The Analysis

Agronomic Information From

Spectrum Analytic Inc.

Winter 2011

As we close another year, we want to take this opportunity to say "Thank you" for your business in 2011. Another year has passed and as usual Mother Nature has presented new challenges and rewarded us with a bountiful harvest. 2011 weather will be remembered by many as the year of drought in the South and extremely wet conditions in the Corn Belt with everything else in between. Spring started off with good field conditions the first of March in many areas. In the South growers were able to get corn planted. Then rains came later in the month bringing field work to a standstill over most of the Corn Belt. Rain continued in Ohio and Eastern Indiana until the last of May. June came and most areas were able to plant all the corn and soybeans by the third week of June. Rain was irregular over some areas east of the Mississippi with some coming close to drought conditions during the summer. When harvest arrived and combines began to hum, reported yields ranged from below normal to higher than normal and everything in between. The north-eastern part of the United States is now experiencing heavy rainfall and a later-than-normal harvest season. But as always with American agriculture, no matter what Mother Nature offers, farmers make it a fruitful harvest season.

The past growing season has brought about some interesting topics for this issue of our newsletter. Potassium seems to be the nutrient that has been the hot topic. At the lab, we receive questions weekly about potassium soil test levels and how it acts in the soil and plant uptake. The library on our internet website (http://www.spectrumanalytic.com/doc/library/article_list) contains many articles on potassium and the other macro and micronutrients and their functions and how they work in the soil. In this issue Scott Anderson has written an article with some interesting facts regarding trends of potassium soil test levels across the United States with other interesting information.

We are now offering the Solvita soil test. This test was first introduced to the market place in late winter of 2010. There is limited research regarding calibration of the test for making nitrogen recommendations; however Woods End Lab and several university soil scientists are doing research to calibrate the test and make it more useful for the agricultural market. For the latest information, consult the Solvita website (www. http://solvita.com/).

All the employees at Spectrum Analytic wish you and your employees and their families a Blessed and Merry Christmas. We hope that everyone enjoys the holidays together with friends and family and that everyone travels safely. In 2012 we will be facing new challenges once again, take these challenges and convert them into an opportunity. May the New Year be successful to you and all your business ventures.

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What's Inside...

Inadequate Potassium is an Increasing Concern

by Scott Anderson

Recently more of our customers have been concerned about potassium (K) nutrition of their crops. This could be due to the continuing high percentage of plant analysis results that show K stress in a wide range of crops as shown in the table to the right.

Percent of Plant Tissue Samples Below Normal in K Range (Spectrum Analytic only)				
Crop	**2008**	**2009**	**2010**	**2011**
Corn	18	13	22	17
Soybeans	32	38	37	31
Wheat	21	11	25	7
Alfalfa	47	31	41	40
Apples	44	41	40	49
Blueberries	0	8	12	15
Christmas trees	28	24	26	29

Potassium shortage has been a significant and wide-spread problem for many years, but as we have noted before, there seems to be a continuing trend toward increasing problems with K shortage in many parts of the country. The International Plant Nutrition Institute (IPNI) published an extensive survey of over 4 million 2010 soil test results titled "Soil Test levels in North America" that illustrates the problem.

Figure 10 from their survey shows the median or mid-point value of the soil K tests surveyed. These results are in ppm, so if you are accustomed to lb/a, simply multiply the value by 2. While we cannot assign a quality determination to these values without knowing either the soil CEC or the soil type, and critical levels can differ between regions and states, some of this evaluation was done and is shown in their Fig. 12. The amount and direction of change in the median soil K level between 2005 and 2010 is shown in Fig. 13. This data indicates that much of the eastern U.S. has lower than ideal soil K levels and the trend in soil K tests is either relatively flat or negative. And, when considering the factors of ever increasing potash prices and the large amount of annually cash-rented acres, the prospects for improving K fertility are probably not good.

