

Time For A Tune-Up

The Fundamentals Of Spring Fertility

LIKE the engine in your car, proper soil fertility truly is what drives a smooth agronomic plan. Just as a poorly tuned engine causes a car to sputter and fail, ignoring soil fertility fundamentals can throw a wrench into your journey to success.

It's certainly easy to take for granted. After all, there are many exciting issues retailers face today — implications of the new Farm Bill, biotech crops, El Nino, environmental issues, technical service provider opportunities, and precision ag developments. However, much of your success in dealing with these issues depends on your application of soil fertility fundamentals. This special *CropLife*™ magazine report, with information provided by the Potash & Phosphate Institute and supported by IMC Global, is your informational "tune-up" as you prepare to execute your 2003 agronomy plans.

In the following articles, PPI staff review soil fertility fundamentals, from using fertility management to reduce the negative consequences of weather extremes to helping growers move closer to attainable yields when weather does cooperate. Along the way, the basics of managing soil test levels, and using nutrient removal information will be reviewed. Our objective — turn a sputtering "engine" into a smooth, efficient, yield-bearing machine.

A PACE Partners Special Report
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Tune-Up Trainer #1

Dealing With Drought

Proper fertility is even more critical when water is scarce.

BY MIKE STEWART AND HAROLD REETZ

WHILE it's too early to predict seasonal weather patterns for 2003, you can be sure that drought will strike somewhere in the U.S. And it's proven that drought will have less impact on yield where nitrogen (N), phosphorus (P), and potassium (K) availability are adequate throughout the growing season.

There are other benefits as well. Yield increases in response to added fertilizer may actually be higher in a

dry year than in a normal year. And good fertility stimulates earlier and deeper root growth, ensuring more efficient use of water and season-long nutrient uptake (see sidebar below).

As you make 2003 plans, here are some other things to consider about drought and fertility:

- Where drought-damaged crops were harvested for hay or silage last year, nutrient removal may have been greater than if a normal grain crop had been harvested. Be sure to adjust crop removal estimates.
- Soil compaction increases the impact of drought

stress. Reducing compaction will help improve root growth and water use efficiency.

- Because root growth will be limited in a dry year, high soil tests and deep placement may be even more important to assure adequate season-long supplies of nutrients.
- Adequate K is necessary for healthy plant water relations. Opening and closing of stomata, which regulate carbon dioxide, photosynthesis, and water vapor exchange (transpiration) between the leaves and the atmosphere, are controlled by K level in the leaves. If K

is inadequate, transpiration water loss increases and photosynthesis decreases.

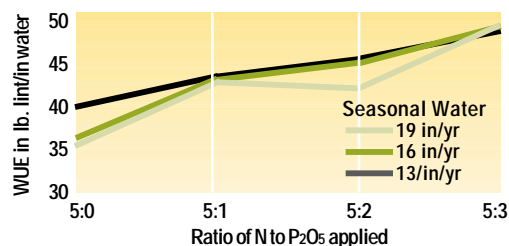
- Development and maturity are accelerated by high fertility levels, allowing the crop to get through critical flowering stages earlier, perhaps before drought stress occurs.
- Selecting varieties with deeper, more vigorous root growth patterns may be beneficial, so long as their yield under normal conditions is also good.
- Other management practices such as early planting, conservation tillage, and adequate weed, disease, and insect control also help

Fertility And Water Use Efficiency

Water use efficiency (WUE) is the units of a crop produced from each unit of available water (e.g., bu/inch, bales/inch, lb/inch, etc.). WUE is affected by soil fertility, and a complete and balanced fertility program helps to produce a crop with roots that explore more soil volume for water and nutrients in less time.

Research on cotton in the water-challenged South Plains of Texas, as shown in this chart, demonstrates the importance of balanced fertility in maximizing WUE. Where no P was applied, WUE was low. However, as balance between N and P fertility was improved, WUE was substantially increased, regardless of seasonal water supply.

Balanced Fertility Boosts Water Use



Improved P fertility increases WUE in irrigated cotton production (Krieg; Texas, 1997). Constant N with variable P, averaged across three methods of P placement.

keep the crop growing at peak performance and enhance water use efficiency.

