

# Nutrient Digest

VOLUME 1, ISSUE 3

SPRING, 2009

## PHOSPHORUS REMOVAL WITH TRITICALE IN MANURED FIELDS

By Brad Brown, Joe Dalton, Mireille Chahine, Bill Hazen, Scott Jensen, and Stephanie Etter

Southern Idaho dairymen use double cropping to increase forage production and phosphorus (P) removal that involves a boot stage winter triticale forage harvest. The default P concentration NRC value of 0.34% P has been used for calculating triticale forage P uptake and balancing manure P added and that removed. However, triticale P concentrations from southern Idaho manured fields were poorly documented. In response, a survey was conducted in 2004 and 2005 to establish an Idaho baseline.

Samples of triticale forage and soil were collected throughout Southern Idaho in spring 2004 (April 23-May 14) from 34 fields and from 10 fields in 2005 (May 12-23) managed by dairies for manure applications. The

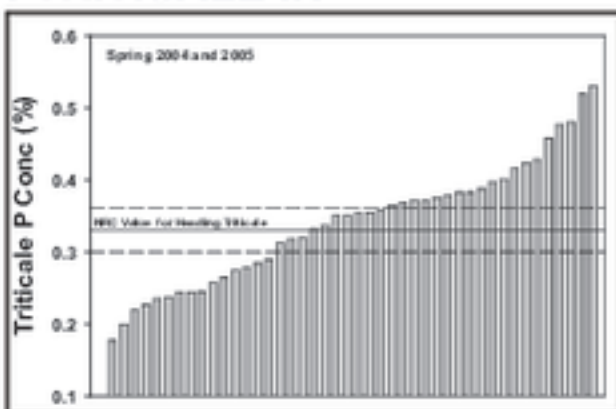


Figure 1. Distribution of boot stage triticale total P concentrations in spring 2004 and 2005 over 44 field locations.

samples ranged in maturity from late stem extension to heading with most samples

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## BLACK SOLDIER FLY LARVAE: A STRANGE BUT EFFECTIVE TOOL FOR MANAGING DAIRY MANURE

By Mireille Chahine, Mario de Haro Marti, Sophie St Hilaire, and Wendy Sealy

Idaho is ranked 3rd in the nation for milk production, with an estimated 549,000 dairy cows in the state (USDA-National Agricultural Statistics Service, 2008). Each dairy cow produces approximately 20 lbs of dry matter manure per day, which adds up to 5,490 tons of dry matter dairy manure produced daily in the state. Although Idaho has a large land base to apply manure to, the majority of dairy manure is applied in close proximity to the dairy. Re-



Black soldier fly larvae digesting dairy manure

peated field applications of manure can rapidly overload the soils with phosphorus, nitrogen, and salts, leading to issues such as impaired air quality and surface and ground water

contamination. As Idaho's dairy industry grows, these concerns are becoming more significant for farmers and the public.

One method for alleviating the pressure of applying dairy manure to fields is to find ways to reduce the amount of the manure. A USDA-SARE funded study is currently being conducted by Mireille Chahine (UI), Mario E. de Haro Marti (UI), Sophie St Hilaire (ISU), and Wendy Sealy (UI) at a local dairy in South-Central Idaho to examine the feasibility of growing black soldier fly larvae

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## NITROGEN AND WATER USE EFFICIENCY IN ONIONS

By Steven Reddy, Jerry Neufeld,  
and Jim Klauzer

Deep percolation of irrigation water containing nitrates is recognized as a contributor to groundwater contamination. Onion production with furrow irrigation may have a high nitrate leaching potential due to high fertilizer application and numerous irrigations. Beginning in 2003, applied research and demonstration plots were installed in commercial furrow or drip-irrigated onion fields. Plots were sampled and compared each year until project completion in 2007. The objective was to demonstrate research-based onion production practices that can improve water and fertilizer use efficiency, and reduce ground water N contamination.

Soil moisture monitors in onion fields were used to schedule irrigations, keep soil moisture within recommendations, and compare efficiency of furrow and drip systems. Additional data were collected including soil nitrate, onion tissue nitrate, water use, fertilizer application, nitrate mineralization, crop yield and quality. Nitrogen use efficiency (NUE) and water use efficiency were calculated for each plot. Specific treatments were introduced during the last three years of the study as follows: 1) Furrow irrigation (Control) using grower's customary production practices, 2) Furrow irrigation (Treatment) using research-based fertility recommendations, and 3) Drip irrigation (Drip) using research-based fertility recommendations and irrigation scheduling.

