods [broadcast incorporated (BCI), broadcast without incorporation (BC), deep band (DB), and seed placed (SP)] were initiated in part of a conventional-tilled wheat field that was converted to NT. Five fertilizer P rates (0, 69, 137, 206, and 275 lb P_2O_5/A) were applied as a one-time application in each of the BCI, BC, and DB placement treatments. The DB fertilizer P was placed about 3 in. below the soil surface in bands spaced 12 in. apart. Fertilizer P rates were reduced 75% for the SP treatment for rates of 0, 17, 34, 52, and 69 lb P_2O_5/A placed directly with the seed at planting for each of four crop years. After four wheat crops, the SP had received the same amount of fertilizer P as the one time BCI, BC, and DB treatments. Each P treatment was further split into two nitrogen (N) treatments (with and without fertilizer N applied; see **Table 1** for N rate). The study was located about 10 miles west of Peetz, Colorado, on a Rosebud-Escabosa loam soil with a medium sodium bicarbonate extractable soil test P level [10 parts per million (ppm)], soil pH of 7.8, and 2.4% soil organic matter. Duplicate sets of plots were established to have all phases of the crop rotation present each year. Data were averaged over the duplicate sets of plots so that treatment yields for each crop represents data collected for two crop years. A NT winter wheat-fallow cropping sequence was followed for eight years and four replications of each treatment were used.

Grain yields did not vary significantly ($p = 0.05$) among P placement methods when averaged over N and P rates (**Figure 1**) for any of the crops and when averaged over crops. When averaged across all four crops, P placement made no significant difference in winter wheat yields. This would indicate that the fertilizer P applied directly with the seed each year at 25% of the rate of

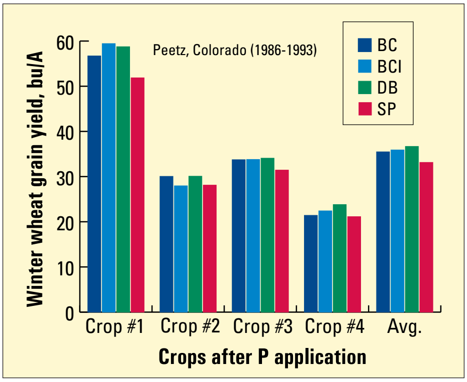


Figure 1. Winter wheat grain yields as a function of P placement method for each crop after initial fertilizer P application, averaged over N and P rates.

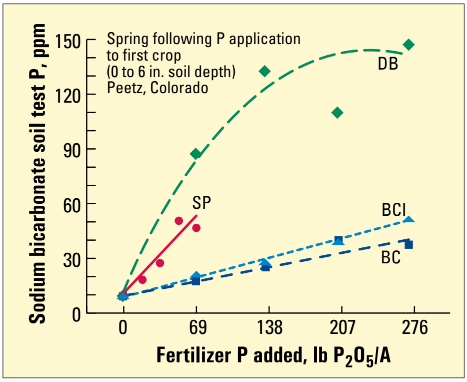


Figure 2. Spring sodium bicarbonate soil test P levels following the fall application of P to the first crop.

the one-time P applications was just as effective as the one-time high rate applications. Soil samples (0 to 6 in. depth) collected in the spring following the fall P fertilizer application to the first crop and analyzed for sodium bicarbonate extractable P may offer an explanation to the observed response. For the DB and SP treatments, soil cores were taken directly through the fertilizer P bands. For the BCI and BC treatments, soil cores were taken at random in the plot area. Levels in the 0 to 6 in. soil depth were extremely high in the DB treatments (**Figure 2**), increasing curvilinearly with increasing fertilizer P rate. Soil test P levels in the SP bands were as high or higher than in the BCI and BC treatments at the higher P rates, increasing linearly with increasing rate of fertilizer P application. Levels increased linearly with increasing P rate for the BCI and BC treatments. Thus, estimates of available P to the crop were similar for the BC, BCI, and SP treatments.

Winter wheat grain yields, averaged

TABLE 1. Years averaged for each crop, fertilizer N rate applied to N treatment, available soil N at planting (0 to 6 in. soil depth), growing season precipitation, soil water used by corn, estimated total crop water use, and environmental factors affecting grain yield each year.

Crop	Year	Fertilizer N rate, lb/A	Planting soil N, lb/A	Growing season precip., in.	Soil water used, in.	Crop water used, in.	Environmental factors
Crop 1	1986	50	148	9.6	0.6	10.2	No major limiting factors
	1987	50	97	11.7	3.2	14.9	Russian wheat aphid
Crop 2	1988	80	88	10.7	6.2	16.9	6.5 in. precipitation in May Drought in June
	1989	75	88	5.7	4.9	10.6	Hail, drought
Crop 3	1990	50	195	1.1	7.9	9.0	Severe drought
	1991	50	195	6.7	5.4	12.1	Hail damage
Crop 4	1992	50	279	10.2	2.7	13.5	Dry April-May, frost, hail damage
	1993	50	197	5.5	5.2	10.8	Dry planting to late May, hail after heading

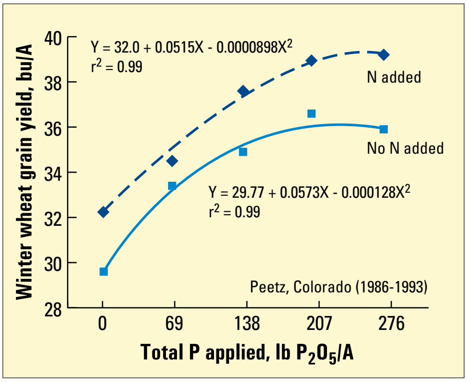


Figure 3. Winter wheat grain yields, averaged over four crops, as a function of total fertilizer P applied.

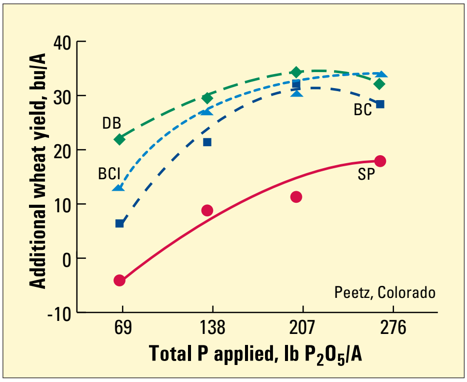


Figure 4. Total grain yield response of winter wheat to P fertilization after four crops for each P placement method.

over four crops, increased significantly with increasing rates of fertilizer P, with and without N (**Figure 3**). Average grain yields appeared to possibly start leveling out with the application of 275 lb P_2O_5/A. This indicates that a significant amount of fertilizer P is needed to optimize grain yields and eliminate P deficiency in dryland winter wheat in the Central Great Plains. Winter wheat responded to fertilizer P application rate similarly for each N rate and P placement treatment. Because of several dry years and hail damage, yield potential for crops 2, 3, and 4 were limited (**Table 1**). This may explain the reduced response to N fertilization.

