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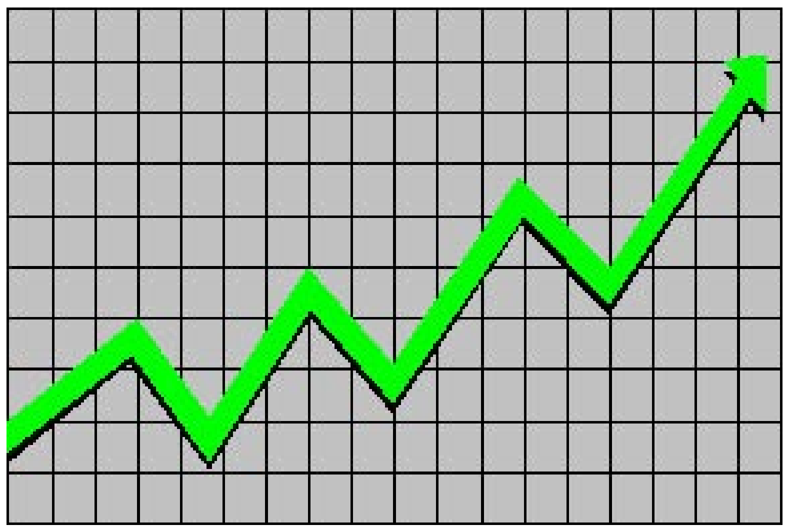
FROM THE GROUND UP
Agronomy News

Strategies For Stretching Nitrogen Fertilizer Dollars



INSIDE THIS ISSUE

New Higher N prices are linked to natural gas prices, and will make farmers take a second look at management practices.

Why are nitrogen (N) prices so high this spring? The N fertilizer prices have more than doubled since last year. This is mainly because of large increases in natural gas prices. What do natural gas prices have to do with N fertilizers? Nitrogen products are manufactured from ammonia synthesized from natural gas, steam and air. Ammonia is the most concentrated N fertilizer, and is upgraded to produce other N products. Nitrogen production costs are affected the most by natural gas prices. The natural gas component of N production costs is roughly 70 - 90% of the total cost.. With the price of natural gas at an all time high, as many as 30% of the nation's ammonia plants may halt production completely. The inflated production costs, as well as the decreased supply of ammonia are resulting in a sharp rise in N fertilizer

Knowledge to Go Places

Strategies For Stretching Nitrogen Fertilizer Dollars (continued)

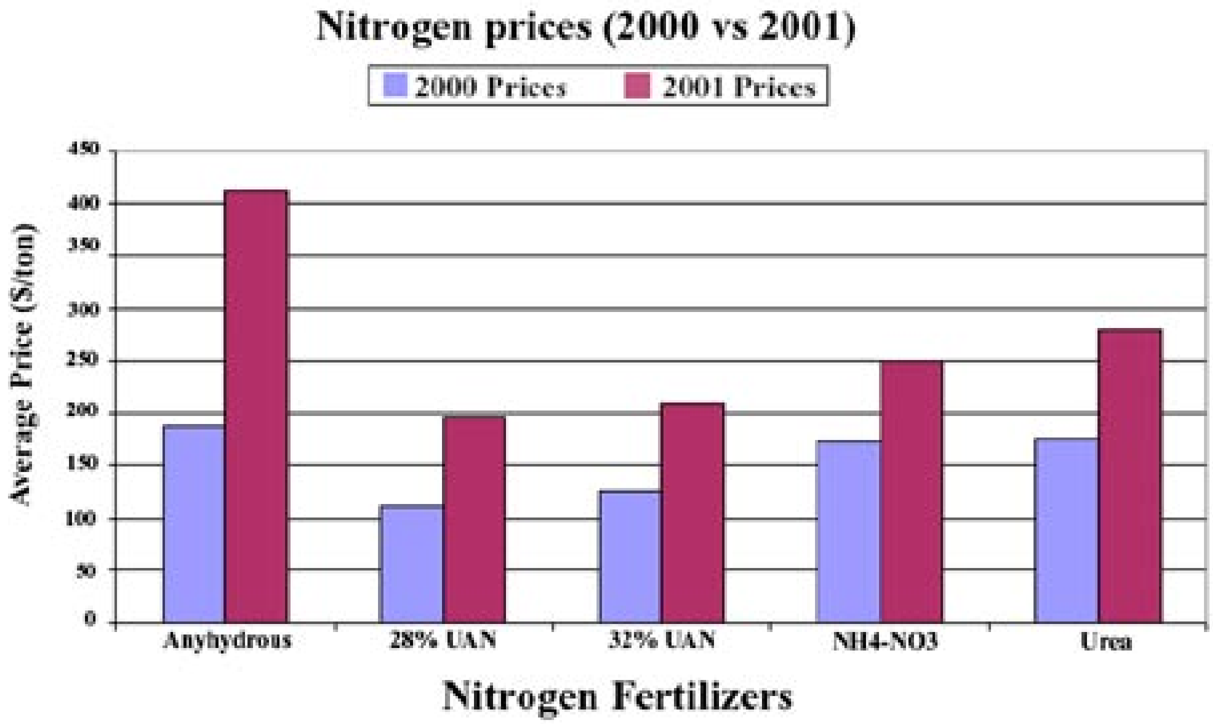


Figure 1. Nitrogen prices comparison 2000 vs. 2001.

prices this year. Figure 1 and Table 1 show the increase in prices of various N fertilizers as compared to last year. The situation may become even worse as current market prices are well below production costs. This, in turn, is forcing N production plants to scale back or shut down. Tighter supplies, along with no signs of a warming trend this winter, will continue to keep natural gas prices high which will keep the price of N fertilizer high. Why don't we import ammonia, the main source of N fertilizers from other countries to meet our deficit? Although more than 75 countries around the world produce ammonia, the cross-border trade is very limited, averaging only about 11 % annually. According to The Fertilizer Institute (TFI), nitrogen imports were up more than 27% from the year before, between July and November of last year. However, this increase is still insufficient to meet our current needs. Further increase in

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FROM THE GROUND UP

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Strategies For Stretching Nitrogen Fertilier Dollars (continued)

nitrogen imports doesn't seem likely, because most countries use their production internally, and demand for ammonia is high there as well.

