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Fertilizer Recommendations

by Albert L. Sims, Soil Scientist

In recent months I have received several inquiries concerning fertilizer recommendations. Some of these questions range from why recommendations vary depending on whom or what organization is making them to what do the numbers in the soil test report mean. This article will hopefully clarify some of the questions about soil tests and how they are used for fertilizer recommendations.

Soil testing is simply a tool from which the information can be used to make management decisions. The value of the soil test as a tool will be no better than the soil sample of the area, grid, or field they are supposed to represent. The first step would be to make sure the soil samples are properly taken to represent the area of interest. Most reputable labs are very good at the actual chemical analysis, but you may want to inquire as to their certification and how they handle their own quality control. In most cases, labs will maintain a check sample that is included with all soil sample analysis. The lab knows the range of values that they should measure on the check sample. If the check sample value is not within a specified range during a particular analysis run, then the entire run is redone. Sometimes things happen that will cause a run to be thrown out. These things can range from mistakes in making reagents to malfunctions of the measuring instrument. This happens, and most labs can deal with the problem promptly and reliably. Nevertheless, sometimes soil test values still come out strange or unexpected. The first area to look for a problem is in the soil sampling and may require re-sampling the field or area of interest.

The soil test analysis are used to make fertilizer recommendations. How those tests are used depends on the philosophy of the individual or organization. There are four basic fertilizer recommendation philosophies used in Minnesota. They can be identified as Crop Removal, Build and Maintenance, Basic Saturated Cation Ratio (BSCR), and Correlation and Calibration. The first three use soil tests to monitor nutrient status in the soil and the last one, Correlation and Calibration, uses soil test as a predictive tool. Another basic difference between these various philosophies is in their approach to making the fertilizer recommendation. Again the first three, Crop Removal, Build and Maintenance, and BSCR, tend to fertilize the soil while the Correlation and Calibration philosophy tend to fertilize the crop.

Crop Removal fertilizer recommendations are based on the expected removal of nutrients by the crop being grown. That is, if the crop is expected to remove 20 pounds of phosphate (P) per acre then 20 pounds of P per acre should be applied as fertilizer. This philosophy may also tend to include several micro nutrients in the fertilizer recommendation. In the purest form of the philosophy, the natural nutrient supplying capacity of the soil is not accounted for. Soil tests are used to monitor the soil nutrient status to determine if soil nutrient mining has occurred.

The **Build and Maintenance** philosophy also uses soil tests to monitor the soil nutrient status. Fertilizer recommendations are based on the philosophy that soil tests for specific nutrients should always be in the high category to maintain maximum production potential. Recommended quantities of fertilizer will attempt to build soil test levels to the high category. Once this has been achieved subsequent recommendations will be based on crop removal. In most cases, P and potash (K) are the primary nutrients being targeted in this philosophy. Again, the natural capacity of the soil to supply these nutrients to the crop plays a minor role in the recommendations. Unfortunately, water quality issues, as it pertains to P contamination of surface bodies of water, can be impacted by maintaining high levels of soil test P. Research has shown that more P is lost in the runoff from soils testing high in P than in soils testing at lower levels. All soils do not respond the same to similar applications of fertilizer, which is primarily attributed to the soil chemistry. Generally, 18 pounds of P_2O_5 per acre is expected to raise the soil test P level by 1 part per million (ppm). Research in Minnesota has shown that 100 pounds per acre of P_2O_5 raised the soil test P level by 1.9 ppm at Waseca, but at Morris the same rate of fertilizer raised soil test P levels by 2.5 ppm.

The **Basic Saturated Cation Ratio** philosophy is primarily centered on the ratios of specific positively charged nutrients. Calcium (Ca), Magnesium (Mg), and K are the primary targets. Soil tests are used to monitor the cation exchange capacity (CEC) of the soil and occurrence of Ca, Mg, and K on these exchange sites. Fertilizer recommendations are based on what is perceived to be the most fertile or productive ratio of these cations with each other. That is, they are based on Ca:Mg, Ca:K, and Mg:K ratios as well as a predetermined evaluation of what percentage of the cation exchange sites should be occupied by each of these cations. Natural conditions of the soil or its natural capacity to supply nutrients for crop needs are not considered. Field research in the North-Central states has not supported this recommendation philosophy.

