Best Management Practices for Nutrient and Irrigation Management in the San Luis Valley

San Luis Valley

WATER QUALITY

Demonstration Project

The mission of the San Luis Valley Water Quality Demonstration Project is to *promote the adoption of water quality conservation Best Management Practices to minimize agricultural non-point source pollution of water resources in the Valley.*

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Preface and Acknowledgments

Shallow water tables, coarse soils, and intensive agricultural production systems increase the risk of agricultural non-point source pollution of water resources in the San Luis Valley of south central Colorado. In 1991, the U.S. Department of Agriculture authorized the San Luis Valley Water Quality Demonstration Project to address the issues of this risk.

The San Luis Valley Best Management Practices (BMP) Advisory Committee was formed to identify and document water quality conservation BMPs for local crops. The committee consists of a cross-section of local agricultural producers, crop consultants, fieldmen and local government agency specialists.

The Project offers sincere thanks to the committee for their willingness and dedication to serve, advise, and support the local BMP process to conserve the quality of local water resources.

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BMP Identification and Implementation

The development of water quality conservation Best Management Practices (BMPs) is a process of identifying and implementing a system of cultural and structural practices to minimize agricultural non-point source water pollution. The focus ranges from a regional perspective to an individual farming operation.

Important aspects of these practices are the economic and environmental soundness. Just as the water quality concerns have site-specific characteristics, local BMPs are selected to be suitable for local adoption. Often, these practices are already in place.

Critical to the success of the BMP approach is the voluntary nature of adoption. Local agricultural producers are inherently concerned about the resources they manage while making a living. Therefore, BMPs are best identified by those who understand the local situation and will be implementing the practices.

Broad regulatory action does not hold the promise of the more tailored BMP process. However, BMPs need to be well-adopted in a region to be effective in addressing water quality concerns. Otherwise, regulatory intervention and guidance may become necessary.

Preface to 1994 Edition

The citizens' of the San Luis Valley have a strong interest and extraordinary knowledge of their groundwater resources. Agricultural producers are leading the effort to protect and wisely utilize the water that makes life possible for people, crops, and wildlife ecosystems within the Valley.

The San Luis Valley Best Management Practices Work Group was formed in February of 1993 in response to a request from the Colorado Agricultural chemicals and Groundwater Protection Advisory Committee. The goal of the group was to prepare a set of site-specific Best Management Practices (BMPs) containing nutrient and irrigation guidelines and recommendations. In structuring the work group, emphasis was placed on utilizing LOCAL expertise. A farmer chairs the work group and the membership includes San Luis Valley producers, agrochemical fieldmen and local ag consultants. USDA and Colorado State University Cooperative Extension personnel participate in the process, but serve only an advisory capacity. This is a work group led by local agricultural practitioners, i.e. those who make their direct living from agriculture.

The work group met for over one year to prepare these guidelines for nutrient and irrigation management. These guidelines are not a complete inventory of nonpoint source pollution prevention strategies, but are some options that San Luis Valley farmers and ranchers can choose to fit their own specific operations.

You are encouraged to review these guidelines and compare them with your current farming and ranching practices. If some of these guidelines can help improve the efficiency of your business, we encourage you to adopt the practice.

Voluntary adoption of Best Management Practices is important to reduce further regulation of agriculture in the San Luis Valley. The group has worked hard to develop a set of guidelines that will be feasible, cost effective, and protect the resources of the San Luis Valley. Please direct any input or suggestions you have to the members of the work group.

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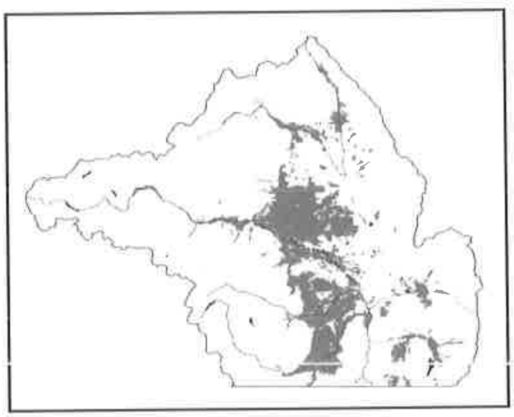
Introduction

Concern about drinking water quality and the environment has put the use of agricultural chemicals in the national spotlight. The threat of pesticide and nitrate contamination of groundwater in the San Luis Valley increases the need for farmers, ranchers, and other chemical applicators to modify some common production practices. Preventing groundwater contamination is particularly important because, once contaminated, it is very difficult and expensive to clean up.