The big question is how do we deal with the current situation? Well, there are various N management options available for producers. Cutting back a few pounds from conventional application rates is unlikely to reduce yields. Also, paying adequate attention to N credits, where available, can make a significant difference. There may be potential to maintain yields with reduced levels of N application, while maintaining reasonable profit margins. As the weather warms up and natural gas prices start to come down we may start seeing changes in N production. In fact, some of the plants are coming back in operation already, although not to their full capacity. However, how long it will take before that is reflected in the N fertilizer prices this year is a good question. The following articles will share and illustrate various nitrogen management techniques of using N fertilizer sensibly without compromising grain yield and farm profitability.

by Raj Khosla
Extension Specialist
Precision Agriculture

Table 1. Nitrogen fertilizer, fertilizer grade, and price (US$) in 2000 and 2001.

Fertilizer	Grade	Prices in 2000		Prices in 2001	
		Range	Average	Range	Average
Anhydrous-NH_4	82-0-0	180-200	187	350-510	412
28% UAN	28-0-0	97-125	111	140-220	197
32% UAN	32-0-0	110-139	125	180-243	210
NH_4-NO_3	34-0-0	138-215	172	250	250
Urea	46-0-0	155-190	176	240-360	279

Soil Testing Is Worth The Cost

Residual soil nitrogen may help reduce fertilizer costs.

An investment in a good soil sample from every field where nitrogen fertilizer or manure is applied will pay off this year! The cost of soil sampling ($1.00 to $2.50 /acre) can be offset by saving only three to six pounds of nitrogen (N) fertilizer per acre at current fertilizer prices. Several laboratories and consultants are reporting high residual nitrate levels in many fields this year. This is most likely due to an extended period of above normal soil temperatures last summer. This condition may have caused soil microorganisms to break down (mineralize) soil organic matter into ammonium and nitrate nitrogen at a higher rate. Take advantage of this situation by sampling all fields for residual soil nitrate.

Soil testing programs start with organizing planting areas into the sites that are similar in soil textures, slope, location or other characteristics that set them apart from other areas. The next step is to obtain a high-quality, representative soil sample. Generally taking 15-25 sub-samples from a uniform area (no more than 40 irrigated acres) will provide the most unbiased composite sample. More sub-samples taken within a designated area will give a better idea of the field's fertility status and will provide a better comparison of data from year to year. Under-sampling may result in striking a fertilizer band that doesn't represent the entire area, not striking any bands, or sampling areas where a heavy application of fertilizer occurred. Fields applied with manure or biosolids should have numerous sub-samples taken to avoid abnormally high or low levels of nutrients. Samples can be taken with coring devices, sampling tubes, augers or shovels. They should be rust free to avoid contamination of the samples with iron. Avoid zinc coated galvanized tools or buckets to prevent sample contamination with zinc.

Sampling depth for surface samples may vary with the type of cropping system used. For most row crops using conventional tillage methods, a surface sample of 8-12 inches is sufficient. For no-till or minimum tillage, a surface sample of 4-6 inches may be more representative, since more plant residues would be present at the surface and phosphorus levels may be much higher than phosphorus levels from 4-12 inches. Subsoil samples taken from 8-24 inches or 12-24 inches are necessary to fully evaluate nitrate levels. Laboratories can make a more accurate recommendation if you sample the subsoil. Subsoil samples are especially needed for corn, small grains and sugar beets. Additional subsoil samples of 24-36 inches and 36-48 inches are needed for sugar beets to measure nitrate levels throughout the soil profile.

Sub-samples should be well mixed and 2-3 cups removed, air dried, and packaged in an appropriate container. A plastic lined soil-sampling bag is ideal, however a plastic resealable bag can also be used. Bags can be obtained from laboratories, crop consultants or Cooperative Extension agents. Don't use glass containers since they easily break when sent through the mail.

Soil sampling every year provides growers enough information to appraise how a particular cropping system is working and provides the best information for determining the most economical levels of fertilizer to apply.

by Jim Self
Manager
Soil, Water, and Plant Testing Lab

Fertilizer Recommendations

Lab recommendations are developed based on a fertilizer philosophy, good samples, and adequate history from the farmer.

Once a soil sample has been analyzed for its nutrient content, the laboratory can make a fertilizer suggestion. However, growers should be aware that contrasting philosophies exist between laboratories, which can result in different recommendations for the same field, soil, and crop. These philosophies include the prescription method, the prescription plus buildup, and recommendations for a full rotation. The prescription method suggests only the amount of fertilizer needed for one season's crop growth. The prescription plus buildup is used to increase nutrients such as phosphorus or potassium in the soil above those levels that are actually needed for one year's growth. The buildup of nutrients ensures that a particular nutrient is always available for plant growth even if adverse growing conditions arise. Applying fertilizer for a full rotation requires the application of a large amount of nutrients the first year with little or no additional fertilizer application in following years.

During this time of higher fertilizer costs and low crop prices it is most economical to apply only those nutrients needed by the crop for one growing season. With the exception of alfalfa, the fertilizer suggestions at Colorado State University are designed to add only those nutrients necessary for one growing season.

While fertilizer suggestions are made using the nitrate-nitrogen (NO3-N), phosphorus and potassium levels in the soil, other information, such as yield goal, percent organic matter, previous crop, manure application rate and water usage are also needed. With the exception of alfalfa, parameters such as yield goal, percent organic matter and NO3-N in the soil determine the nitrogen (N) fertilizer suggestions from CSU. Growers should base yield expectations on a 5-year field average and provide this information to the laboratory.

If the grower does not provide a yield goal, the lab uses a default yield goal to determine a N fertilizer rate. However, the grower can later adjust the amount of nitrogen needed depending on their actual yield goal. For example, the standard yield goal for irrigated grasses is 4T/A, however the grower can adjust their yield goal to any reasonable level by adding or subtracting 40 lb.. N per ton difference in yield goal. Past manure applications and previous crops, especially legumes may reduce the final N fertilizer recommendation. Laboratories use this information to estimate N credits and suggest the most economical fertilizer rate (see article titled Give Credit Where Due!).

For most crops the NO3-N in the surface soil samples is used for N fertilizer suggestions. However, for corn and sugar beets the amount of total soil nitrate is determined from both the surface and subsoil levels of NO3-N, if subsoil is provided. If a subsoil sample is not provided, it is assumed that the subsoil contains one-half of the NO3-N found in the surface soil sample. If a soil sampling depth is not provided, it is assumed that the surface soil sample depth is to twelve inches and that the subsoil depth is 12 to 24 inches. For corn, a weighted average of surface and subsoil NO3-N is used where the amount of NO3-N in the sample is multiplied by depth.