The **Correlation and Calibration** philosophy on fertilizer recommendations is based on greenhouse and field research that has been conducted over many years, soils, and environments. In this philosophy, soil tests are used as a prediction tool for crop response to fertilizer application. This philosophy also recognizes that a particular soil test does not work for all soils. An example is the difference between the Olsen and Bray P soil tests. Research has shown the Olsen P soil test works best on soils with pH of 7.4 or greater, but for soils with pH of less than 7.4, the Bray P soil test works best. The research used in this philosophy has two components: the correlation component and the calibration component. In the correlation component, soil test values are compared to relative crop production. A good correlation shows increasing crop production with increas-

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Smith's Comments

(With the planting weather we have had recently, trying to barricade Dr. Smith's office and convince him to write this article is like trying to find the end of the rainbow. So, this is written by the associate editor, less the flair and expertise of Dr. Smith.)

What a difference a year can make! In April of 1997, we had just experienced the worst flood in the history of the Red River Valley. The winter and spring of 1998 have been fantastic. According to our weather report for the month of April, the average temperature was 48.0°F compared to 35.4°F for last year. But the precipitation for April is only 0.93" compared to 3.24" last year. The farm crew started in the fields on April 20th and planting of small grains and sugarbeets was completed by May 1.Then the weather changed! The station has recorded 5.9" of precipitation from May 1 through the 16th, with the last 3" coming down hard and fast.

The Station has assumed responsibility for dryland potato research formerly done at the potato research farm in Grand Forks. Researchers from St. Paul will be completing plot work in the next few weeks.

The new Controlled Environmental Science Building located next to the Ag Research Center has been completed this winter. It is a state-of-the-art building that links the ARC Bldg to the rest of the campus buildings and is a welcome addition to the Crookston campus, especially during the winter.

Congratulations to Dr. Carol Windels on her promotion to full professor with the University of Minnesota. There are also several new faces on the Station - Dr. Ian MacRae joined the staff on August 1 as an extension entomologist. Kim Hoff is a junior scientist working the soil and water lab. Luther Miller was hired as an assistant scientist and Galen Thompson is employed as a research fellow on the scab research projects. Nancy Vraa is our new custodian, replacing Milan Samshal, who retired. Danny Weber joined the staff just recently as a research plot technician.

Various field schools and field days will be held in July. Watch your newspapers for more details. Have a good summer.

Remick Receives Scholarship

Jason Remick received the 2nd **Sandra M. Smith Scholarship**. Jason, a graduate of Lafayette High School in Red Lake Falls, is completing an electrical lineman course at Wadena Technical College.

Jason was employed at the Northwest Experiment Station for several summers in the pesticides and water quality department.

The scholarship is designated to assist employees, spouses and/or dependents of the Northwest Experiment Station to continue their education at the college of their choice.

Jason is the son of Kristie and Rusty Remick of Red Lake Falls. Rusty is a member of the maintenance crew.

Remick Named Employee of the Year

Russell Remick, better known to the everyone at the Northwest Experiment Station as Rusty, was named as the recipient of the **12th Annual Employee of the Year.**

Rusty has been employed at the Station since January 1994 as a Maintenance and Operations Mechanic, which means he does a lot of different things in the maintenance department.

Rusty is a master electrician and also owns his own business, Sparky's Electric, in the Red Lake Falls area.

Rusty was nominated for this award by his co-workers because of his knowledge of his job, and his friendliness and willingness to help his fellow employees.

The **Employee of the Year Award** was designed to promote and recognize excellence in job performance among Civil Service and Bargaining Unit personnel. Funds for this special award come from a President's Club donation designated especially for this purpose. Congratulations, Rusty!

(L to R) Kristie Remick, Rusty Remick and Larry Smith

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ing soil test levels up to some point beyond which crop production does not improve. In the calibration component soil test readings are placed into categories or soil test levels such as very low, low, medium, high, or very high in accordance to the likely hood of a crop response to fertilizer application. Soil tests in the high to very high category generally result in no crop response to fertilizer indicating there is adequate nutrient available for the crop. Soil tests in very low and low category generally result in a large crop response to fertilizer application. During the calibration phase, fertilizer rates are included to define the most economical rate of fertilizer that should be applied with a given soil test level or category to achieve optimum crop production. The calibration component takes many years of research on many soils and over many environments before fertilizer recommendations can be made with any degree of certainty. The Correlation and Calibration philosophy accounts for the individual soils natural capacity to supply nutrients to the crop and is the primary philosophy used by the University of Minnesota and North Dakota State University to make fertilizer recommendations.