Water application differed greatly by irrigation system. Furrow-irrigated onions averaged

greater water use and greater soil moisture variability than drip-irrigated plots. Drip-irrigated plots consistently showed higher water use efficiency.

Nitrogen fertilizer recommendations were calculated using early season soil samples, estimated yield, and estimated nitrogen uptake efficiencies. For example, 2006 yield goals of 950 Cwt/ac were calculated and N uptake efficiencies of 40% and 60% were assumed for furrow and drip irrigated onions respectively. Conse-

**"The project demonstrated water and nutrient savings available through drip irrigation and by following University of Idaho fertilizer recommendations for onions."**

quently, 325 lbs applied N/ac was recommended for the furrow plots and 171 lbs N/ac for the drip plot. The Furrow Control actually received an initial application plus two side-dressings for 283 lbs N/ac total. The Furrow Treatment received an initial application plus one side dressing for 158 lbs/ac total. This reduction in N application to the Furrow Control plot resulted from monthly soil testing indicating sufficient N. The 2006 Drip plot received only 155 lbs N/ac, but produced a yield higher than the Furrow plots.

The 2005 and 2006 Furrow Treatment onion yields were approximately 4% lower than Furrow Control yields. This slightly lower yield was obtained with 41% less N fertilizer applied to the Treatment than the Control. The

2007 Furrow Treatment yield was 5.2% less than the Furrow Control and was obtained with 44% less N fertilizer applied to the Treatment plot.

In calculating nitrogen use efficiency (NUE), literature suggests that 100 lbs (Cwt) of onion bulbs requires 0.19 lbs N. Furrow-irrigated and drip-irrigated onions, would require 0.475 and 0.317 lbs N/Cwt assuming 40% and 60% N uptake efficiency, respectively.

In 2006, NUE of the Furrow Control was 0.65 lbs N/Cwt indicating inefficient N use. This was the poorest NUE measured and resulted from high fertilizer application combined with lower yield. The 2006 Furrow Treatment NUE was 0.47 lbs N/Cwt, and the Drip NUE was 0.39 lbs N/Cwt of onion bulbs, both close to research predictions. The Drip plot NUE was slightly higher than reference values, so opportunities remain to further improve N efficiency. The best NUE was produced by the 2005 Furrow Treatment plot. Reasons include soil and plant sampling that resulted in reduced N fertilizer and well timed N application in combination with high yield.

Results indicate N fertilizer applications can be reduced and high yields maintained through soil and plant sampling. The project demonstrated water and nutrient savings available through drip irrigation and by following University of Idaho fertilizer recommendations for onions. Growers may further improve efficiency of furrow-irrigated onions or see reason to transition to drip irrigation. More efficient use of irrigation water and N fertilizer can reduce production costs, maintain yields, and minimize N leaching into water resources.

For more information contact Steve Reddy (208) 414-0415  
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**By Glenn Shewmaker**

Alfalfa is a legume, which means that through a symbiotic relationship with *Rhizobium* bacteria, alfalfa can obtain all of the nitrogen (N) required for growth from dinitrogen gas in the atmosphere. However, during establishment when the symbiosis is still developing, applying nitrogen fertilizer at rates of 20 to 40 lbs N/acre is beneficial. Higher application rates during establishment inhibit bacterial symbiosis and may reduce growth in mature plants.

If you get a yield response from applying N to legumes, you have less than effective nodulization by the bacteria within the legume root system. Healthy *Rhizobium* nodules should be pink when cut open if they are effectively fixing atmospheric N. If the nodules are not pink or red, this may be because the seed or soil wasn't adequately inoculated or there might be another nutrient deficiency or pH problem. It is usually more profitable to fix a nutrient problem to provide balanced plant nutrition than to treat the symptom. Soil tests for N-P-K and plant tissue tests for boron, sulfur, and micro nutrients are important to evaluate soil fertility

**"If you get a yield response from applying N to legumes, you have less than effective nodulization by the bacteria within the legume root system."**

and plant nutrition.

Applied N would most likely be needed for alfalfa establishment following small grain production in which the residue is returned to the soil. In this situation, microbes will utilize available soil N to break down resi-



**Alfalfa root nodules, containing nitrogen fixing *Rhizobium* bacteria.**

dues, thus increasing the N requirement to provide enough N for both microbes and alfalfa. Under these conditions, N rates of 30 to 40 lb per acre are suggested if available soil N does not exceed 60 to 80 lb per acre.