Corn and soybeans are the largest acreage crops and while corn does not have a high K removal rate, its companion crop, soybeans do have a high removal rate. And as we all know, soybeans rarely receive fertilizer of any type. The following table lists some typically reported nutrient utilization values for both crops. When considering crop uptake and removal rates, keep in mind that before a nutrient can be built into the harvested portion of the crop, the crop must first build the plant structure to produce that yield. Therefore you cannot ignore the nutrients that are in the portion left in the field.

Inadequate K fertilization of the corn-soybean rotation results in decreasing soil K availability over time. Fruit and vegetable producers tend to do a much better job of fertilizing those crops, but even there, K tends to be overlooked more than many other nutrients. We also have a significant number of customers producing Christmas trees. This crop tends to be produced on land that is much less fertile than other crops and again we find that many of these growers tend to overlook

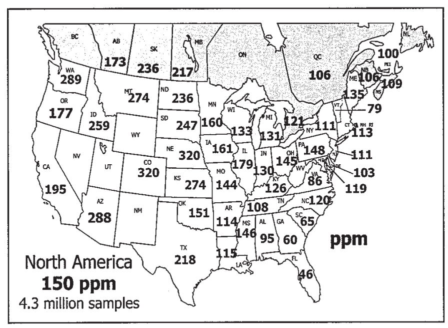

Figure 10. Median soil test K levels in 2010 (for states and provinces with at least 2,000 K tests).

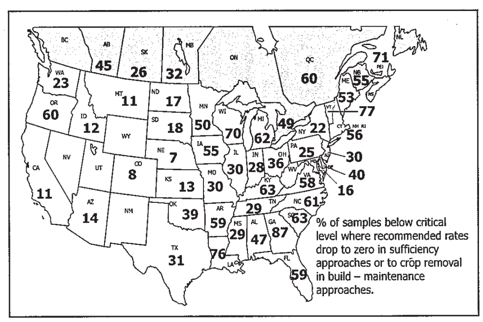

Figure 12. Percent of samples testing below critical levels for K for major crops in 2010.

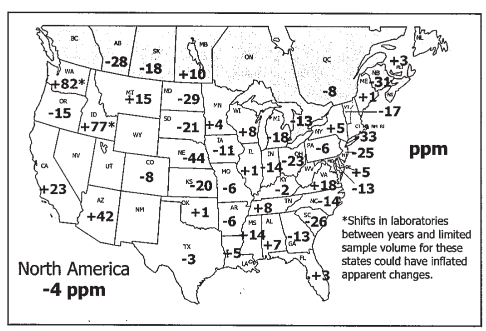

Figure 13. Change in median soil test K levels from 2005 to 2010.

Corn	200 Bu/a	N	P2O5	K2O	Mg	S
	Grain	150	88	58	30	18
	Total	266	114	266	65	33
Soy-beans	60 Bu/a	N	P2O5	K2O	Mg	S
	Grain	240	48	84	12	28
	Total	315	58	205	24	38

the importance of K fertilization. The result of not having used adequate K over a long time span is lower yield potential, more crop diseases, increased drought stress and lower soil K tests in much of the country. While the K application rate is normally the largest factor in determining K availability to crops, it isn't the only one. The other next most important factors are probably 1) the amount and types of clay in the soil, 2) soil moisture, and 3) soil compaction.

It is pretty easy to identify soils with high or low clay content, but not all clay is created equal. In fact, the variations in clay formation, structure and activity is large and complicated enough to warrant its own separate area of science called clay mineralogy. Because of this complexity, we can only touch the surface of the subject here. In simple terms, clay minerals are formed as the result of the decomposition of rocks over geologic time periods. Individual clay particles are the smallest mineral particles in the soil, but they tend to clump together and appear to be much larger. Individual clay particles can be compared to dinner plates and as they occur in the soil they are somewhat like stacks of dinner plates that can expand and contract, somewhat like an accordion. Each of the individual clay particles has electromagnetic charges on their surface, with the edges of the "plates" being somewhat more active. While electromagnetic charges occur in both positive (+) and negative (-) forms, the net effect of all clay charges results in an excess of negative charges on the clay surfaces. These many individual negative charges in the soil act to attract and hold elements with a positive (+) charge (cations) and repel elements with a negative (-) charge (anions). All fertilizer supplied plant nutrients except nitrates (NO_3^-), sulfates (SO_4^-), and the plant available forms of boron (BO_3^-), and molybdenum (Mo) are cations and are attracted to and held by clay. It is not uncommon for farm soils to contain from 30% to 70% clay. Clay is normally the main factor in determining the soil cation exchange capacity (CEC) since it has a net negative electromagnetic charge, a tremendous surface area (due to the small particle size), and most soils contain a lot of clay. The soil CEC is in turn a major factor in determining the soils ability to tie-up, or fix, applied K and other cations, as well as serve as a reservoir for K and other cation nutrients to plants.