The definitions for each philosophy are rather simplistic and probably apply to each philosophy only in its strictest sense. The reality is that the type of research needed for correlation and calibration requires extensive research dollars and time. All of the philosophies, except perhaps the BSCR philosophy, use components of the others. For instance, the monitoring of soil nutrient status in the Crop Removal and Build and Maintenance philosophies uses soil test values that were developed through Correlation and Calibration research. In the Build and Maintenance philosophy, Correlation and Calibration research is used to determine what soil test level is considered in the high category. Nevertheless, these different philosophies can result is substantially different fertilizer recommendations. Experiments conducted in Nebraska and Minnesota have shown that not only do fertilizer recommendations vary among recommending agencies, but also the economic bottom line. Both of these experiments were fertilized according to recommendations given by labs with various philosophies. All labs, including the university labs received soil samples and made recommendations without knowing it was for experimentation. Table 1 shows average yields and fertilizer cost at two locations in Nebraska as recommended by the various labs from 1974 - 1984. The Correlation and Calibration philosophy, which is used by the University of Nebraska, resulted in the least fertilizer cost while resulting in similar corn yields. A similar experiment was conducted at the Southern Experiment Station at Waseca, Minnesota.

Table 1. Average annual fertilizer costs and corn grain yields as a result of fertilizer recommendations from different laboratories and different recommendation philosophies at two locations in Nebraska.

Soil Test Laboratory†	North Platte Exp. Station Grain Yield	North Platte Exp. Station Fert Cost	Northwest Exp. Station Grain Yield	Northwest Exp. Station Fert Cost
	---Bu/A---	---$/A---	---Bu/A---	--$/A/yr--
Lab A	169	47.80	94	24.84
Lab B	168	55.98	95	25.82
Univ of Nebr	169	22.75	95	12.43

† Lab A and B are private labs that vary in their philosophy of making fertilizer recommendations

Table 2 shows fertilizer costs were less, crop returns in terms of dollars were similar, and net return in terms of dollars were greater when following University of Minnesota fertilizer recommendations.

While the Correlation and Calibration philosophy is research based, it does leave room to account for varying yield goals. For example, at a given soil test level, less fertilizer will be recommended for 40 bushel per acre yield goal than a 60 bushel yield goal. Two major weaknesses of the correlation and calibration philosophy are the time and money the research requires and not all soil nutrients can be adequately described through soil tests. An example of the latter is sulfate-sulfur soil test. The sulfur soil test is only correlated for sandy, low organic matter soils, but not correlated on fine textured, loam to clay textured, soil with high organic matter. These finer textured, high organic matter soils frequently test low for SO_4-S, but the crop will not respond to fertilizer.

Table 2. Fertilizer costs, crop value, and economic return as a result of fertilizer recommendations from different laboratories and different recommendation philosophies between 1980 and 1987 at the Southern Experiment Station at Waseca, Minnesota.

Soil Testing Laboratory†	Crop Value	Fert. Costs	Return‡
	--- $/A ---	--- $/A ---	--- $/A ---
Lab A	2657	436	+212
Lab B	2676	547	+120
Lab C	2659	344	+306
Univ. of Minn.	2666	295	+362
Control	2009	0	-

† Lab A, B, and C are private labs with different fertilizer recommendation philosophies.
‡ Return = Crop Value - Value of Check - Cost of Fertilizer

None of the soil testing philosophies are perfect. The soil - plant relationship is very complex and can change with changing weather patterns, management strategies, varieties, and crops. While I am a proponent of the Correlation and Calibration philosophy, it is noted that not all soil, management strategies, varieties, and environmental conditions have been tested. Frequently, individual growers will recognize that the recommended fertilizer rates, regardless of the philosophy used, are not adequate for their conditions. But even in this case, observations by the grower, is the reason they recognize the discrepancy.