Nitrogen application on established alfalfa is not recommended.

Over a hundred studies, including Idaho and Utah, have evaluated alfalfa yield and protein responses to nitrogen fertilization, and very few have shown any positive effects. In studies where yield responses to nitrogen were obtained the response was relatively small and inconsistent (e.g., observed in one year out of three), nitrogen rates were often high and not economical, and responses were frequently due to an increase in growth of

grasses in the stand.

Appreciable application amounts of animal manures, dairy effluent, or other organic N sources will also reduce N fixation in alfalfa. The probability of an N response is usually greatest on coarse-textured soils with low organic matter content. However, excessive nitrogen uptake can increase the forage nitrate toxicity hazard for dairy and beef cattle. In addition, animal manure applications can promote grass and weed growth, which in turn can also increase the potential for nitrate toxicity.

Common nitrogen fertilizers for alfalfa include monoammonium phosphate (MAP) with a grade of 11-55-0 and diammonium phosphate (DAP) with a grade of 16-48-0. However, as stated above there is usually no benefit to adding N fertilizer to alfalfa. We recommend that the ammonium phosphate fertilizers be applied to non-leguminous rotational crops, such as cereal grain, corn, sugar beets, and potato crops. Dairy compost or manure application can improve soil nutrient test levels substantially and are often more affordable in providing P, K, S, and micro nutrients than fertilizers.

The best economical and environmental sustainable use of fertilizers is to apply nutrients when needed, and in amounts needed. Using N fertilizer for established alfalfa is not recommended. *For more information on inoculating legume seed and proper fertilization of alfalfa, refer to CIS 838 Inoculation of Legumes in Idaho, and CIS 1102 Southern Idaho Fertilizer Guide, Irrigated Alfalfa. Or contact Glenn Shewmaker at [gshew@uidaho.edu](mailto:gshew@uidaho.edu), 208-736-3608.*



## UNDERSTANDING IDAHO ONEPLAN NUTRIENT MANAGEMENT PLANNING SOFTWARE

By Dick Johnson

Idaho's official Manure Management planning tool is the Idaho OnePlan Nutrient Management Planner, and is now entering into its seventh year of successful partnering between Idaho's Department of Agriculture (ISDA), United States Department of Agriculture-Natural Resources Conservation Service (USDA-NRCS), the University of Idaho (UofI) and the United States Environmental Protection Agency (EPA). The Idaho OnePlan software was developed to assist planners in preparation of comprehensive nutrient management plans (CNMPs) for animal feeding operations (AFOs) and confined animal feeding operations (CAFOs), as required by state and federal laws and regulations.

The OnePlan planning tool has changed as Idaho's dairy and beef industries have grown, changed feeding rations, and altered manure management practices. The one thing that hasn't changed is the goal of assisting Idaho's dairy and beef industries in meeting EPA's AFO/CAFO National Pollutant Discharge Elimination System (NPDES) requirements.

The OnePlan was designed to bring together 1) Facility Wastewater and Storm Water Runoff Management Plan; 2) Bio-Nutrient (manure) Storage and Transport Plan; and 3) Nutrient Management Plan,

to meet the EPA's NPDES requirements as regulated by ISDA and the NRCS-Idaho Nutrient Management 590 Standard. The primary goal of the OnePlan is to allow a producer to follow the management of the amount, source, form, placement, and timing of the land application of wastewater and biosolids nutrients for production of crops, while minimizing the potential for environmental degradation, particularly impairment of water quality of the United States and the State of Idaho.

The OnePlan document is specific to each AFO or CAFO facility. The latest version of OnePlan has expanded the format to include the element of a CNMP as outlined by USDA and EPA. The CNMP format develops a group of conservation practices and management activities that are uniquely related to the specific AFO or CAFO. When combined into a system approach, the OnePlan will ensure that

both agricultural production goals and natural resource concerns dealing with nutrient and organic by-products and their impacts on the environment are achieved. To be complete, a CNMP must address five natural resources: soil, water, air, plants and animals. Because of the elements of the CNMP, a variety of calculations are bundled within ONEPLAN as a computer tool to gather resources like climate, watershed issues (water quality), soils, and regional and local resource concerns (high nitrate in ground water or high sediment-phosphorus in field runoff). The OnePlan then takes into account the AFO or CAFO facility characteristics, including animal types, housing management, biosolids source, handling and storage characteristics, and quantity. Once the biosolids are grouped into manure types (e.g. liquid, slurry, solids, or compost) and analyzed for nitrogen (N), phosphorus (P) and potassium (K), the software

assists the planner in developing a nutrient application plan based on crop rotations and crop nutrient uptake based on historic yields. What makes the OnePlan unique is its ability to assist the NMP planner in designing

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strategies for prevention of discharge, collection, storage, transport and application of runoff and animal waste in production of crops on and off the farm.