There are many different types of clay, each with different physical and chemical attributes. In agriculture we are most often concerned with the following groups.

- Smectite: Typified by Montmorillonite. These clays are younger, less weathered types with high CEC values. They include the multilayered 2:1 type clays, which mean there are two layers of one type sandwiching another layer of a different type. They are typically expanding types that, when dry, can leave large cracks in the land. These clays are more abundant in the cooler Midwest and Northern areas. They have CEC's ranging from 60 to 150 meq/100 grams
- Illite and Vermiculite: Typified by the intermediate age, multi-layered, non-expanding, mica-type clays. They tend to have intermediate CEC values of from 10 to 45 meq/100 grams.
- Kaolin: Typified by Kaolinite. These clays are older, highly weathered, single-layered or 1:1 type clays. These clay types have the lowest CEC of the

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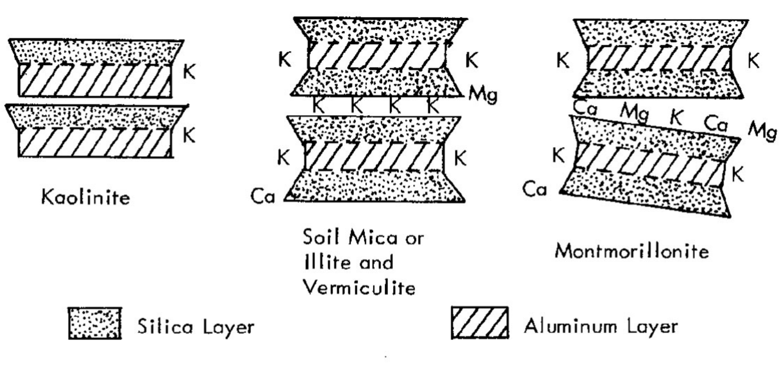

Fig. 3.—The Structure of Four Types of Clay Minerals Found in Kentucky Soils.
AGR-11, Potassium in Kentucky Soils, Issued: 5-73, Revised by: Lloyd Murdock and Kenneth Wells, University of Kentucky College of Agriculture

The Science Behind the Nitrogen Credit for Soybeans

by Dr. T. Scott Murrell, Northcentral Director, IPNI

"Take a N credit for corn following soybean." This statement, or something like it, is common to most N recommendations for corn. The idea is that after a soybean crop, corn doesn't need as much fertilizer N. The common perception is that because soybean is a legume, it adds to the overall N supply in the soil. Let's take a closer look at what is going on with this credit.

The credit itself amounts to a reduction in fertilizer N ranging somewhere between 20 and 60 lb N/A, depending on the recommendation system. It can even be more in some cases. Some universities recommend a fl at rate reduction, while others vary the credit based on soybean yield. Still others use a combination of the two. Common to all of them is that the credit is based on a comparison to a continuous corn system, which typically takes more N to grow a corn crop to the same yield level.

So does corn following soybean use less N or should we really think of it as the continuous corn crop needing more N? It all depends on which one is used as the basis of comparison. A continuous corn crop has more residue that is higher in C. Soil N can be immobilized for a time by soil microorganisms as they utilize the C in this residue, reducing the N available in the soil. Adding the additional 20 to 60 lb N/A makes up for the immobilized N and may also speed the organic matter mineralization process.