The best strategy for dealing with an expected dry year is also the best strategy for a good year... *that is, plan for a good year.* Adequate nutrition is essential to take advantage of the good growing seasons, but it is also the best management approach to preparing for a drought.

Review recent soil tests. Areas that are medium or below should be considered for additional application. If detailed sampling (grid- or management zone-based) has been done and variable-rate application equipment is available, this may be an opportunity to focus limited dollars where they will do the most good. In any case, shortcutting P and K supplies will likely lead to shortcutting yield potential and profits. ■

Stewart is Great Plains director, and Reetz is Midwest director of the Potash & Phosphate Institute.

Study: P & K Are Drought Aids

Results from a 25 year P and K rate study on a corn/soybean rotation in Ohio showed a dramatic response to high fertility as a means of combating drought effects on yield. In this study, corn yields were severely depressed at low soil test levels, but the drought's impact was greatly reduced with high P and K soil test levels, highest yields being where P and K soil tests were highest.

The most dramatic effect was the response to higher K soil tests (over 60 bu/A). There was a positive interaction between P and K soil test levels. Increasing P levels at low K levels resulted in decreased yield, possibly due to interaction with other nutrients. Increasing K soil test levels resulted in increased yield. At higher K soil test levels, there was also an increase in yield as P increased. Soybean yields for the study in 1999 also responded to higher P and K soil test levels (over 10 bu/A).

Tune-Up Trainer #2

Optimum Attainable Yield

Many growers are not getting all the yield they can out of their fields.

BY HAROLD REETZ

IT'S a fact: Many growers and retailers are leaving yield on the table. Why? In many cases, there's a lack of understanding of the basic agronomic principles for the local area. Management systems must make best use of available resources for each field, with the goal of achieving Optimum Attainable Yield. Anything less is detrimental to the entire production chain: profit opportunities decrease for the farmer and retailer, and local and global competitiveness suffers.

How do we know that we're falling short? The first piece of evidence is in Figure 1, which plots average yields in Iowa since 1965 against Iowa yield contest winners. Since the early 1990s contest winners have increased yield substantially while the state average has risen at a much slower pace. The difference is the yield gap, or exploitable yield potential. While everyone realizes that contest yields are not

practical goals, the growing difference between them and average yields reveals a disturbing trend.

The second piece of evidence can be found in the soil test summaries shown in Figure 2 on the next page. They reveal that fertilizer and lime applications (including manure) over the past 20 years have not kept up with crop removal of nutrients.

The reality is, soil test levels for phos-

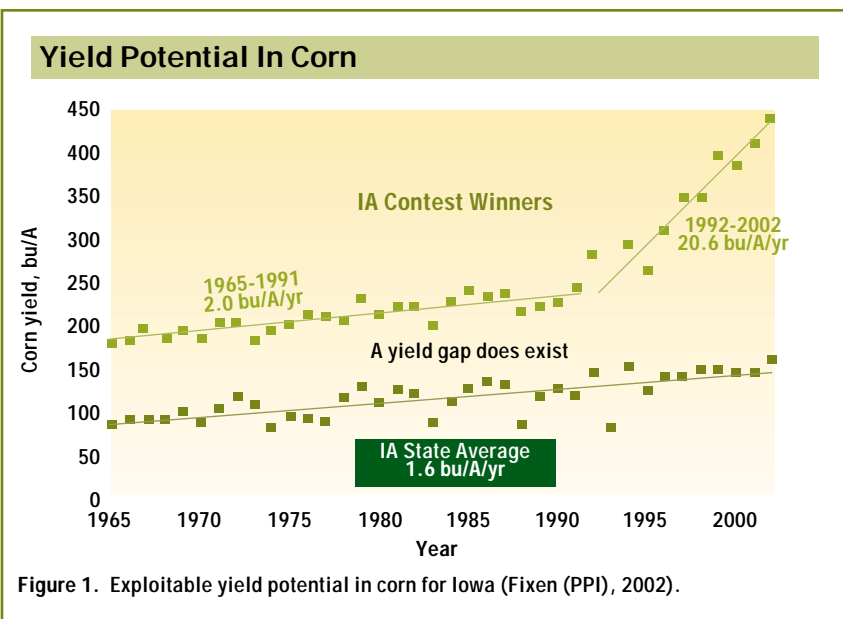


Figure 1. Exploitable yield potential in corn for Iowa (Fixen (PPI), 2002).