The majority of the N, P and K utilized in the production of dairy products and beef are passes through the animals in the form of its waste. The OnePlan was developed by the regulatory and agricultural scientific community as a tool for assisting the producer or his designated planner in the management of these wastewater and biosolids in crop production of crops in concurrence with federal and state regulations. It is the goal of the OnePlan to assist the CAFO and AFO producer in managing wastewater and biosolids with minimum impact of Idaho's environment and its water quality.

For more information, contact Dick Johnson at 208-685-6992, or [ordk.johnson@id.usda.gov](mailto:ordk.johnson@id.usda.gov)



## BACK TO BASICS - UNDERSTANDING CATION EXCHANGE CAPACITY

By Christi Falen

Soil cation exchange capacity (CEC) provides a measure of how well a soil can hold, retain, or adsorb certain nutrients in the "soil bank". Several soluble nutrients exist as positively charged ions (Cations) in the soil solution (soil moisture) or attracted and held (adsorbed) to negatively charged surfaces of soil mineral or organic colloids. The sites of negative charge are called "exchange sites" because adsorbed cations can be replaced with other cations from the soil solution. The CEC is the sum total of these negatively charged adsorption or exchange sites per unit mass of soil. The CEC measurement is used to differentiate and classify soils.

The CEC associated with the mineral surface of a soil depends on several soil forming factors and is relatively fixed. While the mixture of cations adsorbed to the exchange sites can be altered depending on the nutrient cations introduced (manures,

Cations are adsorbed to colloidal exchange sites with varying strength;  $Al^{3+} > Ca^{2+} > Mg^{2+} > K^+ = NH_4^+ > Na^+$ . Very acid soils (low pH) can have high amounts of  $H^+$  and  $Al^{3+}$ . In neutral to moderately alkaline soils,  $Ca^{2+}$  and  $Mg^{2+}$  generally dominate.

Cation mixtures on adsorption sites are in equilibrium with (generally reflect) the cation mixture in the soil solution. As a reservoir or "bank" of cationic nutrients, the CEC is related to the general fertility of soil. Highly fertile soils have higher CEC. The higher the CEC, the more nutrients the soil can potentially hold for plant uptake (Table 1).

Plants can thrive with wide ranges in the cation mix on exchange sites. There is no

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Table 1. Typical CEC values at pH 7

Soil component	CEC (cmol (+)/kg)
Sandy loam soil	12 or less
Silt loam soil	12-30
Clay loam soil	20-40
Finished Compost	38-70
Soil Humus	150-250

fertilizers, or root exudates) or removed (plant root uptake) from the soil solution, the CEC or adsorption capacity is more constant. By itself, CEC says little about the types of cations adsorbed.

### *Soldier fly larvae, continued from pg. 1*

(*Hermetia illucens*) in dairy manure as an alternative method for decreasing volume. The black soldier fly, native to South America, was selected because 1) they will use dairy manure as a primary feed source, and 2) unlike other manure-eating insects, such as house flies, the soldier fly is a non-pest with only a 4-day life cycle in Idaho and is unable to bite livestock or humans due to a lack of functioning mouth parts.

For the study, small scale containers using 640-gallon water tanks were designed so that fresh manure and black soldier fly eggs could be layered. Small ramps that allowed the larvae to migrate when ready to pupate were built in the containers. At the top of each ramp a hole was designed through which pre-pupae fell into buckets. Prior to initiation of the study, a non-functioning structure of manure separator was modified to give sun

and wind protection to the larvae. Preliminary data from the trials showed

that larvae reduced the amount of manure by 40 percent even in less-than-ideal conditions. The best behavior and development of the larvae occurred when the maximum environmental temperature exceeded 30°C.

To determine whether the larvae produced by this manure reduction strategy could be beneficial to another local agricultural industry, two fish-feeding trials using black soldier fly larvae as fish food were conducted at the UI Fish Culture Experiment Station at Hagerman. In the first trial, maggots reared on a dairy manure-only diet were fed to rainbow trout at different inclusion rates. In one diet, the larvae replaced 25 percent of the protein that fish meal would have normally supplied; another diet replaced 50 percent of the protein with larvae. At the highest inclusion rate, growth of the trout fed the larvae dropped off. But, in the

second trial when processing waste from nearby aquaculture-processing plants was mixed in with the dairy manure, no difference in growth of rainbow trout that was fed the larvae was observed even at the highest inclusion level. Perhaps even more importantly, in a blind comparison, 30 testers could not tell the difference between the fish fed only fish meal or those fed any of the black soldier fly larvae-containing experimental diets.