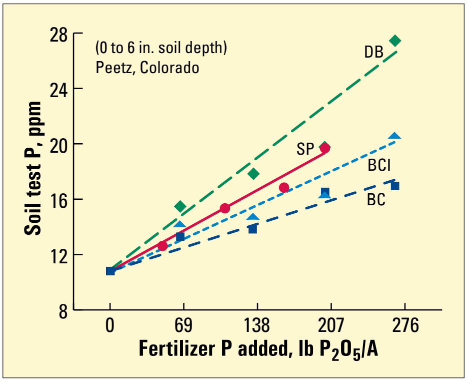


Figure 5. Sodium bicarbonate soil test P level seven years after initial fertilizer P application and before planting of the fourth wheat crop as a function of fertilizer P rate and P placement method.

Although the P placement by P rate interaction was not significant, a single degree of freedom F test contrasting SP total grain yield of four crops with N fertilization to the grain yields of the other placement methods indicated a significant ($p = 0.10$) difference between SP and the other P placement methods. The cumulative additional wheat yield due to P fertilization after four crops with N fertilization is shown in **Figure 4**. As P rate increased, cumulative wheat yields were slightly higher for the DB, BCI, and BC treatments than for the SP treatment. At the highest P rate (275 lb P_2O_5/A) and a cost of \$0.30/lb P_2O_5, about 24 bu of additional wheat per acre would be needed to pay for the fertilizer P at a wheat price of \$3.50/bu. The cumulative additional wheat yield above that without fertilizer P applied exceeded 24 bu/A in four crops at the highest P rate for the DB, BC, and BCI treatments, thus generating profit. Additionally, the residual fertilizer P remaining after four crops will impact wheat yields for many more years, based on long-term P studies in the Northern Great Plains. Soil test P levels measured seven years after P application, but before the fourth crop was produced (**Figure 5**), show that soil test levels for the BCI and BC had declined for all fertilizer P rates. However, the soil

These photos compare various treatments for wheat plots at Peetz, Colorado, in 1986. Shown from left to right are: no P added, 68 lb P_2O_5/A as SP, 68 lb P_2O_5 as BCI, and 278 lb P_2O_5/A as BCI.

test level with no fertilizer P applied remained fairly constant over the seven-year period at about 10 ppm. These results support the concept put forward by Kastens et al. (*Better Crops with Plant Food*, 2000, Vol. 84, 2:8-10) that higher soil test P levels are needed to optimize economic yields in the Central Great Plains. The soil test P levels for the DB and SP treatments in **Figure 5** were determined by taking 10 soil cores across the space within and between fertilizer bands, analyzing each core separately, then averaging across the cores. The results show that soil test levels after seven years increased linearly with the DB placement as P rate increased, and the soil test P levels were greater than those observed for the other placement treatments (SP had received 75% of the total DB rate at this sampling). Soil test P levels for the SP treatment were slightly greater than for the BCI and BC treatment after three crops and nearly seven years after application. These soil test P levels show that yield potential was increased for several future crops.

The results from this study show the need for higher rates of fertilizer P application to optimize winter wheat yields in the Central Great Plains. If soil P is deficient in a NT production system, applying fertilizer P on the soil surface will help alleviate P deficiency even without incorporation. Applying fertilizer P on the soil surface without incorporation will, however, increase the risk of P loss in surface runoff water.

Annual applications of SP fertilizer P at 25% of the one-time BCI rate were effective in increasing wheat yields. However, the total cumulative yield after four crops tended to be less than that of the other placement methods. Wheat yields increased with increasing rates of SP fertilizer P, but high P rates were required to maximize grain yields. Total yield response to P application may have been even greater if environmental conditions for crops 2, 3, and 4 had been more favorable. The results in **Figure 4** show that a high level of available P is needed to optimize wheat yields in the Central Great Plains regardless of P application method.

Dr. Halvorson (e-mail: adhalvor@lamar.colostate.edu) and Mr. Reule are with USDA-ARS, 301 South Howes, Room 407, Fort Collins, CO 80522; phone 970-490-8230. Dr. Havlin is Head, Department of Soil Science, North Carolina State University, Raleigh.

Acknowledgments:

The authors wish to thank PPI/FAR and Farmland Industries (now Agriliance) for providing partial funding support for this project (CO-6F).

Improving Fertilizer Phosphorus Use Efficiency

By S.S. Malhi, L.K. Haderlein, D.G. Pauly, and A.M. Johnston

The efficiency of fertilizer P use by crops ranges from 10 to 30% in the year that it is applied. The remaining 70 to 90% becomes part of the soil P pool which is released to the crop over the following months and years. While this pool contributes to future crop production, increasing the efficiency of fertilizer by improving crop recovery in the year of application could potentially improve crop yields and economic returns.

> Polymer coating of monoammonium phosphate (MAP) improved plant recovery of fertilizer phosphorus (P) and provided a modest barley grain yield advantage relative to uncoated MAP.

Coating P fertilizer could limit the contact of applied P with soil, possibly reducing its precipitation and/or adsorption on soil colloids, and increase its availability to developing plant roots. One of the perceived advantages of matching fertilizer P release with crop demand is that it could increase yield and recovery of applied P. However, this may not be as easily achieved as it sounds, since different crops have varying patterns of P uptake. In fact, slow release of fertilizer P could result in early season deficiencies for crops like wheat, a symptom which has been observed to severely limit crop yield potential (see *Better Crops with Plant Food,* 2001, Vol. 85, 2:18-23).

The development of thin polymer coatings has improved the opportunity to coat fertilizer granules and increased the predictability of when nutrients become available from the controlled-release product.

Greenhouse experiments were conducted at the University of Alberta in Edmonton, Alberta. Barley was grown in a P-deficient soil medium that had been supplemented with nitrogen (N), potassium (K), and sulfur (S). Treatments included a no P control, uncoated MAP, thin and thick polymer coated MAP (Agrium Fertilizers, Redwater, Alberta), and a mixture that included 25% thin coated MAP, 50% thick coated MAP, and 25% uncoated MAP. The P rate evaluated was equivalent to 21 lb P_2O_5/A. Barley plants were harvested at 45 days after planting, and biomass and P concentration were determined.

Field studies were conducted at sites in Alberta and Saskatchewan with malting barley. The treatments involved a no P control, uncoated MAP, and MAP with a polymer coating similar to the thin coated MAP described in the greenhouse study. Rates of P evaluated were 0, 13, 26, and 39 lb P_2O_5/A; however, only the average response is reported here. The MAP was seed row applied in 1995 and side banded in 2000. The N, K, and S were preplant banded in 1995 and side banded at seeding in 2000. Plots were harvested and grain yield determined.

With the exception of the no P control, all greenhouse grown barley plants were headed when harvested at 45 days after seeding. While not significant, dry matter yield (DMY) tended to be higher with P addition (**Table 1**). Addition of MAP increased total P uptake (TPU) over the no P control. Use of the thin coated MAP, alone or in the mixture, improved plant P uptake relative to the uncoated P fertilizer. To estimate the contribution of fertilizer P to total P uptake, the net P uptake (NPU) was calculated as the portion of P uptake in excess of the no P control for each of the fertilizer treatments. Once again, the advantage in plant P recovery with the thin coat polymer and mixture treatment is shown by the increase in plant P recovery.

Did the polymer coating improve the recovery of fertilizer MAP? To determine this we calculated the estimated fertilizer P efficiency (EFPE), by dividing the NPU by the P rate applied and multiplying by 100. From the results in **Table 1**, it appears that the EFPE was increased substantially in the greenhouse by the coating, or use of a mixture of coated and uncoated fertilizer MAP.