Rather than legislate extremely restrictive measures for agricultural producers, the Colorado legislature passed SB 90-126, which encourages the voluntary adoption of water quality conservation Best Management Practices (BMPs). Voluntary adoption of these measures by fertilizer and pesticide users can help prevent contamination of water resources, improve public perception of the agriculture industry, and reduce the need for further regulation and mandatory controls.



The San Luis Valley is located in south-central Colorado. The shaded area within the Valley map represents cropland and pasture land use.

Best Management Practices

BMPs for water quality conservation are recommended methods, structures, and/or activities, designed to minimize water resource degradation while maintaining producer profits. The BMP concept deals specifically with non-point source pollution, such as the leaching of nutrients and pesticides through sandy soils. Implicit within the BMP concept is a voluntary, site-specific approach to water quality issues. Many of these methods are standard practices, known to be both environmentally and economically sustainable. Others may require changes in the way crops and livestock are managed in the San Luis Valley.

The objective of BMPs is to conserve the quality of San Luis Valley water resources, while maintaining the economic viability of agriculture and related industries. Success with voluntary BMPs will depend upon how many producers and agricultural chemical applicators actually adopt and promote them.

Each farmer or rancher must ultimately select the BMPs because of the site-specific nature of individual management systems.

To select the BMPs that achieve water quality goals for your operation, consider:

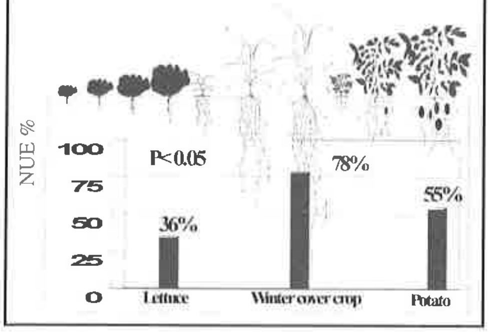
- ✓ Potential leaching hazard of the application site;
- ✓ Overall costs and benefits;
- ✓ Short- and long-term effects on water quality; and,
- ✓ Suitable practices for your crop rotation and your farm management plan.

Integrated Cropland Cultural Practices

Recommendations for nutrient, pest or irrigation BMPs need to include wind erosion control practices for the following reasons:

- ✓ Crops damaged by wind erosion fail to utilize the fertilizer provided, thereby leaving excessive nutrients in the soil profile which may later leach into groundwater;
- ✓ Crops damaged by wind erosion are more susceptible to pests;
- ✓ Wind erosion can decrease soil organic matter and clay content which substantially decreases water holding capacity.

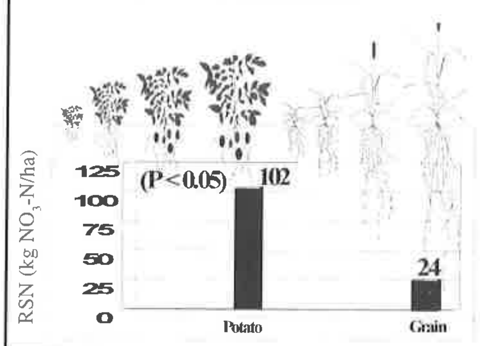
Nitrogen Use Efficiency (NUE) for a lettuce - winter cover crop - potato cropping system



Data collected by USDA-ARS, USDA-NRCS, SLVWQDP, and CSUCE

Delgado, Riggenbach, Ristau, Dillon, Sparks, et al.,

Residual Soil NO_3-N (RSN) for Potato-Small grain cropping sequence



Data collected by USDA-ARS, USDA-NRCS, SLVWQDP, and CSUCE

Delgado, Riggenbach, Ristau, Dillon, Sparks, et al.,

Implementation of the following BMPs can help maintain soil organic matter, tilth and reduce wind erosion.