Future studies will concentrate on designing a facility that provides stronger protection against rain, wind and low temperature as well as the use of renewable energy to heat the facility. Even during summer, the wide differences in temperatures between day and night could provide challenges for growing black soldier larvae outside without heating in high desert climates. For more information Contact Mireille Chahine at [mchahine@uidaho.edu](mailto:mchahine@uidaho.edu) 208-736-3609

in the early boot stage. Samples were analyzed by Dr. Dale Westermann, USDA-ARS Kimberly. Soil samples were also collected from most of the fields that forage triticale samples were removed from.

Triticale total P concentration ranged widely from 0.18 to 0.53 % P with a mean of 0.33 % for boot stage samples (Fig. 1), similar to the NRC value of 0.34 %. The two highest P concentrations occurred with Magic Valley triticale irrigated with lagoon water, and were samples that were not rinsed prior to sample processing. Using a mean value for triticale P concentration for calculating P removal would grossly underestimate P removal in

5.95 tons/A. The P removed by the harvest ranged from 7 to over 36 lb/A. The 36 lb/A is considerably more than we've

means of estimating heading stage triticale P concentrations if measured values of triticale P are not available. For example, with Olsen

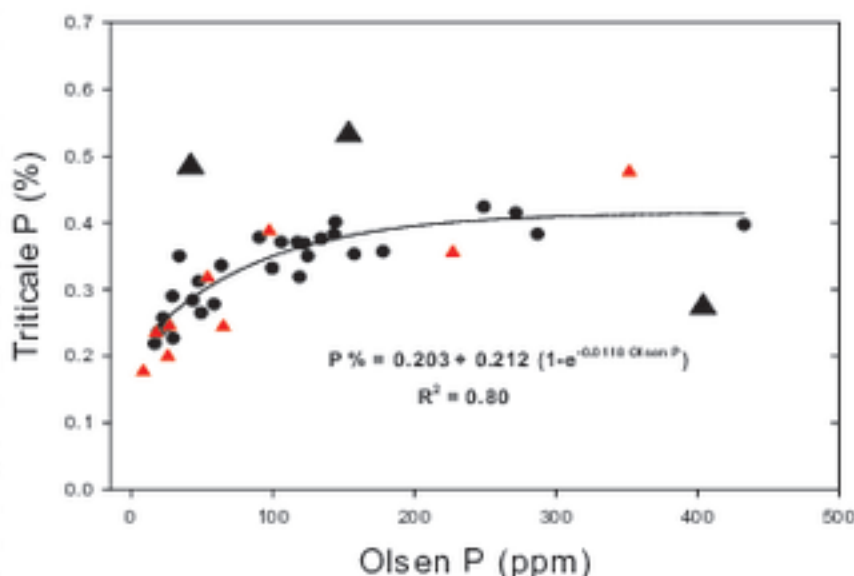


Figure 2. Boot stage triticale total P concentrations as affected by Olsen extractable P.

“Olsen P may be a very reasonable means of estimating heading stage triticale P concentrations concentrations if measured values of triticale P are not available”

some fields and over estimate P removal in others. The range in triticale P suggests considerable potential for accumulating P quantities above those required for growth.

Dry biomass ranged from 1.58 to

documented in research trials to date. Biomass and P removal ranged every bit as much as P concentrations. Total P concentrations and dry matter production both need to be measured for accurate estimates of P removal.

The wide range in triticale P concentrations occurred with soil test Olsen P concentrations ranging from 8 to 432 ppm. Triticale P concentrations were reasonably well related to soil test Olsen P ( $r^2 = 0.88$ ). The very highest triticale P concentrations in 2004 appeared to be outliers and were not included in the non-linear regression. Olsen P may be a very reasonable

P values above 150ppm, triticale forage P concentrations of 0.40% might be assumed. Conversely, Olsen P values less than the 40 ppm threshold could be assigned a value of 0.30%. Intermediate Olsen P values could be assigned a triticale P concentration value of 0.35%. Measurements of triticale P concentration would be the most accurate for documenting the forage P concentrations and P removal. Unfortunately, triticale P concentrations or Olsen soil P were not well correlated with P uptake.