Field trials comparing uncoated and thin coated MAP were set out at locations where pre-seeding soil analysis indicated that a response to P was likely. The increased crop response to uncoated MAP ranged from 3 to 121% over the no P control, with only one site showing a yield reduction (**Table 2**). Similarly, the controlled-release P (CRP) had one negative response, while the remaining sites had yield increases ranging from 6 to 192%. Relative to uncoated MAP, use of thin coat CRP improved the response of barley to P fertilizer addition in five of the seven trials. On average, the CRP increased barley yield by 3 bu/A, or 4%, over the uncoated MAP.

In order for a coated phosphate product to work, it must reduce short-term P fixation by the soil, yet provide adequate release for rapid P uptake in the critical early season period. This delicate balance appears to have been met by the thin coated P product in the greenhouse and some of the field trials. The proportion of P coming from the MAP was improved with coating, reducing the plant's dependence on soil P supply. However, there were a few occasions when the polymer coating did not release P quickly enough, usually when a thick coating was applied. Continued field research using a blend of uncoated and coated MAP may open doors to improving both short- and long-term fertilizer P efficiency.

Dr. Malhi (e-mail: mahlis@em.agr.ca) is a soil fertility researcher with the Agriculture and Agri-Food Canada Research Farm at Melfort, Saskatchewan, Canada. Mr. Haderlein is a research agronomist with Agrium Inc., Redwater, Alberta. Mr. Pauly is an extension agronomist with Alberta Agriculture, Food and Rural Development in Stettler, Alberta. Dr. Johnston is PPI/PPIC Western Canada Director, located at Saskatoon, Saskatchewan.

TABLE 1. Barley DMY, TPU, NPU, and EFPE from greenhouse-grown plants harvested 45 days after planting (average of two soils).

Treatment	DMY, g/pot	TPU,	NPU,	EFPE, %
		mg P/pot		
Control, no P	9.70	23.02	–	–
Uncoated MAP	11.70	25.61	2.59	16.5
Thin coated MAP	12.55	28.14	5.12	32.6
Thick coated MAP	11.68	26.99	3.97	25.3
MAP mixture	12.49	27.79	4.77	30.3
$LSD_{0.05}$	NS	1.74	1.69	–

TABLE 2. Response of barley to added MAP and CRP.

Year	Site	No P control	MAP	CRP	Response over no P control, % MAP	Response over no P control, % CRP
			bu/A			
1995	Humbolt	74.1	79.9	85.0	8	15
	Asquith	84.4	89.8	88.4	6	5
	Neerlandia	103.9	107.4	112.6	3	8
	Calmar	70.1	68.9	74.1	-2	6
2000	Bruderheim	13.6	30.0	39.7	121	192
	Birch Hills	49.0	52.6	56.4	7	15
	Lamont	77.1	81.0	74.7	5	-3
	Mean	67.5	72.8	75.8	8	12

PRINCE EDWARD ISLAND

Phosphorus Sources for Potato Production

By J.B. Sanderson, T.W. Bruulsema, R. Coffin, B. Douglas, and J.A. MacLeod

Potato growers feel increasing pressure about the impact of their cropping practices on the environment. A Prince Edward Island (PEI) Roundtable in 1997, and the Canadian government's 2001 report entitled *Nutrients and Their Impact on the Canadian Environment*, raise questions regarding nutrient losses from potato fields and the sustainability of applying P at rates in excess of crop removal. Currently, 63% of PEI soils test high or above in P. We initiated a project in 1998 to examine the validity of currently used rates of P fertilization and to explore methods to improve P uptake.

Potatoes grown in high phosphorus (P) soil often still need P fertilizer. A three-year study found that liming and P source had little impact on P uptake, yield, and quality, but that cultivars differed in their ability to use soil P.

Field experiments compared monoammonium (MAP) and diammonium (DAP) phosphate applied with and without lime. Growers have traditionally used DAP, but liming in the spring prior to planting is not common. The latter is practiced by some growers trying to increase the calcium (Ca) levels in the tubers.

Placed in a band, DAP initially increases pH, in contrast to MAP which lowers it. These pH changes are temporary and localized to the band. The duration of this initial pH change depends on temperature, however, and within a few weeks soil pH is lower with DAP than MAP. The pH dynamics may impact the mineral nutrition of the young plant. Our aim was to determine if a specific combination of lime, P source and rate would aid P utilization in potato.

Two potato cultivars were planted with typical management practices. Soils in each of the three years had a pH of 5.7 to 5.8 and tested high to very high in P. Rates of applied P were zero, intermediate and typical for each of the two cultivars. Ammonium nitrate provided the nitrogen (N) source to augment the N in the P fertilizer, for a total of 160 lb N/A for Russet Burbank and 135 lb N/A for Shepody. Potassium (K) fertilizer was applied at rates of 145 to 215 lb K_2O/A. Fertilizers were applied according to the typical method of double-banding beside and below the seed piece. Where lime was applied, it was

TABLE 1. Processing pay weight potato yield in response to MAP or DAP applied with and without lime (mean of three years, 1998-2000). Soil test P (Mehlich 3) was over 200 parts per million (ppm.)

P_2O_5 applied, lb/A	Processing pay weight, cwt/A			
	Lime		No lime	
	DAP	MAP	DAP	MAP
Russet Burbank				
0	141	141	152	152
135	146	174	181	171
215	164	165	188	157
Shepody				
0	244	244	252	252
67	248	265	256	260
179	233	244	281	253

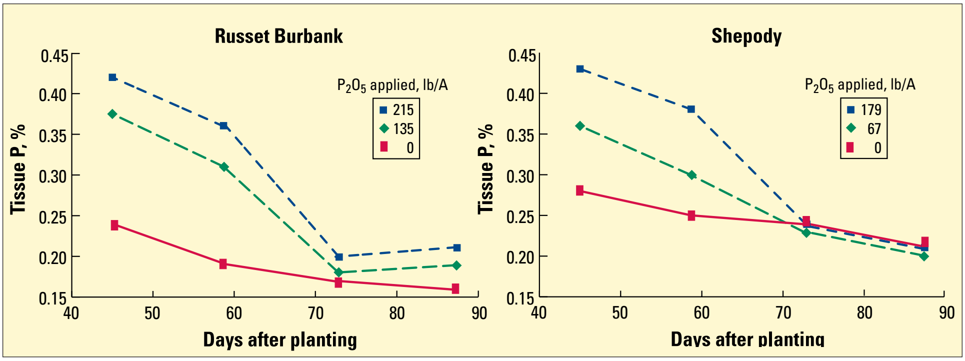


Figure 1. The Russet Burbank cultivar required higher rates of applied P than Shepody to maintain petiole tissue P levels above 0.2% .

calcitic and the rate was 900 lb/A, broadcast and incorporated in the spring.

The percentage of tubers with internal and external defects, and the percentage of tubers < 2 in., according to current French fry processing contracts, were deducted from total yield to calculate processing pay weight.

Previous work showed that Shepody responds less to applied P than Russet Burbank, and the current work supports that observation. The yield of Russet Burbank increased substantially with applied P regardless of source, but Shepody responded less (**Table 1**).