When a subsoil sample is not provided, there could be a lower estimate of the subsoil nitrate level, resulting in less NO3-N in the two-foot profile and a greater N fertilizer suggested rate. Therefore, it is important to provide a subsoil sample to take advantage of the possibility of a greater nitrate level in the subsoil that will reduce the N fertilizer rate.

Fertilizer suggestions provide a guideline for growers to make management decisions regarding the addition of nutrients. Current fertilizer suggestions from CSU provide the most economical fertilizer rates to provide the best return on a crop yield within a given growing season.

by Jim Self
Manager
Soil, Water, and Plant Testing Lab

Give Credit Where Credit Is Due!

Nitrogen sources other than fertilizer can provide a significant contribution to crop N requirements.

Have you applied manure or grown alfalfa on a field within the last three years? Does your irrigation water contain nitrate? Any of these situations contribute nitrogen (N) to the growing crop. The crop doesn't care if the N comes from legumes, irrigation water, or fertilizer! In some cases, these N credits may entirely satisfy crop needs and no additional manure or fertilizer is required. Table 2 shows various N credits. A starter fertilizer may be the only supplemental fertilizer needed to enhance seedling vigor. Be sure your crop advisor or soil testing lab knows whether any of these N credits apply when requesting a recommendation for a field.

Legumes

Legume crops can be a very significant source of plant available N due to bacterial N2 fixation in root nodules (see Legumes Fix Nitrogen). Plowing down a good stand of alfalfa may release more than 100 lbs. of N per acre in the first year after plow down, and 50 lbs. the second. If you have an older stand of alfalfa, you may want to consider rotating it to a high N requiring crop and moving your alfalfa acres to another field. Using the above N credits for alfalfa, the difference between projected price of the rotating crop and alfalfa, and your market price for N, you can decide whether to invest these N credits in another crop or keep the field in hay. Either way, don't underestimate the contribution of this N source.

Manure

We cover this topic in more detail in the next article, but Table 3 provides approximate manure credits for Colorado. Keep in mind that a manure application to a field within the past three years will still be supplying some N to this year's crop. A rule of thumb for N release from manure is that 40% of total N is available in the first year, 20% in the second, and 10% in the third year.

Irrigation water nitrate

Irrigation water containing nitrate can supply considerable amounts of N because it is applied during the growing season and is immediately available for crop uptake, thus potentially reducing fertilizer required. Fields irrigated with water that has nitrate-nitrogen (NO3-N) concentrations greater than 10 ppm are most likely to benefit from crediting. The South Platte River, the Arkansas River,

Table 2. Estimates of N credits from various sources.

N Source	N Credit
Soil organic matter*	30 lb. N per % OM
Residual soil nitrate*	3.6 lb. N per ppm NO_3-N (1 ft. sample)
Previous alfalfa crop**	
>80% stand	100 - 140 lb. N/acre
60 – 80% stand	60 - 100 lb. N/acre
<60% stand	30 - 60 lb. N/acre
Dry Beans	25 - 30 lb. N/acre

*These credits are often factored in N fertilizer rates recommended by soil testing labs and should not be deducted twice.

**For the second year, use ½ of the first year N credit.

Give Credit Where Credit Is Due! (continued)

Table 3. Manure N credits.*

Manure (solid)	% H_2O	Total N	Available 1st Year
		---- lb. N/ton Manure ----	
Beef	32	23	9
Dairy	46	13	5
Swine	82	10	4

*Credit based upon average values for Colorado.
Sample manure for actual nutrient content when feasible.

and the San Luis Valley include several locations where enough NO3-N has accumulated over time in the groundwater to benefit crop production. Producers using this nitrate enriched groundwater to supply most of a field's water will profit by crediting this N source when determining their fertilizer rate. Crediting water nitrate also improves water quality by removing it from the groundwater through crop uptake while reducing their fertilizer needs.

How to calculate irrigation water nitrate credits:

1. Determine the NO3-N content of the irrigation well water by field test kits or laboratory analysis. Initially, sample water twice a year to account for seasonal variability, and then annually.

2. Estimate how much water to credit. Most N uptake is during a crop's vegetative growth stage. Only credit water applied before the crop begins reproductive growth (boot stage, pollination, tuber growth) The upper limit for these credits are: 15 inches for corn; 12 inches for small grains; and 6-10 inches for potatoes. Use Table 4 (chart or equation) to determine the N credit.

Remember that reducing a fertilizer rate by crediting irrigation water nitrate should not be practiced without using soil testing to initially determine a crop's N needs.

EXAMPLE SITUATION:

- Crop: corn
- Well test results: 18 ppm NO3-N
- Seasonal consumptive use for area: 21 inches of water
- Inches of water to credit = 21 inches ET x 70% of seasonal (.70) = 15 inches
- Water Credit = 18 ppm x 0.23 x 15 inches/acre = 60 lb. N /acre

Saves $19/A (@$0.32/lb N

Total all available N sources from irrigation water, legumes and manure determine the total N credit. The "free" N available to your crop might surprise you!

by Troy Bauder
Extension Specialist
Water Quality

Table 4. Irrigation water nitrate credits.

Water NO_3-N (ppm)	Inches of Water to Credit				
	--5--	--7.5--	--10--	--12.5--	--15--
	---- lb. N/A ----				
10	11	17	22	28	34
15	17	25	34	42	51
20	22	34	45	56	70
25	28	42	56	70	84
30	34	51	67	84	101
35	39	59	79	98	118

Equation: N credit (lbs/acre) = NO_3-N ppm x 0.23 x inches H_2O

Note: an acre-inch of water contains 0.23 lbs.. of N for each ppm of NO_3-N
1 ppm =1 mg/L

Legume Crops Fix Nitrogen

Including legumes in crop rotation can contribute to the nitrogen budget.

With the high price of nitrogen fertilizers, legume crops have become more valuable in crop rotations. Legume crops, such as alfalfa, field bean, and soybean have the unique ability to convert atmospheric nitrogen gas (N2) into a form usable by the plant through a process called nitrogen fixation. Because the air we breathe contains more than 78 % N2, there is an abundance of N2 that legumes can utilize. Legumes are able to utilize atmospheric N2 as a result of a mutually beneficial (symbiotic) relationship they form with either Rhizobium or Bradyrhizobium bacteria. Some legumes, such as alfalfa, can fix enough plant available nitrogen (N) to supply their entire N needs after the crop is established (Table 5). Consequently, supplemental N fertilization is usually not necessary. Other legume crops such as field bean and soybean only fix a portion of their N needs and require supplemental fertilizer N for high yield.