An argument for Build and Maintenance and Crop Removal is that soil fertility levels are maintained at natural or higher levels. The thought is that soil productivity and fertility will be preserved for future generations and maintain land value. However, it must be remembered that soils do have a natural capacity to supply nutrients even though it may not be enough to satisfy crop needs. If these nutrients are not utilized, they will either remain in the soil or will be removed from the system by leaching or erosion. The fertilizer that is applied must come from somewhere. In the case of P and K fertilizers, the raw materials from which they are made are mined. Excess fertilizer applications

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simply move resources from one place on the earth to another while at the same time costing growers money that they may not need to spend. This could be an important consideration with farm economics being in a less than desirable condition.

Judicious and careful use of fertilizers are necessary to maintain optimum crop production levels, protect the environment, preserve soil resources, and maintain the farming community. The quantity of fertilizer to apply to obtain an optimum production level for a given soil will depend greatly on the philosophy used to make the recommendation and experience of the grower.

Hopefully, this discussion has clarified some the misconceptions and questions concerning fertilizer recommendations. Without testing the soil to determine nutrient levels, the type and rate of fertilizer to apply are mainly guesses. While soil test based fertilizer recommendations are not perfect; soil tests can be a powerful management tool. Have a safe spring season and may the weather be kind to us to allow a productive and profitable year.

Sources of Information:

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Youngquist Auditorium Dedicated

The former Ag Research Center Auditorium has a new name! The auditorium's name was changed to **Youngquist Auditorium** in honor of former superintendent, Bernard E. Youngquist. Bernie was superintendent of the Northwest School and Experiment Station from 1956 to 1983.

Dr. Youngquist's tenure at Crookston was marked by a doubling in land resources and a substantial increase in staff and research, making the Northwest Station a model for various agricultural research and education needs in the region. He played a key role in the establishment of the University of Minnesota Technical College, the Red River Valley Natural History Area, and the expansion of the Red River Valley Winter Shows where he served as president of the Board of Managers for 26 years. Bernie was also chairman of the Citizen's Advisory Council of the Souris-Red-Rainy River Basins Commission for 8 years. He recently completed his 16th overseas consulting trip where he continues to share his expertise in technical and human service with a non-profit agency working with third-world countries.

Dr. Youngquist is most pleased to have been of service to people. The Youngquist Auditorium is a place where learning takes place; and a fitting tribute to one who champions human resource development on a local, regional and international scale

Pictured at the dedication of Youngquist Auditorium are (L) Regent Bob Bergland, Roseau; U of M President Mark Yudof; Bernie Youngquist and current superintendent Larry Smith

Milan Retires

Pictured below are Milan and Laverne Samshal at Milan's retirement party. Milan was employed at the University of Minnesota for 27 years. He was custodian for the Northwest Experiment from 1990 to 1997.

Congratulations, Milan, on your retirement.

New Faces at the Station

Newest member of the staff at the Northwest Experiment Station is **Danny Weber**. Danny is originally from Crookston and started May 4 as a research plot technician. Danny will provide support in the small grains, soil science, pesticide management and entomology research programs. Danny attended Northland Community and Technical College and UMC. Danny and his family live southeast of Crookston.

Next to the newest member of the staff is **W. Galen Thompson**. Galen is a research fellow on the agronomy department's scab project. Galen's primary responsibilities are the coordination, maintenance and evaluation of a comprehensive spring wheat/barley disease screening nursery.

Galen was born and raised on a grain farm in eastern North Dakota and graduated from Climax High School. He graduated from NDSU with a bachelor of science and from Montana State University at Bozeman with a master of science in plant and soil sciences.

Galen spent about 10 years working with various agronomic crops in Hawaii. Previous to joining the staff he was marketing director and potato research farm manager for the Red River Valley Potato Growers in East Grand Forks.

Kim Hoff is a junior scientist in the soils and water quality lab. Kim joined the staff in June of 1997, where she is responsible for managing the wet chemistry lab and conducting chemical analysis of soil, plant and water samples in support of the soil science and water quality research projects.

Kim graduated from Borup High School. She graduated from UMC in 1995 with a B.S. degree in Technical Studies. Before joining the Experiment Station staff, she was employed at the North Dakota Mill in Grand Forks.

Kim and her husband, Dale, and two daughters reside in rural Crookston.