For both cultivars, increased yield was more than sufficient to pay for the intermediate rate of P fertilizer. Returns were calculated as pay weight value (at $7/cwt) less the cost of the fertilizer ($0.30/lb for P_2O_5), compared to a control with no fertilizer. When averaged across sources and lime treatments and relative to the control, the intermediate rate of P applied to Russet Burbank returned $110 per acre. With Shepody, the intermediate rate returned $43 per acre. While the full rates produced slightly higher pay weight yields, they were not economically justified on these high P soils.

Russet Burbank potatoes grown without (foreground) and with (background) applied P on the iron-rich soils of Prince Edward Island in 1999.

Lime did not increase yields. Neither did it affect the overall response to P. However, there was a tendency for yields to be higher with MAP when lime was applied, and with DAP when it was not (**Table 1**). It is possible that when lime is applied, the pH rise in the fertilizer band induces levels of ammonia that harm the young seedling. For this reason, MAP may be a preferred source of P for banding in recently limed fields.

Lime increased tuber Ca from 280 to 360 ppm in Russet Burbank, and from 160 to 210 ppm in Shepody. Higher Ca in tubers may improve storability.

Lime did not affect the P content of tubers or petioles. It increased specific gravity slightly, by about 0.001. In comparison, specific gravity varied by 0.007 among the three years.

Shepody maintained higher P levels

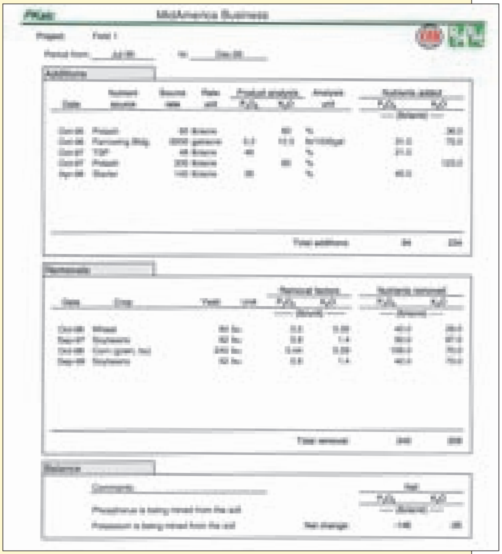
TOOLBOX

PKalc Software Checks Nutrient Balance

"Toolbox" is a new feature on the PPI/PPIC website which holds downloadable software tools for improved nutrient management.

The newest tool is called PKalc (v.1.12), a simple nutrient balance calculator which helps users determine if phosphorus (P) and potassium (K) nutrient additions are keeping up with removal by crops. It is an Excel spreadsheet which enables development of a multi-year, multi-crop nutrient budget. PKalc was originated as part of a project supported by a grant from USDA-Cooperative State Research, Education, and Extension Service (CSREES), through the Initiative for Future Agriculture and Food Systems (IFAFS).

Users of PKalc input crops grown and yields, plus a list of nutrients added (fertilizer and manure). The program then estimates total crop nutrient removal and calculates total nutrient additions and the resulting net balance of P and K. Default crop removal coefficients can be changed if the user prefers. The estimated net P and K balances are intended to get farmers and their consultants thinking about whether or not fertilization programs are meeting goals.



Detailed user instructions are included as pop-up comments within the spreadsheet. A Quick Start Guide and Power Point slide set also provide background information and selected state-level data.

PKalc and other useful programs can be accessed at:

www.ppi-ppic.org/toolbox. BC

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in petioles than Russet Burbank at any given stage of growth (**Figure 1**). It is possible that its root system is more capable of extracting P from the soil. Petiole P increased with each increment of applied P, particularly in the early season. The two P sources did not differ in their effect on petiole P. The application of P did not affect most processing characteristics, including fry color. It reduced specific gravity slightly, by about 0.001.

In summary, we found that liming can increase tuber Ca and specific gravity, but does not increase P uptake at this soil pH. However, results could differ in soils of lower pH.

Applied P, even under high soil P conditions, can boost yield profitably, without influencing processing quality. The two potato cultivars differed considerably in their response to applied P. The greatest opportunity for improving P utilization lies in genetic improvement and cultivar choice. BC

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TENNESSEE

Potassium Fertilization of Cotton Produced on Loess-Derived Soils

By M.E. Essington, D.D. Howard, H.J. Savoy, and G.M. Lessman

High-yielding and fast-fruiting cotton varieties produced on loess-derived soils often display potassium (K) deficiency symptoms during boll filling. Deficiencies result from the combined influence of K fixation by vermiculitic soils and insufficient soil K test data to identify appropriate K fertilizer recommendations. The results of this study clearly demonstrate the need for additional fertilizer K, relative to current recommendations, for cotton production on loess-derived soils.

Fast-fruiting cotton cultivars grown on loess-derived west Tennessee soils commonly display K deficiencies during boll filling, despite the apparent adequacy of soil K. Loess-derived soils are prevalent in the region and are responsible for the vast majority of the cotton production in the state and are also found in several other Mississippi Valley states (16 million acres), including Arkansas, Mississippi, Kentucky, Missouri, and Illinois. Potassium deficiency symptoms commonly appear in older leaf tissue, as K is a mobile element in the plant and rapidly translocated to young tissue and other sinks. However, in fast-fruiting cultivars, they first appear in younger leaf tissue, indicating K requirements exceed plant uptake. The high K demand during boll filling is indicative of the importance of this essential nutrient in the development of the fruiting body. Indeed, the boll contains approximately 60% of all K accumulated in the plant. A K deficiency during this critical stage of development affects both yield and quality of cotton fiber.

Numerous studies have suggested that the current soil K test ratings are suspect relative to cotton production. In order to address the K deficiency problems in the short-term, the Tennessee Agricultural Experiment Station increased the recommended K fertilization rate for cotton produced on medium testing soils, from 72 to 108 lb K_2O/A. Despite this modification, it was still evident that a re-evaluation of the fertilizer K recommendations was needed. For example, a comparison of soil test K and cotton yield data obtained at the Milan Experiment Station in west Tennessee illustrates the mismatch between the current soil test ratings and the yield response (**Figure 1**).

Recent University of Tennessee research has established the characteristics

Production of fast-fruiting cotton cultivars on loess-derived soils may require greater soil K levels than currently recommended.

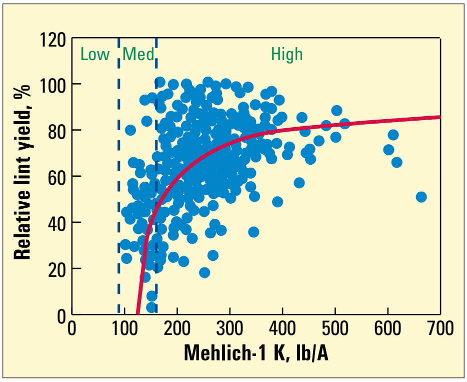

Figure 1. Relative cotton lint yield compared to soil test K levels determined two weeks after spring fertilization of loessial soils at Milan, Tennessee. The vertical dashed lines represent the current soil test ratings of the Tennessee Agricultural Experiment Station.