Table 5. Range of nitrogen fixed per acre by several legume crops.

Estimates of nitrogen fixed per acre*		
	lbs.. N/acre	
Crop	Low	High
Alfalfa	44	308
Dry beans	50	150
Garbanzo beans	25	81
Peas	53	305
Soybeans	53	265

*Note: These are lbs.. N fixed per acre are not credits to a following crop.
See crediting article for legume N credits.

In the symbiotic relationship with the legumes, bacteria invade plant root hair tissue to stimulate the production of a visible structure called a nodule. The plant supplies energy to the bacteria from photosynthesis. For their part in the symbiotic relationship, the bacteria convert atmospheric N2 gas to ammonium (NH4+) in the nodules.

Rhizobium species are identified by their ability to form functional nodules on specific legume species. Each legume requires a specific compatible species and strain of Rhizobium. For example, the species of bacteria that forms nodules with alfalfa will not nodulate dry beans or soybeans. Commercial inoculants are labeled according to the plant species with which the bacteria are compatible.

If the legume crop was grown in the field previously, there is a good chance that the soil already contains the correct rhizobial species for nodulation. However, native rhizobial populations found in soil often are less effective than commercial inoculants composed of rhizobial strains selected for maximum N fixation. Inoculum can be applied directly to the seed prior to planting, or by metering the inoculum into the seed furrow during planting. Three basic forms of commercial inoculum are solid, liquid and freeze-dried. The most commonly used are solid, peat-based inoculants that can be purchased for seed or direct soil application. Liquid inoculants are available in broth culture or as frozen concentrate. Broth or frozen concentrates usually are mixed with water and sprayed into the seed furrow at planting. Because liquid inoculants must be kept frozen or refrigerated during shipment and storage, their availability through normal distribution channels is limited.

Be careful not to mix seed inoculation with chemical seed treatment. Most seed disinfectants, including fungicides, are toxic to rhizobia bacteria. Do not apply inoculum directly to seeds that are treated with a bactericide, such as streptomycin, unless you use a resistant strain of the rhizobia. Although some rhizobia species are slightly tolerant to certain chemical compounds, inoculating chemically treated legume seed requires special precautions. If the seed is pretreated

Legume Crops Fix Nitrogen (continued)

Rhizobia nodules on beanroots fix nitrogeninthe soil.

with pesticide, it is best to apply the inoculum in the furrow.

When in doubt about a field's rhizobial population, applying inoculum is a good practice, especially if the legume has not recently been grown there. However, even when more efficient strains are introduced into the soil, there is no guarantee these inoculated strains will compete well with native strains for entry into plant roots. Many studies have been conducted on the application of commercial inoculants into soils that already contain the correct rhizobial bacteria. In some studies, a significant yield increase has been observed, in other studies, no response occurred. The best method to evaluate the response of inoculants on your farm is to test several inoculants and an untreated control in fields using replicated strip tests. Be sure to dig plants during mid-season to count nodule number, nodule mass and whether they are effectively fixing N. An actively fixing nodule will be pink to reddish when cut open, rather than tan (ineffective) or green (dying).
Maintain proper soil fertility to ensure nodulation and N2 fixation. However, do not apply large amounts of N fertilizer with legumes, because plants tend to stop fixing N2 gas when soil N is high. Phosphorous and potassium can also affect nodulation and N2 fixation. Research shows that additions of phosphorus (P2O5) and/or potassium (K20) increase the number of nodules formed, fresh weight of nodules, and amount of N fixed per nodule. However, in most Colorado soils potassium is usually adequate, while phosphorus is often limiting.

by Mark Brick
Professor

It's A Good Time To Spread Manure!

Improve soil quality while applying this nitrogen source.

With nitrogen (N) fertilizer prices high, it's a good time to re-consider having manure hauled in and applied to your farm ground. Different types of manure have varying amounts of nitrogen in them, and even within a manure type, there is a lot of variation depending on feeding and management practices. Table 6 shows average nutrient concentrations for different kinds of manure.

Based on the current value of the nitrogen and phosphorus in the manure alone, beef manure is worth $13.70 per ton. So if you can get manure for less than that, consider that a good deal! Sheep and poultry manures would be valued even higher due to their higher nutrient concentrations. But be careful to avoid spring applications of fresh poultry or swine manures due to their high ammonium levels that can burn plants.

Of course, manure's value is actually greater than the numbers shown above since manure is also a good source of potassium and micronutrients such as zinc, iron, sulfur, and boron. Plus, manure is a terrific soil amendment. By increasing soil organic matter levels, manure can improve a soil's water and nutrient holding capacity and also improve drainage and aeration. Manure also makes a good food source for the bacteria, fungi, and worms that recycle soil nutrients and improve it physical properties.

One important thing to remember about manure nitrogen is that it will mineralize or become available to crops more slowly than commercial fertilizers. In effect, manure acts as a slow release N source, releasing the N over about a three year period. So will applying manure now (in the spring) delay the availability of the manure N even more? Dr. Merle Vigil of the USDA Great Plains Research Center in Akron and Brad Jakubowski (CSU graduate student) studied N availability from fall and spring applied beef manure. Under irrigated conditions, N availability to corn was identical for either application time (measured at both V6 and tassle growth stages). On the other hand, under dryland conditions, fall applications had significantly more N available at V6 than spring applications. By the time corn was tasseling, there was no significant difference in N availability from fall and spring applications, even under dryland. This research demonstrates that under irrigated conditions, manuring now (in the spring) will not delay N release from manure.

When you are spreading manure, choose fields with the lowest soil NO3-N levels and the highest N need, rather than those with a long-term manuring history. Choosing crops that will give you a yield response

Table 6. Approximate nutrient content of various types of manure at the time of land application.

Manure Type	Total N (lbs/ton)	P_2O_5 (lbs/ton)	Value of N and P_2O_5 ($/ton)
Beef	23	24	$13.60
Dairy	13	16	$8.32
Sheep	29	26	$16.04
Chicken	33	48	$23.04
Turkey	27	20	$13.84
Horse	19	14	$9.72
Swine	10	9	$5.54

Dollar value is based on $0.32/lb for nitrogen and $0.26/lb for phosphorus ($P_2O_5$).