Nancy Vraa is the new building and grounds person. Being Nancy is only part time, she continues to work at a group home in Red Lake Falls along with custodial duties at the Red Lake Falls Veterinary Clinic. Nancy, her husband, Neal, and their family live in Red Lake Falls.

Nancy is also a member of the Red Lake Falls Voluntary Ambulance Force. She enjoys using her knitting machine, crocheting, snow mobile riding, and family activities.

Luther Miller joined the staff as an assistant scientist working on the scab project in the soil science department.

Luther is originally from West Fargo, North Dakota, and graduated from NDSU with a B.S. degree in soil science. Luther is a member of Phi Kappa Phi Scholastic Honor Society.

Luther was a research technician in the Soil Science Department at NDSU where he helped collect data on soil fertility/plant nutrition research trials. He also worked at the Fargo Forum previous to accepting employment with the NWES.

Dr. Ian (E-N) MacRae, extension entomologist, started August 1, 1997. Ian received his B.S. from the University of Prince Edward Island, P.E.I., Canada. His M.S. from the University of Victoria in British Columbia and his Ph.D. in entomology from Oregon State University.

Ian was a post-doctoral research associate in the Dept. of Entomology in Colorado before coming to Crookston. Ian has a unique position in that his appointment is split between teaching at UMC, research at the NWES, and outreach and extension for the Dept. of Entomology in St. Paul. Ian has experience in using GIS and other computer tools to examine spatial aspects of population biology.

Ian and his wife, Colleen, are making their home in Crookston.

When Should Dairy Calves Be Weaned?

By George D. Marx, Dairy Scientist

The average age of weaning dairy calves by producers is 7.9 weeks as reported by the USDA in the National Dairy Heifer Evaluation Project Summary. This is nearly double the period required under good management. With the high cost of milk or milk replacer this is a significant factor in the cost of raising baby calves. These questions of when to best wean dairy calves prompted the study which was recently completed at the Northwest Experiment Station and reported at the 1996 summer meetings of the American Dairy Science Association in Corvallis, Oregon.

Forty dairy calves were utilized in a trial that compared weaning at four weeks or eight weeks of age. Calves were fed colostrum the first three days and whole milk thereafter at 4.5 kg (10 lb) daily, divided between two feedings. The grain starter was fed free choice, was 18% protein and balanced to NRC standards to meet requirements. Water was available free choice with automatic waterers in each individual pen. Feed samples were collected weekly and composited for nutrient analysis. Daily feed intakes were recorded along with any weigh back. No forage was fed until the start of the fifth week and then fed ad libitum. Body weights, calf health, severity of scours, and medical treatments were recorded.

Housing was indoors, in individual calf pens 4' x 5' in a separate insulated and continuously ventilated calf facility where temperature was maintained at 10°C (50°F) during the winter months. Data were analyzed statistically by General Linear Models (GLM) procedure of SAS. Performance data of calves weaned at four or eight weeks included weight gains, milk consumed, grain starter, and forage intakes. Males versus females and large sired versus small sired animals along with the economics of early weaned and late weaned calves were also studied.

In summary, the following conclusions were reached based on the results of this study:

- Early weaned calves consumed 95% more grain starter.
- Early weaned calves consumed 45% more forage.
- Late weaned calves required twice as much milk.
- Late weaned calves gained 27% more weight.
- Body weights, grain starter and forage intakes were all statistically different ($P<0.05$) between early and late weaned groups.
- Forage intake was low during early calfhood.
- Early weaned calves had 33% lower feed costs.
- No unusual health problems and no deaths occurred in either group.

In general, early weaning is more profitable and has no apparent detrimental effect on the calves when properly managed. If interested, a more detailed four-page report on this study is available from the Northwest Experiment Station, Crookston.

George Marx Receives Farm Bureau Award

George Marx, professor of animal science at the Northwest Experiment Station was honored by the Minnesota Farm Bureau Federation recently. The award "recognizes the important role that professionals play in helping farmers keep up-to-date on new technology, encouraging young people to choose agriculture as a career and working with others in the ag community such as our Farm Bureau leaders," said, MFBF President Al Christopherson.

Marx has observed farm operations in numerous countries. In the past year, he has supervised training of dairy milkers, herdsmen and farm managers from Russia.

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