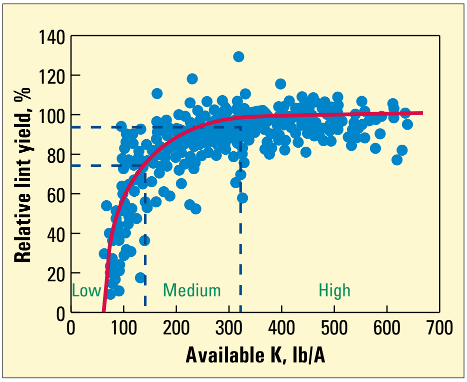

Figure 2. Relative cotton lint yield compared to available soil K (soil test K determined prior to fertilization + fertilizer K) determined for numerous locations in west Tennessee. The division between a low and a medium testing soil occurs when the relative yield is 75%; the medium to high break occurs when relative yield is 95%.

of loessial soil that are responsible for restricted K availability. Specifically, it was found that the clay fraction is composed of vermiculite and hydroxy-interlayered vermiculite (HIV), which is a natural weathering product of vermiculite in slightly acidic soils. These clay minerals are responsible for the exchange and nutrient retention capacity of a soil. However, they are also well-known for their K (and ammonium) fixation capabilities.

Evidence of the influence of K on the nutrient retention capacity of a soil can be seen by examining the cation exchange capacity (CEC) when the soil is saturated with different ions. For example, loessial soils saturated with calcium (Ca^{2+}), the dominant native exchangeable cation on the exchange complex, have CEC values that range from 8.71 meq/100g ($cmol_c$/kg) to 12.16 meq/100g. Potassium-saturated soil displays CEC values that are significantly lower, ranging between 4.12 meq/100g and 8.13 meq/100g. These data directly indicate that a portion of the K retained by the clay fraction of the vermiculitic loessial soils can not be displaced and is unavailable for crop uptake. In addition, the K that remains exchangeable is difficult to displace by native cations, such as Ca^{2+}, further reducing K availability.

Based on field observations and the mineralogical character of loessial west Tennessee soils, it was hypothesized that the current Mehlich 1 soil K test ratings and fertilizer rate recommendations are not sufficient to maximize the production of fast-fruiting cotton cultivars. In order to address this problem, studies were initiated at three locations in west Tennessee: Milan Experiment Station in Milan, West Tennessee Experiment Station in Jackson, and Ames Plantation Experiment Station near Grand Junction. The study involved several soil types, including Memphis, Lexington, Loring, and Henry soils (Hapludalfs, Fragiudalfs, and Fragiaqualfs). A randomized complete block design with five field replicates and seven broadcast K fertilizer rates: (0, 30, 60, 90, 120, 150, and 180 lb K_2O/A) was tested at each location. Plots also received nitrogen (N) at 80 lb/A as ammonium nitrate (NH_4NO_3) and 30 lb P_2O_5/A as triple superphosphate. The plots were seeded with the cotton cultivars DP 50 (during 1995 and 1996) and DP 5409 (1997

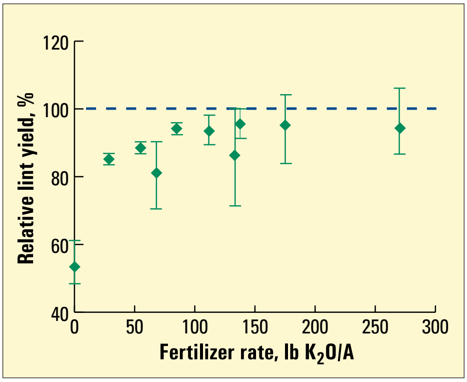

Figure 3. Relative cotton lint yield response to K fertilization on low-testing loessial soils. The error bars represent to 95% confidence level.

TABLE 1. Currently used and proposed Tennessee Agricultural Experiment Station soil K test (Mehlich1) results and associated ratings.

	Soil test rating			
	Low	**Medium**	**High**	**Very high**
	lb K/A			
Current	<90	90-160	160-320	>320
Proposed	<140	140-320	>320	–

through 1999) and managed in no-till. Soil K fertility status was evaluated each fall prior to K fertilization, using a Mehlich 1 extraction of 0 to 6 in. soil samples.

Annual fertilizer K rate explained most of the variability in relative yield. The best fit with relative yield resulted when the extractable soil K level (before annual fertilizer K application) and the annual fertilizer K rate were combined and considered as available K. (This does not necessarily imply that fertilizer K rates should be added to the extractable soil test K level for other soils, other extractants, or other crops. Nor does it imply that the fertilizer K rate will result in a 1:1 incremental change in soil test K level.) The available K levels in the soils that generate a relative yield of 75% of the maximum (the cut-off between low-testing and medium testing soils) is 140 lb K/A (**Figure 2**). Correspondingly, the available K that identifies a high-testing soil is approximately 320 lb K/A.

A comparison of soil test results to those that are currently employed by the University of Tennessee Agricultural Experiment Station is made in **Table 1**. According to our results, soil K test levels required to achieve a particular rating for cotton production should be modified. In essence, soils that currently rate medium or high should actually rate low or medium, respectively. In addition to a change in the soil K ratings, the experimental evidence also supports a change in the fertilizer recommendations. A comparison of yield response to fertilizer K rate (**Figure 3**) indicates that maximum yield on low-testing soils is achieved when the K fertilizer rate is in excess of 180 lb K_2O/A. A similar evaluation for medium testing soils indicates that maximum yields will be achieved with a K fertilization rate of 110 lb K_2O/A.

As a result of our evaluations, it is evident that the production of fast-fruiting cotton cultivars on loess-derived soils requires greater soil K levels than currently deemed acceptable. Modifications in the evaluation of soil K and in the fertilizer recommendations will be necessary. First, soils that currently rate medium and high testing must be classified as low and medium testing for cotton production. Second, the fertilizer recommendation for a low testing soil must be increased from 140 lb K_2O/A to 180 lb K_2O/A.

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INDIANA

High Oil Corn Yield and Quality Responses to Fertilizer Potassium versus Exchangeable Potassium on Variable Soils

By Tony J. Vyn, Brian J. Ball, Dirk Maier, and Sylvie M. Brouder

High oil corn production (Topcross^{R} pollination system) is currently recommended only for productive soil types under conventional tillage. The reasons include concerns for achieving desired plant populations (of both the male-sterile female and male pollinator plants), minimizing stress to the grain pollinator, and achieving consistency in grain yields and oil concentration. There is little information available on HOC response to fertilizer K, and whether oil concentrations are at all affected by K fertilizer rate or placement.

Potassium (K) is important in the production of high oil corn (HOC) because of its benefit to yield and overall role in improvement of HOC grain quality parameters as soil exchangeable K (SEK) levels increase.

Aside from a general recommendation to plant HOC on productive soils, and presumably those with phosphorus (P) and K concentrations above the critical level for yellow dent corn, little information is available on whether K fertilizer requirements for HOC are any different from those with dent corn. Potassium availability to HOC may be important since K is so essential in the plant enzymes responsible for oil synthesis in plants, and because grain oil concentrations in HOC are approximately double those in normal dent corn.