It's A Good Time To Spread Manure! (continued)

for the added manure nutrients, makes the most out of the manure application, and saves you the most in fertilizer costs. If there are other yield limiting factors such as heavy weed populations, high water table, or poor irrigation uniformity, this will limit the impact of the manure nutrients on yields. Apply manure where nutrients are the greatest yield limiting factor to get the most bang out of your manure spreading dollar.

If you value manure for it's N content, it is critical to conserve that N so that plants can use it. It's important to minimize volatilization losses (losses of ammonia gas into the air). If manure is broadcast and not incorporated, up to 30% of the ammonium in the manure will be lost to the air within just four days of spreading. Incorporating immediately will reduce that loss to less than 5%. So to get the most N value from the manure, be sure to incorporate as soon as possible.

If you manage a feedlot, leaving manure in open lots results in the greatest N losses to the air. Storing manure in a manure pack reduces N loss by about a third. Scraping pens and hauling manure out on a daily basis reduces N losses even more. So, if you value manure for its N content, manage manure to minimize N volatilization and add value to the manure.

Lastly, you'll get the most out of the manure application if it is applied as uniformly as possible with properly calibrated equipment. When you load the spreader trucks, be sure to even out the load in the truck, because uneven loading results in uneven application. Monitor the distribution of manure as it comes out the back, so you can get the proper overlap to even out the application rate. Otherwise, you may end up with N deficiencies in some spots and too much N in other spots, even though over the whole field, the application rate was correct.

You may have avoided manure application in the past because of high transportation costs. But check your figures again this year, since the fertilizer value of the manure may outweigh the transportation costs. And what other fertilizer increases soil organic matter and improves soil properties?!

by Jessica G. Davis
Extension Specialist
Soils

EPA Proposes New CAFO Regulations;

Public Comment Accepted Through July 30

The U.S. Environmental Protection Agency released their proposed regulations to address water pollution from Concentrated Animal Feeding Operations (CAFOs) on December 15, 2000. There are numerous changes that could have serious implications for Colorado's livestock industry. For example, the proposal includes reducing the number of animal units that define a CAFO from 1000 to 500, or possibly even to 300 when certain conditions apply. All CAFOs would be required to have a NPDES permit and a nutrient management plan. In addition, the proposed regulations would require CAFOs to document whether manure should be applied on a N-basis or a P-basis using a tool such as the Phosphorus Index. This could drastically reduce manure application rates on many fields that have received manure over a long period of time. There are many other proposed changes. To view a summary of the proposed regulations or the entire document, go to the EPA web site at www.epa.gov/owm/afo.htm.

EPA encourages public comment on these proposed regulations. This regulation is open for public comment through July 30, 2001. You can comment by email to CAFOs.comments@epa.gov or through the mail to:

Concentrated Animal Feeding Operation Proposed Rule
USEPA Office of Water
Engineering and Analysis Division (4303)
1200 Pennsylvania Avenue, NW
Washington, DC 20460.

In addition, there will be a public meeting on the proposed regulations on March 27, 2001 from 1-5 pm at Denver's Executive Tower Hotel. However, this meeting is not a mechanism for submitting formal comment. There will be a brief presentation by EPA officials followed by a question and answer session.

by Jessica G. Davis
Extension Specialist
Soils

In-Season Tools Manage N Closer To Margin

Pre-sidedress nitrate test (PSNT) and chlorophyll meters offer corn growers confidence tools.

Current nitrogen (N) fertilizer recommendations in Colorado are based on soil samples taken in the fall or in the early spring. However, most N uptake by corn occurs in midsummer from the 8-leaf growth stage to pollination. Mineralization of N from manure or other organic matter, and nitrate leaching, can significantly change soil N status before this time. The pre-sidedress nitrate test (PSNT) measures these potential changes. By complementing preplant soil testing with PSNT, growers can better predict yield response from N fertilizer, saving unnecessary fertilizer costs.

The PSNT is based on nitrate concentration in the top 12 inches of soil when corn is 6 to 12 inches tall (V6 growth stage). Under typical Colorado conditions, CSU researchers found the critical PSNT level is 15-ppm nitrate-N (NO3-N) in the top foot of soil at this growth stage. If the PSNT level is lower than 15 ppm NO3-N, sidedress N should be applied. If the PSNT level is higher than 15 ppm NO3-N, the probability of a yield response to additional N is very low (see Table 7). Although the PSNT was originally calibrated for non-manured fields in Colorado, the 15 ppm NO3-N should also be sufficient for fields with recent manure applications or legume crops. The test is most useful for predicting whether or not soil N is sufficient - not for making an N rate prediction. You must assess yield potential as well as soil nitrate levels to determine how much additional N is needed if the PSNT is below 15 ppm.

Proper soil sampling may be the most critical step in the PSNT procedure. To sample a field, take a minimum of 15 to 20 random soil core samples from a uniform soil area or 40-acre field. On surface irrigated fields, we recommend collecting equal numbers of soil samples from the furrow and shoulder of the bed (see Figure 2) and sampling depth of 12 inches. Get the soil sample to a testing lab right away and tell the lab you are evaluating the sample for PSNT and need your results quickly. Using the PSNT will give you more confidence to evaluate your sidedress decision, and you may see savings in both fertilizer and sleep.

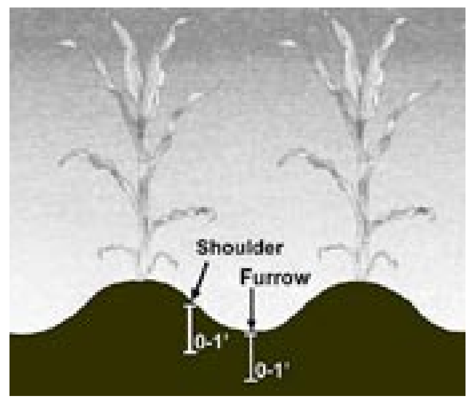

Figure 2. Recommended sampling positions for PSNT testing of irrigated fields.

Table 7. The yield response of corn to sidedress N application of 60 lbs/acre when PSNT was above or below the critical NO3-N concentration at V6.