Crop Rotation

- High residue crops (small grains) and alfalfa or grass should be a part of the rotation. One or more years of these crops should be grown to balance each year of low residue crops (i.e. potatoes, lettuce, carrots and other vegetables).
- Low residue crops should not be grown in consecutive years without a winter cover crop.
- Winter cover crops such as wheat or rye should be planted between consecutive years of low residue crops for nitrogen salvage and green manure.

Soil Management

- Leave adequate crop residue on the soil surface to reduce wind erosion potential. Incorporate residue into the soil surface with non-inversion implements to keep residue in the upper two inches.
- Maximize soil surface roughness by ridging the soil. Surfaces should be ridged perpendicular to prevailing southwest winds. Ridges should be two or three inches deep and 12 inches apart (1 to 4 ratio).
- Apply 1/2 inch irrigation after fall tillage to crust the soil surface. This crust should not be disturbed by tillage prior to planting (2-3 days).
- Reduce unsheltered distances across fields. Wind strip barriers may be planted in low residue crops to protect crops and soil. Avoid bare ground on adjacent low residue fields lacking separating stable boundaries. Establish field windbreaks or perennial grass or alfalfa strips on the leading edge to predominant wind directions.
- Contact your local Natural Resources Conservation Service office if you need assistance in evaluating erosion potential and control options.

General Nutrient Management

- Fertilizer rates should be based upon results from laboratory analysis of soil, plant tissue, and irrigation water using environmentally and economically sound standards for the San Luis Valley.
- Soil samples should be collected annually for each field to the depth of the effective crop root zone. As a guideline, at least 15-30 soil cores should be collected and mixed to represent one uniform soil type per cropped field.
- Growers should calculate realistic crop yield expectations for each crop (variety or cultivar) and field, based upon soil properties, available moisture, yield history and management level.
- Nutrients applied to fields with high wind erosion potential should be subsurface banded or incorporated as soon as possible after application.
- Fertilizer containing nitrogen should not be applied before the crop is planted when a high potential for large amounts of precipitation exists.

Nitrogen Fertilizer Management

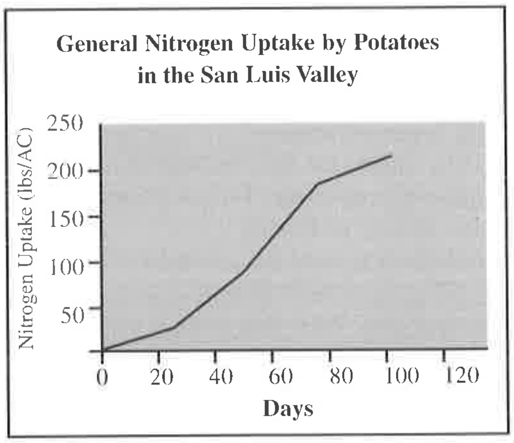
Coarse textured sandy soils and shallow water tables combine to create a high nitrate, (NO_3), leaching potential. Managing the amount, form, placement, and timing of nitrogen, (N), applications is a practical approach to minimizing surface and groundwater contamination.

Drinking-water with high nitrate concentrations poses known health risks to humans and livestock. Water supplies that contain more than 10 mg/l of NO_3-N, or 45mg/L as NO_3, exceed the national drinking water standard (U.S. EPA). The most susceptible to the NO_3 health risk of methemoglobinemia are infants and children under six months of age and the elderly. The University of Wisconsin (1983) suggests that NO_3-N levels of 40 mg/l or greater are risky for livestock and that water containing over 100 mg/l NO_3-N should not be used.

Proper nutrient management includes:

- ✓ Accounting for crop nutrient needs based on realistic yield expectations;
- ✓ Applying appropriate inputs as determined by N budget (see N Management Record Sheet worksheet on page 13); and,
- ✓ Applying N when and where the crop can use it most efficiently to minimize the risk of leaching.

These steps will help minimize residual soil NO_3. Nitrogen fertilization BMPs can also help producers and fertilizer applicators maximize economic returns from fertilizer dollars while benefiting water quality.



Graph by Richard Sparks, NRCS, 1999.

Nitrogen By Cultivar Interactions

Efficient fertility management for potato cultivars include use of realistic yield goals, applications based upon soil and irrigation water test results and proper crediting of manure or tilled in forage, and appropriate timing, placement and choice of fertilizer materials.