Contrary to common perception, levels of nitrate in the soil are often lower after a soybean crop than they are after a corn crop. Soybeans get their N either from the nitrate already present in the soil or from the N fixed by the bacteria present in the nodules. The more nitrate present in the soil, the less comes from the nodules. Consequently, soybeans actually deplete, rather than increase, soil nitrate levels.

So where does the "extra" N come from following a soybean crop? It is currently thought that exudates from soybean roots, as well as the roots themselves, increase a pool of organic N that is easily mineralizable. In the Midwest and Northern Corn Belt, this N becomes available early enough in the season that it reduces the fertilizer N needed, leading to the credit. However, in the warmer, more humid southeast U.S., this N can be mineralized too early in the season, resulting in no credit. In fact, many states in the southeast U.S. do not have a soybean credit.

The soybean credit therefore appears to have more to do with the soybean root system than with the above-ground stem, leaf, and pod residue left after harvest. Consequently, a late season disaster like hail damage wouldn't be expected to reduce the N credit much if the crop was near maturity when it happened. In fact, it likely increases the credit since the high N soybean seed is left in the field and will quickly mineralize once contact with the soil occurs. The magnitude of this credit will be influenced by the duration of warm soil temperatures and the amount of precipitation received afterward in the fall and subsequently in the spring.

The N credit is more than a number. Although it is a simple part of recommendations, it actually reflects a complex set of reactions in soils. Having a better understanding of the science behind the credit can help advisers make adjustments under changing conditions.

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Is There A Need For More Calcium?

by Dr. Robert Mikkelsen, Western North America Director, IPNI

Humans and animals need Ca to build strong bones. Plants also require plenty of Ca to develop strong cell walls and membranes. Animals fed a diet with low Ca develop weak bones and osteoporosis. Similarly, insufficient Ca in plants leads to a breakdown of cell walls and membranes, and to a variety of disease and post-harvest problems. In addition to plant nutrition benefits, sufficient Ca has a role in maintaining soil physical properties, alleviating subsoil acidity, and the reclamation of sodic soils.

There are soil conditions where Ca applications are very helpful. Sandy soils and crops irrigated with low Ca water may be particularly vulnerable to low Ca availability. Soils with low pH generally have low Ca availability. Unusually high exchangeable Mg may pose a problem for Ca uptake by roots.

Most agricultural soils contain considerable amounts of Ca. A good estimate is that each cmol of exchangeable Ca is equivalent to 400 lbs/A (in a depth of 6 2/3 in.). Many soils contain several tons of exchangeable Ca on cation exchange sites. Therefore, it may take large applications of Ca to make significant changes in soil chemistry.

Probably the best known symptom of Ca deficiency is blossom-end rot of tomato fruit, but this problem is closely related to plant water stress and the difficulty in delivering Ca to the fruit. This illustrates one of the problems with Ca deficiencies—is it a lack of Ca that is the problem or is it a problem with delivery of Ca within the plant?

In soil that seems to have adequate Ca, why do deficiency symptoms sometime occur? The problems often appear when Ca does not adequately move to the plant organs where it is needed. Calcium moves primarily with the transpirational water moving up from the roots. Once in the plant, Ca is not readily mobile from one plant part to another. Plant organs that have low transpiration (e.g. fruits such as melons, apples, and tomatoes with a waxy skin, or the inner/sheltered parts of leafy plants such as lettuce) can develop low-Ca disorders. When these disorders develop, sometimes it is related to the soil Ca supply, but it is frequently related to water stress, cool temperature, and limited transpiration.

When low Ca is causing plant problems, start with getting the soil tested. Make sure there is adequate Ca present and low pH is not a problem. Large amendments with Ca inputs such as lime or gypsum may be recommended to address these conditions. When targeted inputs are needed during the growing season, several highly soluble Ca sources are available. They may be best applied to the active root zone to promote rapid uptake. Foliar sprays containing Ca can also be beneficial to address potential deficiencies, but only a limited amount of Ca can be assimilated this way.

Calcium is required by plants in relatively large amounts. Many forage crops, such as alfalfa, remove over 100 lbs Ca/A/yr in harvested hay. When plant deficiencies occur, it is necessary to examine the cause of the problem in order to know the best response. There are many excellent sources of Ca available, but their appropriate use depends on your individual situation.