In addition, the justification for the conventional tillage recommendation for HOC is vague. More variability in stand establishment and productivity is presumed, especially on

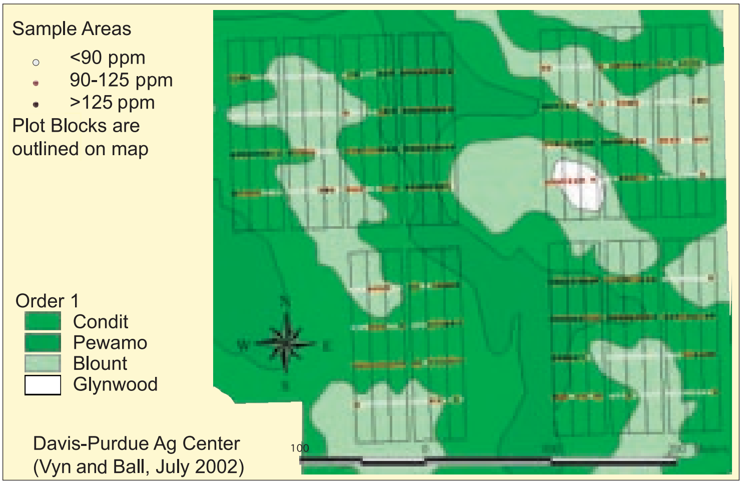

Figure 1. Order 1 soil survey of the experimental field in 2000 (east block) and 2001 (west block). Soil exchangeable K status is indicated in colored circles for samples taken at a depth of 2 to 6 in. during spring of the respective year.

variable soils, when HOC is planted with residue-conserving tillage systems. The basis for the conventional tillage recommendation has not been experimentally verified.

Another common concern in HOC production is the within-field consistency of oil concentrations in the grain. Fields with uniform soil types have been generally considered desirable for HOC, even though no real reason to exclude HOC production from fields with more variable soil types has been demonstrated. Certain tillage and K fertility management systems might affect the consistency of oil concentrations on fields with variable soils.

Experiments were conducted in 2000 and 2001 to evaluate the response of HOC to conservation tillage systems and associated K fertilizer placements on soils varying in texture, drainage, and SEK. The field site was located at the Davis-Purdue Agricultural Center (PAC) in east-central Indiana. This site was selected because of its soil variability, because no-till corn is not a common practice on these poorly drained soils, and because of availability of appropriate site-specific technologies.

Three tillage (main) treatments were evaluated: fall chisel with spring cultivation (CT), fall strip tillage at 8 in. depth (ST), and no-tillage (NT) following no-till soybeans in rotation. Three K (sub-block) treatments were also evaluated within each main tillage treatment: fall application of 90 lb K_2O/A via broadcast or deep-banded (Fall K), fall application with an additional 50 lb K_2O/A

TABLE 1. Ear-leaf K concentrations as affected by tillage, K fertilizer, soil series, and soil exchangeable K in 2000 and 2001.

2000

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Earleaf K, %						
No-till	1.82	1.74	1.85	1.90	1.72	1.84	1.91
Chisel	1.85	1.77	1.91	1.96	1.65	1.91	1.94
Strip-till	1.82	1.74	1.83	1.91	1.71	1.84	1.94
No K	1.72 *b*	1.62	1.77	1.79	1.52	1.80	1.86
Fall K	1.86 *a*	1.77	1.89	1.93	1.74	1.91	1.93
F&S	1.91 *a*	1.86	1.92	2.04	1.82	1.89	1.99
Mean	1.83	1.75 B	1.86 A	1.92 A	1.69 C	1.86 B	1.93 A

2001

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Earleaf K, %						
No-till	1.33 *b*	1.16	1.44	1.36	1.10	1.44	1.46
Chisel	1.47 *a*	1.34	1.55	1.49	1.35	1.48	1.59
Strip-till	1.41 *a*	1.25	1.48	1.57	1.29	1.54	1.55
No K	1.29 *b*	1.14	1.35	1.44	1.12	1.40	1.46
Fall K	1.44 *ab*	1.24	1.52	1.56	1.26	1.46	1.63
F&S	1.48 *a*	1.38	1.59	1.41	1.36	1.61	1.52
Mean	1.40	1.25 B	1.49 A	1.47 A	1.25 B	1.49 A	1.53 A

Data followed by the same letter, or no letter, within a row or column are not significantly different according to a protected LSD $p = 0.05$ or a t test (GLM model) at $t_{crit} = 0.05$. Letters distinguishing differences among individual tillage and K treatment means within a column are italicized. Overall mean differences within a row are shown in upper case. No K = no K, Fall K = fall applied K, F&S = fall and spring applied K.

spring banded (F&S), and no K (No K). High oil corn followed no-till soybeans in both 2000 and 2001, and the fields had been in conservation tillage systems for at least five years previously. Response of HOC in the 24 sampling positions (six replications and four sampling positions per plot) associated with each tillage and fertility treatment combination was evaluated in three manners: a) mean response, b) after partitioning sampling positions into three soil series (Blount, Condit, Pewamo), and c) after partitioning sampling positions into three ranges of SEK concentrations...<90, 90-125, >125 parts per million (ppm)...present in the depth interval of 2 to 6 in. See **Figure 1**.

An Order 1 soil survey was completed for the experimental site in the fall of 2001. The Order 1 survey has a representative accuracy of 3 to 15 ft. Its differentiation of soil series may be even more useful in outlining the boundaries of management zones than earlier soil surveys. For example, the Order 2 soil survey for this county was published in the mid 1970s mainly for utilization in soil conservation decisions and had an accuracy varying from approximately 100 to 150 ft. Theoretically, the Order 1 soil survey should be more precise in evaluating responses in crop yield and quality in large plots on variable soils, but this has not been widely evaluated.

Pioneer high oil hybrid 34B25 was planted on May 12, 2000 and May 1, 2001 at populations of 31,000 seeds/A. Nitrogen (N) and P starter fertilizer was applied to all plots at a rate of 38 lb N/A and 25 lb P_2O_5/A as all, or part of, a liquid blend. In treatments with spring applied K, an additional 50 lb K_2O/A was applied in the starter. Application of 190 lb N/A as anhydrous ammonia was sidedressed at the V4 to V6 corn growth stage in both years.

Soil K stratification was observed in the plot area across all tillage and broadcast treatments. **Figure 2** shows the mean soil K concentrations (ammonium acetate extraction) for the combined year data. In 2000 the concentrations at the 0 to 2 in. depth averaged 228 ppm, while in 2001 the 0 to 2 in. concentration average was 179 ppm. Soil exchangeable K concentrations averaged 107 ppm in the 2 to 6 in. depth and 96 ppm at the 6 to 12 in. depth for both years.

Grain yield was obtained from the combine's yield monitor. Grain quality (oil and protein) was determined from HOC grab samples pulled from each harvest area. Grain kernel concentrations were obtained through near infrared analysis. Each corn sampling position was assigned to a soil series using ArcView Geographic Information Systems (GIS) software.

Results

Ear-leaf K concentrations responded positively to K fertilizer in both years (**Table 1**). We observed no differences among tillage systems in 2000, but in 2001 ear-leaf K values were lower in the NT treatment when compared with CT and ST. Corn leaf K responses to tillage and K fertilizer treatments were consistent across the three soil groups and SEK ranges.

