Phosphorus and Potassium Economics for the 21st Century

By Jess Lowenberg-DeBoer and Harold F. Reetz, Jr.

In the U.S., building soil phosphorus (P) and potassium (K) levels typically becomes an issue on farms that have had limited nutrient application and when doing site-specific management. Intensive soil sampling often reveals islands of low P and/or K in otherwise well-managed fields. Most soil fertility recommendations suggest a slow buildup of those low fertility areas. Financial analysis indicates that if it is profitable to build up soil P and K levels, it is most profitable to do it as quickly as possible. This article outlines the potential benefits of rapid buildup and the soil chemistry constraints to such a strategy.

> Farmers acquiring land with depleted nutrient levels or identifying low-fertility 'islands' within fields that need significant buildup under site-specific systems may find a rapid buildup program (one or two years) to be most appropriate under today's economic and risk management constraints. Rapid buildup reduces risk of lost profits.

Phosphorus and K fertilizers are an investment in long-term soil fertility. In general only a portion of this year's P and K application is used by this year's crop. A large part goes to increase overall soil fertility. In economic terms, the cost of building soil fertility is the potential gain on investments not made because funds were tied up in P and K in the soil. Depending on the farm, those alternative opportunities or investments might include paying off existing loans, replacing equipment, new livestock facilities, or a non-farm business. Sometimes this opportunity cost of not investing is referred to as the time value of money.

Because of compounding, the time value of money tends to favor investments that pay off quickly. While the mechanics of compound interest and net present value (NPV) can be complicated, the idea is simple. (Net present value is the sum of discounted profits, minus initial costs. The weights used in discounting future returns are a function of the opportunity cost of capital and the time since the initial investment.) If an investment is profitable quickly, it provides additional income which can be reinvested to generate even more profit. For crop producers this means that a mismanaged field or a low fertility island should be brought up to maximum economic yield (MEY) as quickly as possible given the constraints of financing and soil chemistry.

Slow Buildup Fits Small Farm Scenario

In the early 20th century, when farms were small and the agricultural credit system was in its infancy, cashflow was a key constraint to building up soil fertility. It was difficult for farmers to pay for P and K fertilizer that built soil fertility when the cashflow generated by that buildup stretched over the next three to five years. In that case, the best they could do was to build soil fertility slowly, applying only as much buildup P and K fertilizer as could be paid for out of current cashflow.

Risk and short-term farm rental also contributed to a preference for slow soil fertility buildup in the 20th century. While P and K in the soil may be a good investment, it is a highly illiquid asset with minimal use in risk management. Tenants on one-year leases

with high turnover were reluctant to invest in building soil fertility.

Most Extension fertilizer recommendations seem to have been developed with this small farm scenario in mind. The current situation in the U.S. and Canada is much different. Most commercial farms can obtain credit for profitable investments. Risk is still important, but government farm programs, availability of crop insurance, contracting, hedging, and options provide producers with some tools to help manage that risk. Many farms are still on one-year leases, but many of these are repeatedly renewed, and landlords are increasingly aware of the importance of soil fertility as a way to make their investment profitable. This is particularly true on professionally managed farms. It is time to re-examine those slow P and K buildup recommendations that were designed to deal with the problems of an earlier period of agricultural history.

Agronomic Limitations

A larger part of the response to buildup fertilizer applications may come from the first increments added than from the latter amounts. The response will depend on how low the initial soil test was and on soil characteristics. If soil tests are low, more of the yield will likely come from the added fertilizer than from the background soil supply. Splitting the buildup over time into two or more applications will slow the buildup process, but may still achieve more rapid increase in yield than in soil test.

In most cases, rates required for rapid buildup plans need not be limited by agronomic concerns. However, there is potential for salt injury if required K applications are extremely high. If the recommendation exceeds 600 lb K_2O/A, it may be best to limit the first year application to 600 lb/A and complete the buildup process in the next fertilizer application. Since accuracy of soil tests may be less reliable at the lower end of the scale, this will also allow for another soil test to be taken to reaffirm the need for the higher rate. The majority of the crop response will be obtained with the first increment, so the yield loss from splitting the application will be minimal.