Tune-Up Trainer #2, Continued

phorus (P) and potassium (K) are declining in several agriculturally important areas of North America. Again, these gaps represent market opportunities for dealers for services to help identify the problem and products to help correct it. It is profit we are leaving on the table every year this situation is not corrected.

Work with customers to develop the data records and tools that will help them define their respective yield goal, either for individual fields or management zones within fields. Help them establish on-farm research to develop and test the management plan that will support higher yields. Help them implement the plan.

The process is not new...good dealers have always provided this kind of help. What is new is the availability of modern tools that help

soil testing does not identify the problem. Checking nutrient levels lower in the root zone may identify yield-building opportunities.

STARTER. Applying even a small amount of starter fertilizer may help provide the initial boost needed for uniform emergence and early root growth, and help establish a higher yield potential at the start of the season. Reduced tillage systems have increased the probability of a starter response. Low P concentrations prior to the 6-leaf stage in corn causes reduced kernel initiation and reduced grain yield.

STRIP-TILL, STRIP FERTILIZATION. More efficient use of nutrients can sometimes be achieved by placing them below the surface at a 6 in. to 12

able for uptake. Deeper tillage, incorporating crop residue and nutrients, encourages deeper root growth. This makes more water and nutrients available to support higher yields, without increasing soil test levels. Encouraging deeper root growth without tillage, as in no-till systems, is a challenge that many farmers and researchers are working on.

TRACK YIELDS AND NUTRIENT APPLICATIONS. Even if recommendations based on expected yields are followed carefully, it is important to track crop removal based on actual yield and make adjustments in nutrient applications if necessary. See the article on nutrient removal for more information on this topic.

NO SHORTCUTS. Many farmers fall into a trap thinking that they can get by with a band of low analysis fertilizer and cut back on broadcast applications. This may work in the short run, but every bushel of grain harvested still removes the same amount of nutrients from the soil and they must eventually be replaced or productivity will decline. Simple nutrient budgeting can help prevent "mining" of nutrient resources that are critical to sustained and improved productivity.

ON-FARM RESEARCH. Because many of the key practices for high yield depend on local, site-specific information, on-farm research is important for every farmer. It also provides essential information for using a variety of crop models that are becoming available to assist in management decisions. Tools of site-specific management—yield monitors, variable-rate application equipment, and associated information stored in a geographic information system (GIS) record system with global positioning system (GPS) coordinates are part of the 21st-century farmer's toolbox. Future success in helping customers build high yield management systems requires learning to use these tools. ■

Reetz is Midwest director of the Potash & Phosphate Institute.

Potassium: Critical Shortfalls in Corn Country

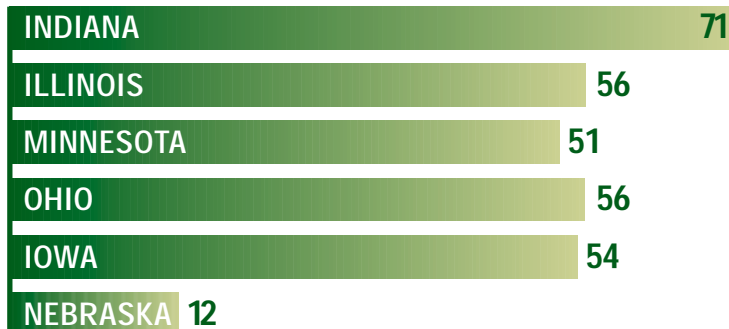


Figure 2:

The bar graphs reveal that potassium replacement is not keeping up with removal in most cases in the six leading corn states. The number indicates the percent of soil tests falling below 160 parts per million of K, the general level expected to give an economic yield response to applied K.

make this support possible on a site-specific, custom-tailored basis for each customer.