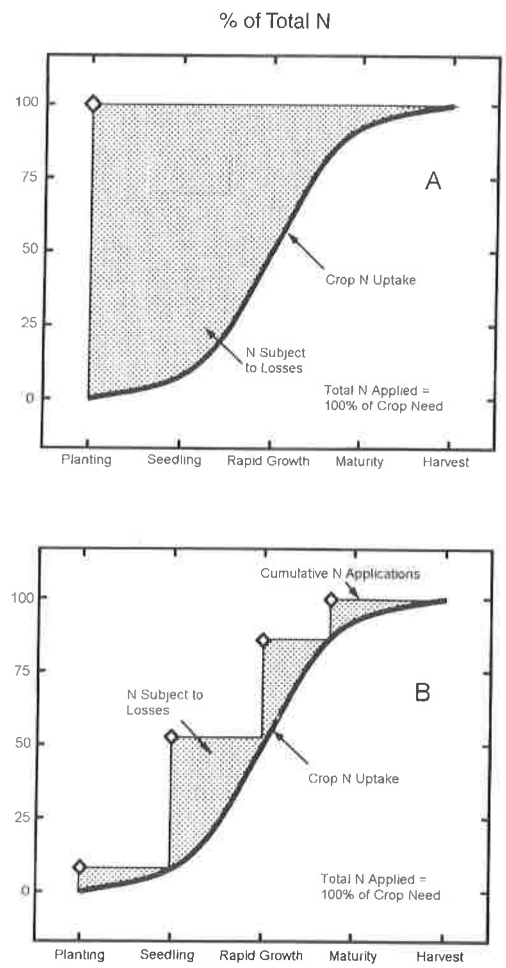
Nitrogen deficiency symptoms for potatoes are typical of those found in other plants: slow growth or stunted plants, chlorosis that is particularly noticeable in older foliage, and "firing" of leaf tips and margins beginning with more mature leaves. Since nitrogen is mobile within plants, it will move from older to younger tissues when in short supply. Additional symptoms include early vine senescence, poor yields and increased disease susceptibility. Foliar early blight and Verticillium wilt are generally more prevalent in a crop faced with nitrogen shortages because the pathogens take advantage of the stress placed on the crop. Conversely, a well fertilized and watered crop is able to resist some levels of infection by these pests.

Excessive nitrogen may delay tuber initiation and bulking, may increase second growth in susceptible cultivars and will promote unnecessary vine growth. Tuber maturation and skin set will be delayed with excessive nitrogen levels late in the season. This can increase susceptibility to skinning, bruising and tuber early blight infection. This may affect internal tuber quality such as increased sugar levels and decreased dry matter (starch) content. Additionally, production costs will be increased due to an unnecessary input.

Potato cultivars vary in their requirement for nitrogen. This variation is due to genotypic differences in vine, root and tuber traits. Growth habit, maturity, root size and depth, time of tuber initiation, rate of bulking, and desired end use of the tubers, are some of the cultivar specific characteristics influencing timing and rate of nitrogen applications. Indeterminate cultivars form a succession of branching stems and produce new flushes of foliage and flowers. Determinate cultivars are those with more of a bush type of growth habit and one flush of flowering. Both tuber initiation and tuber bulking occur earlier in the season for determinate versus indeterminate cultivars.

Early maturing cultivars generally require less nitrogen than later maturing cultivars, due to lower total yield potential, however they often need more in the early stages to aid in establishment of a healthy canopy and root system. Cultivars with a more compact root system generally require more nitrogen to attain maximum tuber yield, while those with a more extensive root system need less. When producing processing cultivars, it is important to monitor late season applications, as specific gravity may become too low and sugar levels excessive to produce high quality products. Tablestock producers may benefit from additional nitrate applications. However, they must still be cognizant of delayed skin set and the potential for an increase in bruising. Nitrogen fertility practices may influence degree of netting on russet cultivars and intensity of skin color for reds.

Attention to differences in cultivar habits and characteristics provide nutrient management clues. Cultivar specific profiles incorporate this information to aid producers in attaining maximum yield, grade and economic returns, while minimizing environmental impacts.