Rapid buildup strategies for P and K may be the most economical approach when soil tests are medium or low.

For surface-applied fertilizer, especially P under reduced tillage, splitting large applications may help reduce risk of environmental problems. In soils with a high sand content or other cases where leaching is a high risk, or on soils where there is a high rate of fixation of P in unavailable forms, heavy applications to build soil test are not advised. The best approach on these soils will be annual applications. For most farms, buildup is sound management, and rates should not be restricted for agronomic reasons. Rapid buildup will generate the quickest return and lead to a more profitable level of management in the shortest period of time.

The example below compares three different scenarios of buildup P and K, with an economic and agronomic evaluation that is more appropriate for 21st century farms.

Example

A partial budget example was developed using the P and K response functions and soil carryover relationships presented by Schnitkey, Hopkins and Tweeten of Ohio State University. These relationships are based on Ohio data, but results would be similar anywhere in the Midwest. The land is assumed to be in a corn/soybean rotation (starting with corn) and have a cation exchange capacity (CEC) of 20 meq/100 g. The baseline compares three buildup strategies:

- **Rapid Buildup** – Enough P and K is

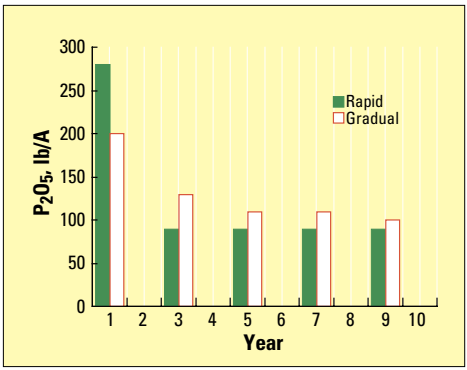

Figure 1. Phosphorus buildup alternatives (application every second year).

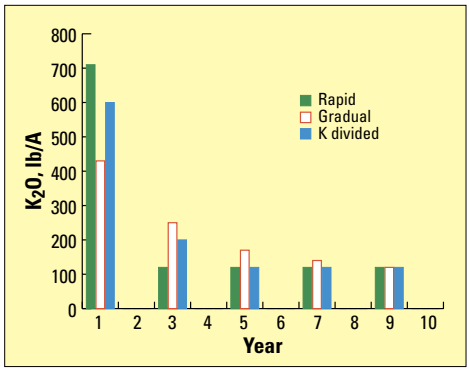

Figure 2. Potassium buildup alternatives (application every second year).

applied the first crop season to build soil tests to critical levels. The critical levels from the Tri-State university recommendations (Michigan, Ohio, Indiana) are used: P, 30 lb/A; K, 250 lb/A for a CEC = 20.

- **Gradual Buildup** – The equations in the Tri-State recommendations are followed, resulting in a buildup over about seven years.
- **Rapid Buildup with K in Two Applications** – Like the Rapid Buildup strategy, but when first year K_2O is limited to 600 lb/A (Hoeft and Peck, 2000).

When soil tests reach the critical levels, the Tri-State recommendations are followed, which specify maintenance applications based on crop removal. The example assumes that initial soil test levels are 10 lb P/A and 100 lb K/A.

Baseline price and cost assumptions are: corn, $2/bu; soybeans, $5/bu; P_2O_5, $0.22/lb; K_2O, $0.13/lb; nitrogen (N), $0.20/lb; drying, $0.10/bu; and hauling grain, $0.20/bu. Fertilizer applications are assumed to be made only in the corn year. A 10-year planning period was used. Only costs of fertilizer and drying and hauling grain are deducted in the net return calculation; all other costs are assumed to be the same for all three strategies. A sensitivity test was conducted assuming: higher grain prices – $3/bu for corn and $7/bu for soybeans; lower P and K prices – P_2O_5, $0.10/lb; K_2O, $0.10/lb; and higher P and K prices – P_2O_5, $0.30/lb; K_2O, $0.20/lb.