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Inadequate Potassium

Continued from page 3

three listed here at from 5 to 15 meq/100 grams. They are more abundant in warmer Southern areas.

All soils contain various proportions of several types. The manner in which a particular soil ties up and releases K, and the amount of K that is affected depends in large part to the mixture of clay types and the total amount of clay in that soil. The CEC value on a soil test report is a good indicator of both the amount and type of clay in a soil. High CEC's tend to have more total clay and may have more Smectite types of clay while low CEC soils are likely to have less total clay and/or less Smectite clay types. Soils that have high clay content, but low CEC's are typical of those with a majority of kaolin clay types.

While soil moisture affects the uptake of all nutrients, K uptake is probably more sensitive to dry soils than many other nutrients. What is worse, a primary role of K in plants is to control the stomatal activity of the leaves, thus controlling the plants ability to regulate internal water balance. The result is that dry soils reduce K uptake which is critical to the plants ability to withstand that same drought. A K shortage can mean an ever-increasing downward spiral in crop performance during dry weather. A wheat study illustrates this point.

The author found that while increasing drought stress always reduced photosynthesis, increasing K applications greatly reduced that stress. Since the rate of photosynthesis is central to yield potential, adequate K fertilization is also central to improved yield potential. This next statement might seem illogical, but after a summer of severe drought and K stress it is very likely that a fall soil sample could show a higher K test, even though the crop suffered from reduced K uptake. This is because as the soil dries out subsoil water moves to the surface. As this happens, whatever is dissolved in the water moves to the surface as with the water, including K. The dissolved materials do not evaporate with the water and are left in the top layer of soil. This effectively "mines" the subsoil of K and other relatively mobile nutrients. It is likely that the crops in such a soil may initially benefit from the upward movement of this K, but as the drought persists, any benefits are probably short-lived and the continuing lack of water would begin to take a toll on potential yields. The resulting lower K uptake and any remaining upward K movement during grain fill and in the fall ultimately contribute to a somewhat higher soil K test for that fall after the crop having suffered from a K shortage. Later snow melting and spring rains normally restore the "correct" soil K test.

When most people think about the effects of soil compaction on nutrient uptake, they usually think of the problems caused with P uptake. This is normal, because P is so immobile in the soil that it requires vigorous root growth for the plants to access the available P in the soil and compaction prevents vigorous root growth. However, compaction hurts the uptake of most nutrients, including K. Two of the main mechanisms that cause lower K uptake in compacted soils are probably lower oxygen content in compacted soils and a lower availability of N and P in compacted soils. Plants require oxygen for respiration, just like animals. Plants respire and consume oxygen 24 hours per day, just like we do. When the oxygen supply is too low, they also suffer in the same way as we would under those conditions. With most plants, the oxygen in the roots is obtained from the soil atmosphere, not by having it transported down from the leaves. A typical soil should contain 20% or more free oxygen (O_2) in the soil atmosphere. Soil with poor aeration, due to compaction may have as low as 0.2% O_2. In such low oxygen conditions, the roots begin to suffocate. You might think of it in the same way as mountain climbers as they approach the 10,000 foot level. At that altitude, there is too little oxygen in the atmosphere to support normal human functions and the climbers have to strap on oxygen masks to continue the

Effect of water stress and K^+ supply on net photosynthesis rate in wheat leaves.

K^+ application (mM)	Photosynthesis (µmol CO_2 m^{-2} s^{-1})		
	Water stress in leaves		
	low	mild	severe
0.2	38	11	2
2.0	47	42	21
6.0	46	45	28

Source: Sen Gupta et al., 1989

climb. Nitrogen and P are also typically limiting in compacted soils. We have mentioned the reasons for the P shortage. Nitrogen can be thought of as the nutrient that gives plants their vigor for aggressive growth. When N is deficient it reduces the uptake of nearly all other nutrients, including K. Compacted soils normally lead to less N uptake. Nitrogen is typically deficient in compacted soils because when soil is compacted, the pore spaces in the soil that contains most of the soil air are compressed into smaller volumes. The smaller average volume of soil pores mean that it takes less water to saturate the pores. When the pores become saturated, denitrifying bacteria in the soil take their oxygen from the available nitrate molecules (NO_3), thus converting them to nitrogen gas (N_2) and that N is lost to the atmosphere (denitrification). As the plants begin to suffer this N shortage, and probably a P shortage as well, they become very inefficient at obtaining K and other nutrients. Since the plants need large amounts of K, they are now faced with a shortage of all three major nutrients and yields suffer.