(Sampling Depth: 0 - 12")	Number of Observations	Yield response from sidedress N	Prediction accuracy
		# of Sites	%
Below critical level (15 ppm)	35	19	54**
Above critical level (15 ppm)	21	0	100
Total	56		71

*Based on equal sampling intensity from both furrow and shoulder positions

**16 sites did not respond to additional N

In-Season Tools Manage N Closer To Margin (continued)

Assessing plant N status
Measuring plant tissue or plant sap to evaluate N sufficiency has several advantages and disadvantages. Benefits include ease of sampling, direct feedback from the plant, and relatively low cost. However, tissue testing is often inaccurate because of the many factors that impact plant N status at the time of sampling, little calibration on the results, and poor sampling technique. Although a tissue sample tells you what the N content of the plant is at the time, it does not tell you what the soil reserve is.

Another method of evaluating N sufficiency during the growing season is to use the Minolta SPAD-502 chlorophyll meter. Although most research on the meter has been done on corn, it has also been researched on other crops including small grains, beans, and sugar beets. The portable chlorophyll meter provides instantaneous, nondestructive evaluation of plant nitrogen status, giving producers who have the ability to fertigate a tool to manage N more efficiently. The appropriate application of the chlorophyll meter is to compare the average greenness of corn leaves to a well-fertilized reference strip in the same field. When the average chlorophyll reading for the field drops below 95% of the reference strip, additional fertilizer is suggested.

Optimal SPAD reading times are between the 6-leaf and tassel (corn) stages. Corn hybrids differ in greenness, so do not compare readings of one hybrid to another to make fertilizer decisions. Systematic sampling technique and a sample size of at least 30 leaves per field is needed to accurately determine N response. Sampling the same leaf from each plant is important. For plants that have not tasseled, sample the uppermost fully expanded leaf with an exposed collar. After tassel, use the ear leaf. It is also very important to consistently measure greenness at the same location on the leaf. A sampling position halfway between the stalk and leaf tip will give a consistent reading.

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Nitrogen Application

What, when, where and how you apply nitrogen all matter.

Well-timed and placed nitrogen (N) fertilizer applications can greatly enhance plant uptake of nitrogen and maximize return when you're trying control input costs. The greatest N use efficiency occurs when N fertilizer is applied in increments to match crop needs. If possible, reduce or eliminate applying N preplant. When this is not an option, consider applying an ammonium N form, such as urea or anhydrous ammonia, because the ammonium ion (NH4+) is not subject to immediate leaching. Nitrate (NO3) forms of N fertilizer are readily available to crops, but are subject to leaching losses. Although transformation of NH4 to NO3 under warm, moist soil conditions occurs

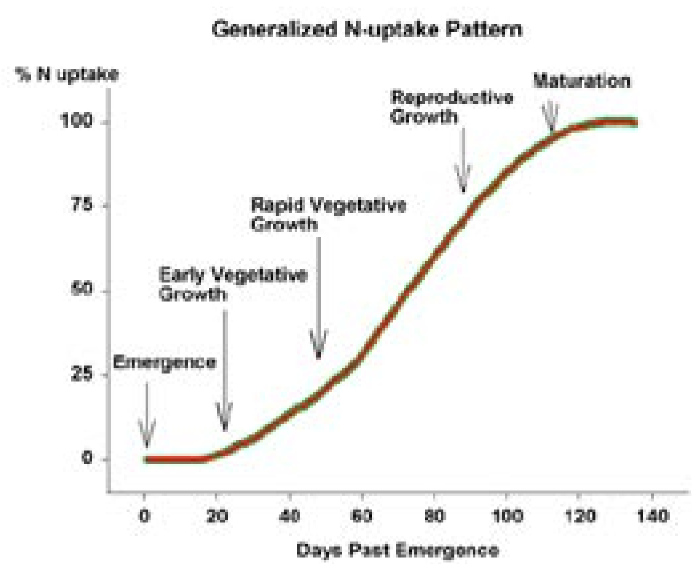

Figure 3. Nitrogen uptake pattern across growth stages

Nitrogen Application (continued)

rapidly, applying ammonium forms early in the season may reduce leaching losses. Slow release N fertilizers may also be feasible this year, particularly for high value crops. Immediately incorporate all surface applied fertilizers to reduce runoff and volatilization.

Fertilizer applications should be timed to coincide as closely as possible to the period of maximum N uptake which is during rapid vegetative growth (see Figure 3 and Table 8). A starter fertilizer, followed by sidedress application or fertigation improves crop N uptake efficiency and is a good strategy this year. Application of N through high efficiency irrigation systems such as center pivot or surge systems during rapid growth maximizes crop N uptake. It is not recommended that nitrogen be applied through low efficiency furrow or flood systems due to runoff and deep percolation losses. Waiting until the crop is well established before applying large amounts of N also allows you to more accurately determine the crop yield potential. Poor stands, weed control, and below average precipitation are good reasons to adjust N rates downward at sidedress time. Conversely, exceptional conditions warrant increased N at sidedress.

Table 8. Time of application has a big impact on efficiency.

Nitrogen use efficiency	Time of Application
Highest	Sprinkler applied during rapid growth
▮	Sidedress applied immediately before rapid growth
▮	Post-plant incorporated
▮	Pre-plant incorporated
Lowest	Fall application

Another thing producers must keep in mind when making fertilizer choices is how much you are actually paying for the element nitrogen. Often producers will price fertilizers by the ton rather than by the pound of actual N. This is unfortunate because price per ton can be misleading. Table 9 presents a comparison of cost of nitrogen fertilizer per ton and per pound of N. Notice that 28% UAN has the cheapest price per ton, but is among the most expensive sources of N for actual price per pound. Conversely, anhydrous ammonia is the most expensive N fertilizer in price per ton, but is the cheapest source for actual price per pound of N.

Nitrogen is not a stable element in soil and some portion of your fertilizer will be lost to leaching and other transformations. Application timing, technique and fertilizer form all can help reduce these loses and keep your N dollar doing its job, producing yield.

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Table 9. Comparison of cost of nitrogen fertilizer per tone and per pound of N in 2001.

Fertilizer	%N	lb. N/ton	$/ton	$/lb N
Anhydrous-NH_4	82	1640	412	0.25
28% UAN	28	560	197	0.35
32% UAN	32	640	210	0.33
NH_4-NO_3	34	680	250	0.37
Urea	46	920	279	0.30

Zoning In On Nitrogen Needs

Productivity level management zones should determine nitrogen applications.