Tips for Improving Yield Potential

SOIL TEST. Even where soil tests average in the recommended range, 50% or more of the field area may need build up nutrient applications to reach optimum levels. Crops remove nutrients beyond the normal sampling zone. If the 6 in. to 12 in. zone or below is depleted of nutrients, normal

in. depth. Such placement reduces potential for run-off losses and helps provide an available nutrient supply later in the season when the soil may become dry enough to reduce nutrient uptake from the upper root zone.

ROOT ENCOURAGEMENT.

Management practices that encourage root growth support increased yield. Roots of a corn plant normally occupy less than 1% of the soil volume. Increasing root growth increases the amount of P and K that can be avail-

So often when the importance of balanced fertility is brought up, the focus is mostly on nitrogen (N) and phosphorus (P), P and potassium (K), or a combination including all three; N, P and K. In reality, crops require all sixteen plant nutrients to grow and reproduce. Although crops require greater amounts of N-P-K, secondary and micronutrients are just as essential for high-yielding, efficient crop production.

Balanced Fertility Is More Than N, P and K

secondary and micronutrients. Two nutrients, magnesium and sulfur, are absolutely critical; yet they are often overlooked in fertility programs.

MAGNESIUM

Magnesium is the central atom in the chlorophyll molecule. It is responsible for trapping sunlight, which is essential for sugar manufacturing. It has also been well established that magnesium assists in phosphorus absorption—another good reason for maintaining a balance of nutrients.

THE BIGGEST CHALLENGE

One of the greatest challenges in soil fertility management is making sure adequate amounts of plant nutrients are in the root zone at the right times. Different nutrients often require different management systems. Some of these differences depend on soil chemistry as well as the nutrients themselves. Nitrogen and sulfur, for example, are very mobile as opposed to phosphorus, which moves very little. The short-term recovery of phosphorus, however, is quite low as it is often tied up in the soil. Being cations (positive charges), potassium, calcium and magnesium often attach themselves to soil particles and become available as nutrients are removed from the soil solution. Even micronutrients have unique characteristics that affect their availability to crops. The availability of crop nutrients is very complex, often depending on temperature, moisture, compaction, root development, texture, and pH.

SULFUR

There are few functions within the plant where adequate levels of sulfur are not required. Sulfur is critical to many plant functions, such as protein synthesis. With inadequate sulfur, an important crop such as alfalfa cannot fix and metabolize nitrogen. When sulfur is deficient, plant and fruit maturity is often delayed.

K-MAG®: A VIABLE OPTION

Where magnesium, sulfur and potassium are required to help balance a fertility program, K-Mag offers a unique option. A three-in-one nutrient mineral, it provides these three nutrients in a water-soluble form ready for plant use. Often blended or granulated as an N-P-K fertilizer, K-Mag is non-acid forming and reduces the risk of plant burning. Mined as a



natural mineral near Carlsbad, New Mexico, it has helped provide magnesium, sulfur and potassium in the right balance to growers for over 50 years.

STEP 1: SOIL TEST

Monitoring soil nutrients is critical to understanding a proper soil fertility program. The more a grower knows about a particular tract of land, the better job he can do in managing the availability of nutrients. Soil testing and maintaining records are important management tools. Plant analysis also can be a valuable tool when used in combination with soil testing.

BALANCED FERTILITY... A KEY TO SUCCESS

There are many good reasons for growers to pay special attention to their fertility program. One of the best reasons, however, is the financial buffer it can provide in times of extreme weather. More so than at any other time, crops respond to a good, balanced fertility program under stress conditions. Don't let your fertility program be the limiting factor. Make it work for you!

STEP 2: BALANCED FERTILITY PROGRAM

High-yielding, profitable crops require a good, balanced fertility program including N, P, K,

Managing Soil Test Levels

Past applications of fertilizer are a valuable capital investment – don't overlook them.

SCOTT MURRELL
AND PAUL FIXEN

WHY focus on managing soil test levels for phosphorus (P) and potassium (K) instead of on rates of P and K fertilizer? Because you cannot assess the economic value of application without considering residual value.