For more information, contact Brad Brown at 208-722-6701, or [bradb@uidaho.edu](mailto:bradb@uidaho.edu).





## Questions from the field



### Question – How much plant available nitrogen (N), phosphorus (P), and potassium (K) can I expect to get from field applications of manure or compost?

A new extensions publication from Oregon State University Extension, entitled Estimating Plant-Available Nitrogen from Manure - EM 8954-E, goes through the steps on how to estimate available nitrogen, phosphorus, and potassium from manure sources, with an

online worksheet that can automatically calculate nutrient availability and cost value based on your inputs. Here is the whittled-down summary: **Step 1)** Know the dry matter, total N, ammonium ( $\text{NH}_4\text{-N}$ ), nitrate ( $\text{NO}_3\text{-N}$ ) (for compost only), total P, and total K, content for the manure. (Contact your UI county extension faculty for advice on this.) **Step 2)** Calculate organic N content by subtracting  $\text{NH}_4\text{-N}$  and  $\text{NO}_3\text{-N}$  content from total N. **Step 3)** Estimate plant available N from the organic N fraction using the table below. **Step 4)** Estimate ammonium retained in the soil after incorporation using the table below. **Step 5)** Assume that all of the P and K in the manure will be plant available. **Step 6)** Sum available organic N and retained  $\text{NH}_4\text{-N}$  for an estimate of plant available N. For more information, refer to the publication at: <http://extension.oregonstate.edu/catalog/pdf/em/em8954-e.pdf>

Dairy manure source	Dry matter (%)	Plant available N from organic N fraction (%)					Ammonium-N retained in the soil after application, based on time to incorporation (%)		
		Current year	1 year ago	2 years ago	3 years ago	4 to 9 years	Immediate	1 day	7 days
lagoon water	< 1	40	15	7	3	2	95	95	95
thin slurry	1-5	40	15	7	3	2	95	70	55
thick slurry	5-10	30	15	7	3	2	95	60	40
manure solids	>10	30	15	7	3	2	95	50	20
separated solids	>10	10	5	5	3	2	95	50	20
compost	>50	10	5	5	3	2	100	100	100

If you have a nutrient management question from the field, please email your question to [amberm@uidaho.edu](mailto:amberm@uidaho.edu).

### CEC, continued from pg. 5

"ideal" cation mixture or ratio that has been proven for all soils. Extreme cation imbalance does exist however, and is related to infertile sodic affected soils, or deficiencies of K, Ca, or Mg, or toxicities of Al and Manganese (Mn).

Since negatively charged cation exchange sites attract cations, they therefore limit cation movement. This is why we generally think of cations in soils as being "immobile" or less mobile, and less subject to leaching than most nutrients or forms

of nutrients that exist in solution as negatively charged ions (Anions). Consider immobile ammonium-N ( $\text{NH}_4\text{-N}$ ) and highly mobile nitrate-N ( $\text{NO}_3\text{-N}$ ) for example.

Soil clay and organic matter (OM) provide the bulk of adsorption sites for holding cations. Soil CEC is affected largely by the amount of OM and clay, and the type of clay (kaolinite, vermiculite, montmorillonite). Surface area has a large influence on CEC. Sand and silt particles can attract cations with their negative charge, just not to the degree of clay or OM.

Adding OM to low OM soils not only adds nutrients to the soil bank and improves soil physical properties. As the OM decomposes and becomes more stable as humus, it provides additional adsorption sites for increasing CEC. Increasing CEC basically increases the reservoir or vault for storing cationic nutrients. Therefore, adding OM is a long term investment into your "soil bank" structure and the assets it can hold. For more information contact Christi Falen (208) 886-2406 [cfalen@uidaho.edu](mailto:cfalen@uidaho.edu)

## Nutrient Digest

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### Upcoming Events and Contact Information

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#### UPCOMING EVENTS

- April 4th-DEQ water fair at KMVT-TV community center in Twin Falls. 10am-3pm. Bring a water sample for free nitrate testing. Call 208-739-2190 for more information.
- May 19th, 20th and 21st - Western Odor and Water Quality workshop, Red Lion Hotel, Twin Falls. Call Mario De Haro Marti at 208-934-4417 for more information.
- June 14 - NCAP's Food and Farm Fest, Boise, Boise Urban Garden School on Franklin Road. 1:30-3:00. Email NCAP at [info@pesticide.org](mailto:info@pesticide.org) for more information.

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