The increase in nitrogen (N) fertilizer prices, creates some hard decisions for producers. The current situation provides an excellent opportunity to delineate management zones within a field. Management zones are sub-regions of the field that are similar in productivity potential. We all know by experience that grain yields harvested from different areas of a field are not uniform. In the last several years of research (ongoing research conducted by scientists from CSU, USDA-ARS) we have been able to develop a system to divide farm fields into different sections or areas that are referred to as productivity level "management zones". Management zones can be identified based on all or one of the following information layers:

(1) Farmer's personal experience and grain yield history,
(2) Aerial imagery of bare soil and other stable soil properties, such as organic matter content, and
(3) Topography of the land.

Using this method we can divide fields into at least three different management zones, "High, Medium, and Low" based on the productivity potential of these areas (Figure 4).

Management zones provide an opportunity for growers to optimize their nitrogen fertilizer applications. That means areas of the field that traditionally yield high would get a high N rate, medium productivity areas would receive a medium N rate and low producing areas would receive a low N rate. This insures that N use will be maximized where it is needed. It also reduces the overall amount of N applied without affecting yields. Yields may even increase using these management zone techniques. On-farm research conducted in Colorado has proven that these management zones are real, and there are significant differences in grain yield across management zones. Therefore such an approach may reduce nitrogen fertilizer costs. Also, it introduces grower to the concepts and benefits of the precision farming approach.

Although the management zone concept presents itself as a positive response to the N price increases, there are considerations. This process may require more time and planning by the producer. Also, there may be start up costs associated with this management practice. Growers will have to look hard at the cost/benefit issues associated with this practice and compare it to their current situation. Many presume that as natural gas supply increases, costs will decrease. Therefore, why adopt a new management strategy that may cost money. This is a valid concern. However, adoption of such techniques will prepare the grower for current and future price increase in nitrogen fertilizer. By beginning to adopt this new management practice now, a grower can reduce inputs, save money, and plan for the future.

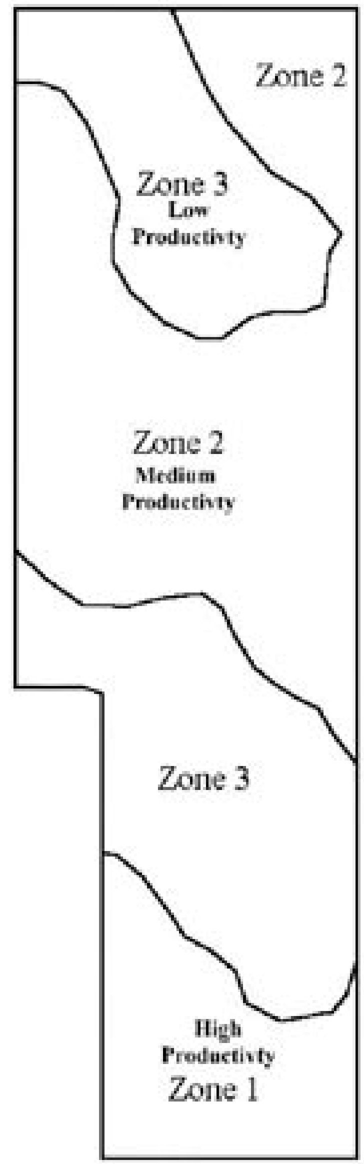

Figure 4. Productivity level management zones in a field.

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Managing Irrigation Water

Efficient water application is key under tight nitrogen management scenario.

Efficient water management is critical to achieving high use nitrogen (N) efficiency. Nitrate-nitrogen is soluble and moves readily downward with soil water. Applying more irrigation water than can be stored in the crop root zone will increase nitrogen losses through nitrate leaching and negate other positive N management strategies. Adjusting irrigation management to increase both efficiency and uniformity will result in more N available for crop uptake throughout the growing season.

Producers should reevaluate their irrigation scheduling method when growing crops under a tighter nitrogen budget. Decide when to irrigate based upon an estimate of crop and soil water status, as labor and water delivery permits. If currently irrigating on a fixed day schedule, consider whether increasing the length of time between irrigations is feasible, especially when the crop is not in a sensitive growth stage.

Experienced producers know how long it takes them to get water across their fields and are proficient in avoiding crop stress during years of average rainfall. The difficulty lies in applying only enough water to fill the effective root zone without unnecessary deep percolation or runoff. Several devices, techniques, and computer aides are available to help producers in determining when they need water and how much is required.

Producers should choose the scheduling method which best suits their needs and management capabilities. Information necessary to improve scheduling includes:

- soil water-holding capacity
- current available soil moisture content
- crop water use or evapotranspiration (ET)
- crop sensitivity to moisture stress at current growth stage
- irrigation and effective rainfall received
- availability of water supply
- length of time it takes to irrigate a particular field.

Consider using an irrigation scheduling service offered by crop consultants as a cost-effective method of scheduling irrigations to maximize return from N fertilizer inputs.

Improving the water distribution across a field (uniformity) is also important when focusing on keeping N in the root zone under surface irrigation. Producers should probe fields within 72 hours after irrigation to find depth of application along the irrigation gradient. Checking for visual signs of plant stress can also show areas of poor water penetration. Most commonly, the upper end of the field is over-watered and the lower end under-watered.

Surface irrigators should consider using surge irrigation or adjusting irrigation set size, stream size, set time, and length of run to improve both efficiency and uniformity. When properly used, surge valves can save labor and water with no loss of crop yield. Irrigators currently

Using atmometers to schedule irrigation is one cost-effective technique.

Managing Irrigation Water (continued)

using conventional furrow irrigation on coarse-textured soils, fine soils with cracking problems, or slopes greater than 1% would benefit most from using surge valves

Using polyacrylamide (PAM) allows irrigators to use a higher stream flow rate (twice or higher), which will also improve application uniformity. However, using PAM without increasing flow rate is not recommended. Driving all rows can reduce excessive water intake on coarse soils early in the crop season before the first irrigation. Another irrigation strategy is to irrigate every other row and band apply nitrogen fertilizer on the ridge of the nonirrigated row. Researchers in Idaho (Lehrsch et al., 2000) found that this practice maintained or increased yields and increased N uptake on a silt loam soil. However, this practice may not be as beneficial on finer textured soils (clay loams).