Ear-leaf K concentration was significantly affected by both soil series and inherent SEK in both years. It is interesting to note that the lower topographical soils (Condit and Pewamo) had the higher ear-leaf K concentrations, while the Blount soil on the higher elevations had significantly lower concentrations. This may be due to the inherently higher SEK concentration and higher available soil moisture on the Condit and Pewamo soils. Consistently higher ear-

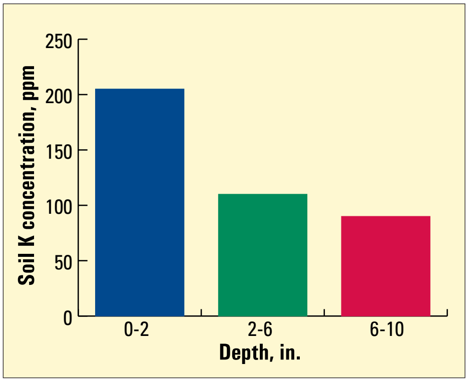

Figure 2. Combined year soil exchangeable K concentration from different depth intervals.

leaf K was observed when soil K was high. As anticipated, considerable spatial variability of leaf K response to K fertilizer resulted from the initial soil characteristics.

Tillage systems did not affect grain yields in either year, but higher K fertilizer rates increased yields in both years (**Table 2**). A particularly large yield advantage occurred with starter K band application in 2000. Soil series did not significantly affect yields in either year; however, lowest yields in both years were evident on the Blount soil. Highest yields occurred with both fall-applied and starter-banded K in both years. This positive response is an indication of the possible importance of K in the starter or, alternatively, a possible response associated with higher overall K fertilizer rates.

In 2000, all HOC yields with the highest SEK category (>125 ppm K) were lower than expected because of poor corn stands. Excessive rain after emergence thinned plant populations more in this category than those with lower SEK. In fact, average final populations per acre were 25,000 with SEK <90 and 23,000 with SEK from 90 to 125, but only 21,600 at the highest SEK. Plant populations in 2001 were higher and more consistent, and the proportion of male pollinators (always above 8%) was not affected by tillage or K treatments in either year. Despite the population challenges in 2000, HOC yield response to the fall plus starter K treatment was not affected by the inherent SEK category in either year.

It is encouraging for soil conservation-

TABLE 2. Grain yield as affected by tillage, K fertilizer, soil series, and soil exchangeable K in 2000 and 2001.

2000

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Grain yield, bu/A						
No-till	126	120	130	140	129	122 *b*	132
Chisel	134	138	133	125	135 AB	148 a *A*	124 B
Strip-till	135	134	133	142	135	137 *a*	133
No K	127 *b*	123	127	133	119	136	130
Fall K	129 *b*	132	128	123	137	127	123
F&S	140 *a*	137	140	123	142	144	136
Mean	132	130	132	136	133	136	130

2001

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Grain yield, bu/A						
No-till	178	178	179	175	180	177	178
Chisel	178	173	179	182	172	179	183
Strip-till	181	178	184	176	180	182	182
No K	174 *b*	171	176	175	173	173	177
Fall K	179 *ab*	178	180	179	178	179	182
F&S	183 *a*	180	185	178	182	185	183
Mean	179	176	180	177	177	179	181

Data followed by the same letter, or no letter, within a row or within a column are not significantly different according to a protected LSD p = 0.05 or a t test (GLM model) at t_{crit} = 0.05. Letters distinguishing differences among means within columns are italicized. Mean differences within a row are shown in upper case. No K = no K, Fall K = fall applied K, F&S = fall and spring applied K. Populations with >125 ppm in 2000 were 8, 18, and 15% lower for No K, Fall K, and F&S, respectively, relative to <90 ppm.

ists to note that both NT and ST resulted in HOC yields similar to those with CT. The latter confirms the possible successful adoption of conservation tillage (even on more challenging poorly drained soils), just as is currently possible in regular yellow dent production when planting dates are not delayed.

Overall, oil concentrations averaged 7.15% in 2000 and 8.18% in 2001. Year to year variation in oil concentration of HOC is a relatively common occurrence; lower oil concentrations are sometimes attributed to late planting and poor growing conditions in certain years. These annual variations were bigger than those resulting from tillage and K fertility management factors within a year.

Oil concentrations were significantly lower in NT versus CT and ST in 2000 (**Table 3**). Tillage treatments did not significantly affect oil contents in 2001, but did

TABLE 3. Grain oil concentrations as affected by tillage, K fertilizer, soil series, and soil exchangeable K (2 to 6 in. depth) in 2000 and 2001.

2000

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Oil concentration, %						
No-till	7.04 *b*	7.00	7.07	7.17	6.99	7.04	7.14
Chisel	7.24 *a*	7.19	7.29	7.28	7.18	7.24	7.31
Strip-till	7.17 *a*	7.09	7.23	7.20	7.13	7.07	7.27
No K	7.12	7.05	7.16	7.11	7.04	7.18	7.22
Fall K	7.15	7.08	7.21	7.30	7.08	7.04	7.29
F&S	7.18	7.14	7.23	7.24	7.18	7.13	7.21
Mean	7.15	7.09 B	7.20 A	7.22 A	7.10 B	7.12 B	7.24 A

2001

		Soil series			Soil exch. K at 2 to 6 in., ppm		
Treatment	**Mean**	**Blount**	**Condit**	**Pewamo**	**<90**	**90-125**	**>125**
	Oil concentration, %						
NT No K	8.17 *ab*	8.25	8.08	8.51	8.06	8.10	8.34
Fall K	8.13 *b*	8.09	8.06	8.25	8.05	8.08	8.12
F&S	8.23 *a*	8.09	8.32	8.32	8.08	8.26	8.38
Mean	8.16	8.14	8.15	8.36	8.06	8.15	8.30
CT No K	8.16	8.00	8.18	8.39	8.10	8.15	8.34
Fall K	8.16	7.94	8.14	8.45	8.05	8.08	8.30
F&S	8.12	7.96	8.11	8.33	8.10	7.86	8.28
Mean	8.15	7.97	8.14	8.39	8.05	8.03	8.31
ST No K	8.21 *ab*	8.07	8.22	8.49	8.06	8.29	8.44
Fall K	8.31 *a*	8.19	8.30	8.65	8.25	8.31	8.48
F&S	8.14 *b*	8.03	8.17	8.32	8.12	8.07	8.30
Mean	8.22	8.10	8.23	8.49	8.14	8.22	8.41
Grand mean	8.18	8.07 C	8.17 B	8.42 A	8.09 B	8.13 B	8.34 A

Data followed by the same letter, or no letter, within a row or within a column are not significantly different according to a protected LSD $p = 0.05$ or a t test (GLM model) at $t_{crit} = 0.05$. Letters distinguishing differences among tillage and K treatment means within a column are italicized. Overall mean differences resulting from soil series and SEK are shown as upper case. No K = no K, Fall K = fall applied K, F&S = fall and spring applied K.

have a significant interaction with K fertilizer treatments because lower oil concentrations occurred with fall K in NT treatments, compared to CT and ST treatments. Potassium fertilizer applications did not significantly increase kernel oil concentrations in either year. Oil concentration responses to tillage and K treatments, although relatively small, were not influenced by the inherent soil series or the initial SEK status of the soil at the sampling positions.

Soil series significantly affected grain oil concentrations in both years. The Pewamo was observed to have the highest concentration in 2001, and both the Pewamo and Condit soils resulted in somewhat higher oil than the Blount soil in 2000. The effects of soil series are largely associated with differences in SEK in these soil series (data not shown).