Given initial soil test levels, the rapid buildup plan requires 280 lb P_2O_5/A and 910 lb K_2O, compared to 200 lb P_2O_5 and 530 lb K_2O/A under the Tri-State recommendations for gradual buildup. With the rapid buildup plan, subsequent applications are at a maintenance level (**Figures 1** and **2**). With the

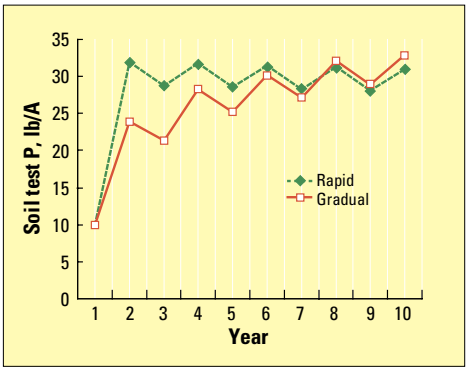

Figure 3. Phosphorus buildup plan soil tests (application every second year).

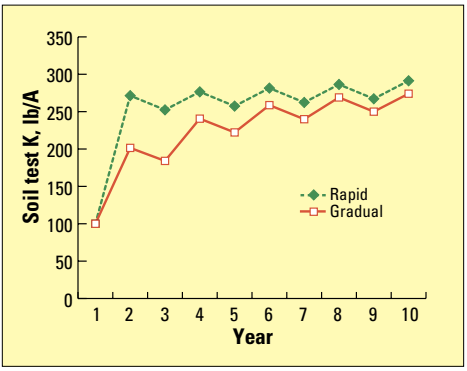

Figure 4. Potassium buildup plan soil tests (application every second year).

TABLE 1. Estimated benefits of rapid P and K buildup under different price scenarios.

Scenario	Rapid, $/A	Split K applications, $/A
Baseline	3.34	2.74
Higher grain prices	4.94	3.97
Lower P and K prices	3.46	2.77
Higher P and K prices	2.86	2.47

gradual buildup, applications remain above the maintenance level for the whole 10-year period.

With rapid buildup, soil tests reach the critical level in year two (**Figures 3** and **4**). Because of the application only for corn, soil tests overshoot slightly in the corn year to allow enough soil fertility to carry through the soybean year, resulting in a zig-zag soil test time path. With the gradual buildup strategy, soil tests rise throughout the 10-year planning period. When the K_2O is limited to 600 lb/A the first year, the soil test reached the critical level in the third year.

Under baseline assumptions, the estimated benefit of rapid buildup is an increase of over $3/A in the average net return over the 10-year period (**Table 1**). The rapid buildup plan has a much lower expected net return in the first year because of the large fertilizer application, but more than makes up for it with higher returns in subsequent years (**Figure 5**). Three dollars per acre is not a large sum of money, but when fine tuning farm management every dollar counts.

When the K application is spread over two years, rapid buildup is still expected to be more profitable than with the gradual plan, but the difference is smaller. The reduction comes because K is below the critical level for two years, and the full effect of the P buildup is not felt during that time because K is still limiting.

When grain prices are higher, the rapid buildup plan becomes even more profitable. It shows an estimated advantage of almost $5/A in average net return in this example when K can be applied in the first season. The rapid buildup advantage grows slightly when P and K prices are lower and shrinks

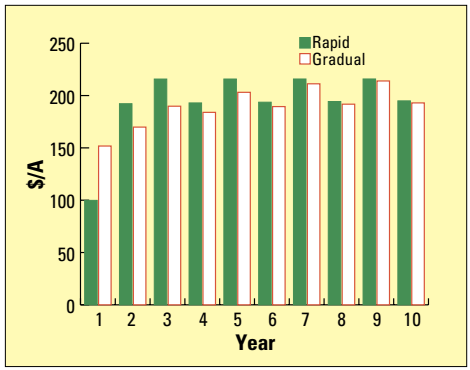

Figure 5. Buildup plan net returns (application every second year).

when prices are higher, but this is a relatively small change.