One final problem affecting proper K fertilization is annually cash rented land. Tearing down and building up soil K (and P) fertility is not a one year proposition. Even if high fertilizer rates are applied to a poor P or K soil test, much of that fertilizer will likely be tied up by the soil and yields are not likely to be proportionate to the rates applied. You might say that this nutrient tie-up is like the soil trying to re-balance itself, but regardless of what we call it, nutrient efficiency on a poor soil test is low. This is why agronomists have long compared a good soil test to a bank account. It's great to have a big one, but if you keep making withdrawals it will eventually run out.

Nitrogen in Soil Organic Matter

How Much is Released in Your Field?

by Dr. Clifford S. Snyder, Nitrogen Program Director, IPNI

The most difficult task for any farmer and crop adviser who is developing a N management plan is estimating the fertilizer and/or manure N rate for the expected crop uptake demand. While crop N uptake demand can be estimated based on a three to five-year yield history, knowledge of expected uptake (and removal) at the targeted crop yield, new crop genetic yield potential, and the provision of other essential nutrients and adequate plant protection… the most unpredictable factor that complicates such estimation is the weather.

In sandy mineral soils of the southern U.S., the soil organic matter content of the surface soil is often below 1%, while in the Midwest and Great Plains it can range above 4% because those areas natively supported productive grasslands. Humus is considered the more stable fraction and makes up roughly two-thirds to more than three-quarters of soil organic matter. The N content of organic matter is approximately 5%. The rate of release of the N from soil organic matter depends to a great extent on the C to N ratio of the organic matter acted upon by soil microorganisms. On average, soil organic matter has a C to N ratio of 10:1. If we assume that an acre of soil roughly 6 2/3 in. deep weighs about 2,000,000 lb, then that surface soil depth may contain between 20,000 and 80,000 lb of organic matter; or between 1,000 and 4,000 lb of total N/A.

It is not uncommon for some to use a general rule of thumb of about 1 to 2% release of N in soil organic matter, during the spring through summer growing season each year. The release rate varies with soil texture or CEC, soil pH, soil microbial population, the prevailing temperature and moisture, as well as with any soil disturbance by tillage. The range of N released (mineralized) by soil microbes may be approximately 10 to 80 lb/A each growing season, or more. Obviously, more N is released during warm, moist conditions as opposed to those that are cool and dry. With such a broad range, it is no surprise that there have been many attempts to develop more reliable measures of "potentially available soil N", and in some regions, soil N tests have met with some calibration and field validation success. Often, these "potentially available soil N" tests require sampling beyond the typical 0 to 6 in. depth, and may require sampling to 2 or 3 ft. deep.

In 2007, the International Plant Nutrition Institute (IPNI) published 13 papers from the Proceedings of a 2006 Symposium on Managing Crop N for Weather at the Meetings of the Soil Science Society of America (SSSA). For more specifics and guidance on ways to better account for weather in your 2012 crop N management plan, consider visiting the IPNI webpage where the proceedings may be purchased: http://ppi-store.stores.yahoo.net/books.html. Also consider contacting your Land Grant University extension office or your crop adviser to learn more about soil N testing and how to improve your crop N management plan. By integrating weather variability into your planning, and by using in-season direct plant tissue N testing, or surrogate measures by chlorophyll meters and precision agriculture crop N sensors, you may achieve improved N use efficiency.

The Analysis is published as a service to agricultural dealers and crop consultants by Spectrum Analytic Inc.

If you have any questions or comments, please call 800-321-1562 or 740-335-1562 or Fax us at 740-335-1104.

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