To do this, we use soil testing to reflect the accumulated residual value of many past fertilizer or manure additions and the associated soil test calibration research to tell what soil test level generally produces optimum yields.

A farmer needs to build soil test levels to that optimum level only one time — it's a capital investment that will never wear out provided nutrients removed by crops are replaced (see next page).

Long-term studies like the one summarized in Table 1 offer insights into soil test level management. In this Iowa study, a one-time appli-

cation of 298 lb P₂O₅/A produced a 14-year total return of \$661. The application also raised soil test levels approximately 20 ppm. At the end of the study, the yield response to the application made 14 years earlier was still 20 bu/A. Similar residual effects occur

State University that resulted in a significant upward shift in K soil test categories.

Research like this allows specific numbers to be associated with soil test categories that we use to communicate with each other about soil test results and to make management decisions.

Risk management. There are three basic types of risk that producers face in their fertilization program: 1) risk that a fertilizer application will not be profitable, 2) risk that soil test levels within a field are yield-limiting, and 3) risk that soil test levels are not high enough to cushion errors or financially-trying times (re-

high allows more room for error and reduces the risk that soil tests might be yield limiting. In addition, producers who have built their soil tests to high or very high levels may be able to skip an annual P or K application, but use row applications where appropriate. However, building soil tests to levels higher than medium increases the risk that annual yield returns will not cover fertilizer expenses. Each producer must realize the risks associated with the various soil test levels and make decisions based on the risks he or she is willing to accept.

Land tenure. The more years you have to realize the bene-

Table 1. Residual effects on corn grain yield from a one-time P application of 298 lbs P₂O₅/A, applied in the spring of 1975.

YEAR	Corn grain yield ¹ , bu/A		Yield increase from P bu/A	Bray P-1 soil test ² ppm	
	0 lb P ₂ O ₅ /A	298 lbs P ₂ O ₅ /A		0 lb P ₂ O ₅ /A	298 lbs P ₂ O ₅ /A
	1977	134	135	1	13
1980	158	170	12	9	24
1983	120	147	27	6	14
1986	117	158	41	7	15
1989	123	143	20	4	8
Mean	133	153	20		

¹ Webb et al. (ISU), 1992. ² P check tested 17 ppm in fall of 1975.

with K.

So, how do you determine the P or K soil test level to maintain? The answer involves three major factors.

Soil test calibration. This is an on-going function of most state Land Grant institutions and serves as the foundation for soil test interpretation. It results in an ability to predict the probability of response or long-term relative yield at a given soil test level. It should be as current and local as possible. A good example is new calibration research by Iowa

duced flexibility). Figure 1 shows how these risks are related to soil test levels. At lower soil test levels, there is a higher probability that a fertilizer application will be profitable in the year of application, but increased risk that soil test levels are yield-limiting or do not allow much room for error. Soil fertility held very near medium, based on general small plot soil test calibration research, requires that soil testing and sampling be performed well and that the sampled field have fairly uniform soil test levels. As within field variability increases, the average resulting from a field composite sample usually tends to overestimate the actual field fertility level. Building soil test levels to

fits of soil test build-up, the higher the optimum level will be. Leases can be developed that equitably share the cost of build-up between landlord and tenant and that make P and K management more profitable for both parties.

Other factors – factors such as taxes, personal land ethic, crop quality, winter kill, crop value, opportunity costs, and soil P or K fixation come into play at a field or grower level when target soil test levels are being determined. ■

Murrell is Northcentral director, and Fixen is North American programs coordinator of the Potash & Phosphate Institute.

Soil Test Levels And Risk

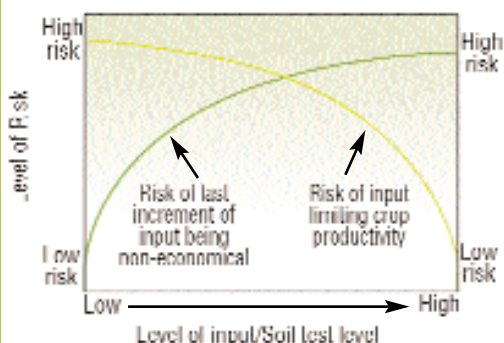


Figure 1. Risk incurred at various soil test levels (D. Leikam, personal communication).