When the time value of money is taken into account, the benefits of the rapid buildup are clearly seen. Rapid buildup results in an increase in the estimated NPV of about $12/A under the baseline conditions and $24/A under the higher grain prices. The split K application plan shows an expected NPV advantage of $11/A for the baseline and $20/A for the higher grain price scenario.

Conclusions

In the past, P and K buildup was often spread over several years because of how farms were managed. Financial constraints, risk management problems, and rapid turnover in rental land motivated farmers to build soil P and K in small increments. Soil chemistry issues, such as salt buildup and unreliability of soil tests, also contributed to this decision, but were usually not the determining factor. With the development of agricultural credit, improvement in risk management tools, and changes in the rental market, those slow buildup strategies should be revisited.

There are several situations where a rapid buildup program (one or two years) is the most economical approach when initial soil test levels are low or medium.

1. Farmers who take over run-down farms and want to get them into full potential production as quickly as possible should consider a rapid buildup strategy.

2. A crop-share landlord who acquires a mismanaged farm and wants to get it into full production as quickly as possible should work with the tenant to adopt a rapid buildup program.
3. A cash-rent landlord who pays for the buildup P and K fertilizer and purchases land with low soil tests should build P and K levels quickly so that higher cash rents can be justified.
4. Producers who use intensive soil sampling and identify low fertility islands in otherwise higher fertility fields should consider a rapid buildup. If the islands are a small part of the farm area, the cashflow effects of the extra fertilizer application will be correspondingly small. BC

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References

Hoeft, R. and T. Peck. Soil Testing and Fertility. In: *Illinois Agronomy Handbook: 2000-2001*, College of Agricultural, Consumer and Environmental Sciences, University of Illinois, Urbana-Champaign. 2000. p. 84-124.

Schnitkey, G., J. Hopkins, and L. Tweeten. 1997. An Economic Evaluation of Precision Fertilizer Applications on Corn-Soybeans Fields. In: *Precision Agriculture: Proceedings of the 3rd International Conference.* P.C. Robert, R.H. Rust and W.E. Larson, Editors. American Society of Agronomy, Madison, WI. pp. 977-988.

Vitosh, M., J. Johnson, and D. Mengel. 1995. *Tri-State Fertilizer Recommendations for Corn, Soybeans, Wheat, and Alfalfa.* Michigan State University, The Ohio State University, Purdue University. Extension Bulletin E-2567.

Precision Farming Profitability Book Discusses Site-Specific Management Topics

A recently-released book written by Purdue University specialists offers information on site-specific tools and strategies to improve crop management. Titled *Precision Farming Profitability*, the 132-page publication contains 14 chapters on subjects such as: estimating precision farming benefits, variety-performance testing with global positioning systems (GPS), drainage, soil fertility, yield monitoring and mapping, soil sampling, variable-rate technologies, Geographic Information Systems (GIS), and on-farm research. It also includes a glossary and reference information.

"This book won't make people experts in the new technology, but it will help them identify questions to ask in adapting to individual farm situations," explains Dr. Jess Lowenberg-DeBoer. He is Director of the Purdue Site-Specific Management Center and Coordinating Editor of the new publication. It was prepared in cooperation with CNH Global N.V., which manufactures Case IH and New Holland equipment.

Fifteen Purdue specialists wrote chapters or assisted with content of the book. They represent the School of Agriculture, Departments of Agricultural Economics, Agronomy, Agricultural and Biological Engineering, Botany and Plant Pathology, and the Purdue Agricultural Centers. In North America, about 30,000 producers currently use yield monitors and an increasing number use GPS.

Precision Farming Profitability can be purchased for $25.00 by calling the Purdue Media Distribution Center toll-free at (888) 398-4636 or by e-mail at MediaOrder@ces.purdue.edu. A printable order form is available on the Purdue site-specific management website at http://www.purdue.edu/ssmc. BC