Grain oil concentrations responded more to initial SEK than K fertilizer treatments (annual additions of K). Consistent increases of oil were observed with increasing SEK in both years in nearly all treatments; oil concentrations were significantly higher in both years with >125 ppm SEK than with the lower SEK concentrations. More research is needed to confirm our findings that oil concentrations can be increased in HOC through maintaining SEK at higher levels.

Conclusions

Analysis of site-specific data within and among replicated plots indicated that HOC response to tillage and K fertilizer treatments was not affected by either soil series or the SEK status of the individual sampling positions. Both soil series and the initial SEK status below the 2 in. depth had more influence than either tillage or K fertilizer treatments on both ear-leaf K and oil concentrations. However, grain yield in HOC was more dependent on K fertilizer treatments than on inherent soil characteristics.

Both soil series and SEK concentrations accounted for most of the within-field variability in HOC performance. Higher SEK concentrations were consistently associated with increased concentrations of ear-leaf K and grain oil, as well as higher concentrations of grain protein and grain K (data not shown).

High oil corn receiving fall K plus starter K (at left) showed a height advantage and higher yields compared to the zero K plot (right) at Davis-PAC.

Potassium management is important in the production of HOC, both for its initial benefit to yield and its overall role in maintaining SEK concentrations high enough to obtain maximum possible oil concentrations. The consistency of HOC response to tillage and fertility treatments across variable soil series and SEK levels suggests that conservation tillage systems are feasible in HOC production, and that decisions about short-term and long-term K fertilizer management are more important in obtaining optimum yields and quality of HOC than decisions about tillage. BC

Dr. Vyn (e-mail: tvyn@purdue.edu) and Dr. Brouder are in the Department of Agronomy and Dr. Maier is in the Department of Agricultural and Biological Engineering, Purdue University. Mr. Ball is now with Sunray Co-op in Texas.

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InfoAg 2003 Plans Progress

The sixth Information Agriculture Conference, InfoAg 2003, is set for July 30 through August 1, at the Adam's Mark Hotel, Indianapolis Airport. An optional precision ag field day (hosted by Ag One Cooperative of Wilkinson, Indiana) is planned for Monday, July 29, preceding the conference.

The field day will have a separate registration fee. Transportation from the Adam's Mark Hotel and a cookout lunch will be provided. Attendees on July 29 will be able to view equipment close-up and network with retailers and others participating in the InfoAg program.

Keynote speaker for InfoAg 2003 will be Bruce Vincent, agriculture advocate known for developing positive programs and messages directed to community groups and children. One of his significant efforts has been a program called Provider Pals, which matches classes of school students with individuals in service industries, including agriculture. The students exchange correspondence and form a relationship with the industry representatives to further understanding and communication.

More details regarding program plans, registration and exhibitor fees, and related information will be available at the website: **www.ppi-far.org/infoag.**

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Donald L. Armstrong, Editor

Research Notes

Colorado: Precision Farming Strategies in Western Great Plains Irrigated Agriculture Research Project

This precision farming research project is a multi-disciplinary, multi-site, multi-crop, multi-agency undertaking that encompasses several facets of agricultural science. It is a cooperative effort between various academic departments at Colorado State University (CSU) and the USDA-ARS Water Management Unit in Fort Collins (see acknowledgments below). This study is being conducted on three farmer fields in Colorado. Field sites are located near Greeley, Wiggins, and Yuma.

The Western Great Plains area is among the leaders in U.S. crop production. Corn grain yields in this region usually exceed the national average. Such high yield production requires significant quantities of inputs, including irrigation, nutrients, and pesticides. However, due to inherent spatial variability in the field, not all areas require the same input levels.

One focus of this project is to develop and assess various techniques of identifying production level management zones (MZs). Four different techniques are being investigated to delineate MZs into regions of high, medium, and low yield productivity. The idea is to manage inputs variably in each MZ to optimize crop production and profits on farmer fields. The goal is to maximize yield and minimize potential environmental degradation due to over-application of inputs.

Four different methods of delineating MZs are being investigated. Within each management zone approach, eight methods of nitrogen (N) application are being studied to assess which method results in the highest N use efficiency, grain yield, and economic returns. Treatments are replicated up to four times in each field. Variable-rate N applications are made along the experimental strips based on MZs from the four approaches.

The goal of the N management aspect of the project is to determine which N treatment and MZ approach maximizes farm profitability while minimizing potential environmental degradation. Another objective is to determine levels of spatial nutrient uptake and removal by corn plants. Nitrogen, phosphorus (P), potassium (K), zinc (Zn), and several other nutrient uptake rates and removal concentrations are being analyzed to determine if plant uptake and removal vary across MZs.

Acknowledgment of the multi-disciplinary team:

This project is funded primarily through USDA-Initiative for Future Agriculture and Food Systems (IFAFS) competitive grant funds. The lead investigators for the project are Drs. Raj Khosla and Dwayne Westfall (Soil Fertility); Drs. Phil Westra, Frank Peairs and Howard Schwartz (Weed Sciences, Entomology and Plant Pathology); Drs. Robin Reich and Marshall Frazier (Spatial Statistics and Ag Economics); and Mr. Bruce Bolsey (Extension and Outreach), all from Colorado State University; and Drs. Dale Heermann, Walter Bausch, and Gerald Buchleiter (Water Management and Remote Sensing) from USDA-ARS Water Management Unit in Fort Collins, CO. There are several research associates (Kim Fleming as Project Manager, Tim Shaver, and Bill Gangloff) and graduate students working on this project. For more information, please contact Dr. Raj Khosla, e-mail: rkhosla@lamar.colostate.edu.

BARBARA STILL REMEMBERS THE FARM

A chronic frustration during my 36+ years as a working agronomist has been the lack of understanding of farming among city folks. The selections of healthy, tasty, and economical foods at supermarkets are almost infinite. Yet, how many people associate them with what goes on at the farm? Some are more likely to be critical of farmers – because they are ‘paid not to grow crops’ or are ‘polluting the environment’. A few choose to pay a premium for organically grown foods, thinking they are more nutritious or better for the environment. Misunderstanding and uncertainty about agricultural production are common.

Barbara is different, though. She knows about farming and, as I discovered, is more than proud of her Minnesota farm heritage. We met a few weeks ago when Pat and I were looking for a piece of furniture. Barbara sold us a table and, while writing up the ticket, asked me where I worked. I told her a little about the Institute and then suggested that she probably wouldn’t be interested in hearing about agriculture. Whoa! She went into a 10-minute sermon about why she is interested and showed me that she knows a lot about farming, especially corn and soybean production.

As it turns out, Barbara’s dad was a grain farmer who won a national corn yield contest back in the late 1950s. She proceeded to describe how he was able to grow such marvelous corn and even estimated by her hand spread how long the ears of corn were. (I suspect Barbara was also a good fisherman at one time because she stretched those corn ears out pretty good.)

Then Barbara grew pensive, as the conversation brought back fond memories of her father. But she brightened when she told us about a picture of her dad and his corn that is now hanging in her kitchen. Unlike many today in professions not directly related to farming, she continues to maintain a strong, positive appreciation of the importance of food and fiber production. She remembers.

Without realizing it, Barbara made my day – my week. As I left the store, it occurred to me that all of us should be a little more like her...proud of our heritage. Maybe then we would be more inclined to remind our city cousins about the essential role of modern agriculture.

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