Nutrient Removal

Consideration of the crop's use of soil nutrients is an important element of your fertility plan.

ADRIAN JOHNSTON
AND TOM BRUULSEMA

NOW that we've talked about the importance of maintaining soil test levels for optimum long term phosphorus (P) and potassium (K) fertility, it's time to address another key part of the equation — nutrient removal.

Nutrient removal is the quantity of nutrients contained in the grain or forage that is removed from the field. Nutrient removal rates can be determined by submitting your grain or forage sample to a lab for nutrient analysis, and then calculating the actual removal using yield data.

Average nutrient contents

in the harvested portion of crops also can be used to estimate the removal amounts.

Table 1 shows the amount of nitrogen (N), P and K removed in the harvested portion of selected crops. If the crop residues are all returned to the soil, the removal amount is that which must be replaced to maintain a long-term status quo. Both P and K are presented as oxide equivalents (P₂O₅ and K₂O, respectively).

The values in Table 1 are not recommended rates of nutrient application per unit of production, but merely quantities of nutrients removed in harvested product. It may be possible to farm some highly fertile soils for years (even decades) before their ability

to adequately supply certain nutrients is diminished. Other soils may be depleted in just a few years.

Soil fertility levels should not be allowed to drop to the point that yields are threatened. In general, soils with more clay and organic matter are better buffered. That is, it takes longer to deplete these soils of their available nutrients. And, logically, fields intensively managed for higher yields are more rapidly depleted.

P and K uptake and removal vary considerably between crops. Oilseed and grain legume crops have a high P demand relative to cereals. Soybeans have a particularly large appetite for K. Since plants retain most of

the K taken up in leaf and stem rather than in seed, the K removal by forages can result in a rapid drawdown on soils with a poor K supply rate

A new tool called "PKalc," developed by PPI scientists, helps users determine if P and K nutrient additions are keeping up with removal by crops. It is an Excel spreadsheet which enables quick assessment of a multi-year, multi-crop nutrient budget. PKalc can be accessed at: www.ppi-ppic.org/toolbox. Further details on nutrient uptake and removal can be found at PPI's Web site, www.ppi-ppic.org.

Soil fertility planning based on soil testing to estimate residual nutrient levels, along with crop removal estimates, will not only move us closer to maintaining long-term soil fertility, but also help us achieve maximum production potential. ■

Table 1. Nutrient removal in the harvested portion of selected crops.

Crops	unit	N removal	P ₂ O ₅ removal	K ₂ O removal
Barley	lb/bu	1.10	0.40	0.35
Canola	lb/bu	1.88	0.91	0.46
Corn	lb/bu	0.75	0.35-0.44 ⁴	0.29
Cotton	lb/bale	32	14	20
Oats	lb/bu	0.80	0.25	0.20
Potatoes	lb/cwt	0.35	0.15	0.56
Soybean ²	lb/bu	4.00	0.80	1.40
Sugar beets	lb/ton	4.00	1.50	6.60
Sunflower	lb/bu	2.80	1.10	0.60
Wheat (12% protein ¹)	lb/bu	1.30	0.50	0.35
FORAGES³				
Alfalfa ²	lb/ton	56	15	60
Bermuda grass	lb/ton	46	12	50
Bromegrass	lb/ton	36	13	59
Corn silage (67% water)	lb/ton	8.3	3.6	8.3
Fescue	lb/ton	38	18	52

¹ At same moisture content as grain yield measured.

² Legume crops obtain most of their N from atmospheric N fixation.

³ Forage yield on a dry matter basis except corn silage.

⁴ Recent data show typical removal varies substantially across the U.S.

Electronic Version Available

You can download an Adobe Acrobat version of this insert, as well as additional tables and figures, by visiting www.back-to-basics.net. The electronic version includes two additional articles on managing fertility in wet and flooded soils, and a comparison of broadcast and banded application techniques.



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understand the difference between
soil and pay dirt.**

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