Upgrading to an improved irrigation system usually results in improved water and nitrogen efficiency. Among these are systems such as low-pressure center pivot, LEPA (Low-Energy Precision Application), surge, and drip-irrigation. However, these improvements require capital, energy, or increased management costs, that may not pencil out in the short term. However, in some cases the additional labor savings will justify installation of improved systems over a period of several years.

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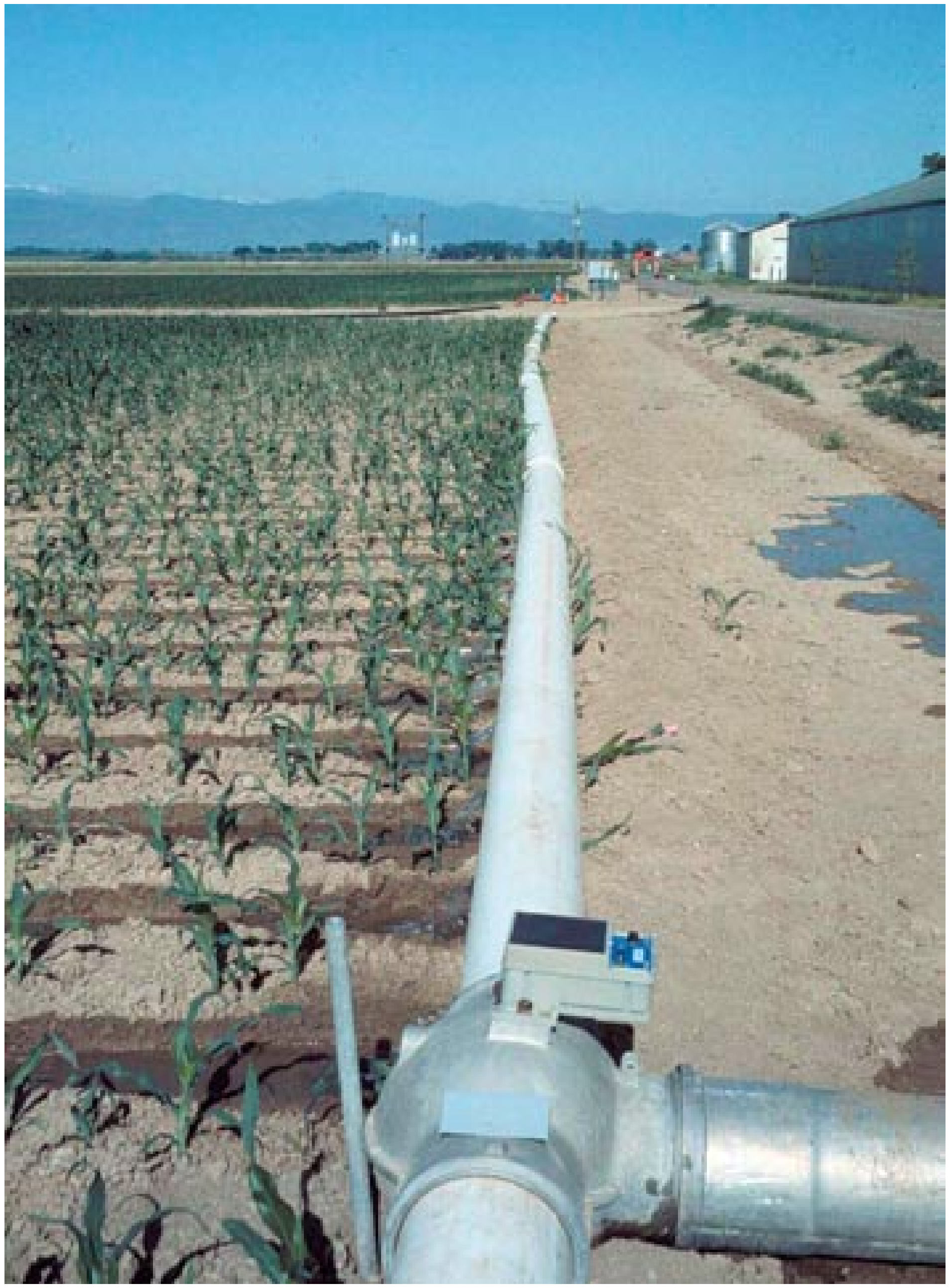

Surge irrigation can increase both efficiency and uniformity.

Information on the Web

Nitrogen from legume crops:
An article on alfalfa nitrogen credits on the cover of the Winter 2001 issue of the HayMaker publication at:
http://www.wlresearch.com/haymaker-winter%2001.pdf

University of Wisconsin Integrated Crop and Pest Management page provides a table for calculating nitrogen credits from legumes at:
http://ipcm.wisc.edu/pubs/cards/a3591.htm

Nitrogen from manure:
Colorado State University Fact Sheet 0.560 Cattle Manure Application Rates discusses value of manure and how to calculate rates: http://www.ext.colostate.edu/PUBS/CROPS/00560.html

Using chlorophyll meters to manage nitrogen:
University of Nebraska NebGuide G93-1171-A Using a Chlorophyll Meter to Improve N Management:
http://www.ianr.unl.edu/pubs/soil/g1171.htm

Tips on improving nitrogen and irrigation management:
Various issues of this newsletter provide information on these topics. See the index at :
http://www.colostate.edu/Depts/SoilCrop/extension/Newsletters/news.html

Various publications from University of Nebraska Institute of Agriculture and Natural Resources address this topic. See the index at: http://www.ianr.unl.edu/pubs/water/index.htm#WATER

Various articles at the University of Nebraska CropWatch Newservice address this topic. See the index at:
http://cropwatch.unl.edu/

Soil Testing
Colorado State University Fact Sheet 0.500 Soil sampling at: http://www.ext.colostate.edu/PUBS/CROPS/00500.html

Colorado State Unviersity Fact Sheet 0.501 Soil testing at: http://www.ext.colostate.edu/PUBS/CROPS/00501.html

Colorado State Unviersity Fact Sheet 0.502 Soil test explanation at:
http://www.ext.colostate.edu/PUBS/CROPS/00502.html

Colorado State Unviersity Fact Sheet 0.520 Selecting and analytical Laboratory at:
http://www.ext.colostate.edu/PUBS/CROPS/00520.html

Colorado State University publications on CSU fertilizer recommendations, nitrogen management, and related topics see index at : http://www.ext.colostate.edu/PUBS/CROPS/pubcrop.html