Potential N losses occurring when fertilizer is applied to irrigated barley in a single (A) vs. split application (B).

Data collected from "Barley Management Practices for Colorado", Colorado State University.

Best Management Practices for Nitrogen Fertilization

Guidance Principle: Manage nitrogen applications, to maximize crop growth and economic return, while minimizing losses to the environment.

- A yearly N management plan should be developed for each field and crop (See N Management Record Sheet for suggested format on page 13). The plan should include, as a minimum:
  - Previous crop, variety or cultivar, and yield;
  - Current crop, variety or cultivar, and yield goal;
  - Current soil test analysis data showing the amount of available N in the topsoil and subsoil;
  - An estimate of the amount of N available from soil organic matter, manure, previous legume crops, or green manure crops that will become available during the crop growth period;
  - The amount of supplemental N to be applied to meet expected crop yield. This amount includes N from fertilizers, organic sources, irrigation water and other sources; and,
  - Special management practices needed to reduce nitrate leaching including: timing of application, multiple applications, side-dressing, banding, foliar feeding, fertigation or needed changes in crops or crop sequence.
- The rate of N applied to each crop in a given year should be limited to that amount necessary to meet projected crop needs and should not exceed the recommended rate unless weather conditions, additional soil tests or plant tissue analyses indicate a need.
- Plant crop varieties/cultivars with higher N use efficiency. Contact your local Colorado State University Cooperative Extension Office for nitrogen use information.
- Nitrogen fertilization should be split and timed to meet crop needs.
- Nitrogen fertilizer for spring planted crops should not be applied in the fall. Apply N for stubble decomposition before September 15.
- Actively growing fall crops or perennial crops may be fertilized according to plant needs.
- Apply N fertilizers where they can be most efficiently utilized by the crop. For example:
  - Banded fertilizer used in conjunction with alternate row furrow irrigation can reduce downward movement of N.
  - Multiple, small applications of N through sprinkler irrigation systems can increase fertilizer efficiency and reduce total N fertilizer application.
- Nitrogen applied in irrigation water should be metered and properly calibrated. Nitrogen applied with irrigation water will have the same field

distribution as the water. Therefore, this technique should only be used where deep percolation below the root zone is minimal.

- Shallow rooted crops with low N use efficiency, such as potatoes, should be followed in the rotation by a deep rooted, high N use crop which will use the excess N (such as small grains or alfalfa).
  - Winter cover crops such as rye, triticale or wheat can also be grown to recover excess N when planted prior to October 1.

Fertilizer Handling and Storage

- Fertilizers should be mixed and stored at least 100 feet away from all wellheads or surface water bodies, except at fertigation sites. Fertilizer should be mixed, loaded, and stored on impervious surfaces.
- Fertilizer application equipment should be inspected and calibrated at least annually.
- When cleaning fertilizer equipment after application, excess fertilizer and all wash water should be recovered for application. Rinse water should be used in the subsequent fertilizer batch when possible, or be applied at agronomic rates on cropland, avoiding high runoff areas.
- Refer to state regulations for specific handling and storage requirements.

Phosphorus Management

Phosphorus (P) from agricultural sources does not generally pose a significant threat to San Luis Valley water resources. Wind and irrigation induced erosion can move P on soil sediment into surface waters.

High levels of P in water allow algae and aquatic plants to produce abnormally high amounts of biomass, resulting in a depletion of oxygen and ultimately causing death of fish and other aquatic animals. Nutrients from manure and commercial fertilizers should be prevented from entering surface waters by implementing soil erosion reducing practices and structures, as well as BMPs when appropriate.

Best Management Practices for Phosphorus Fertilization

Guidance Principle: Practice efficient P management by placing fertilizer to optimize plant uptake and minimize loss.

- Sample the tillage layer of soil in each field and have soil analyzed to determine available soil P levels prior to applying P fertilizer. Credit all available P from manure and other fertilizers to the P requirement for the crop.
- Apply P fertilizers where they can be most efficiently taken up by the crop. Band application of P in the root zone reduces surface loss potential and enhances nutrient availability in cold or deficient soils. Incorporate surface applied P into the soil where any potential for surface runoff or erosion exists.
- Manure stockpiles should be located at least 150 feet from all water supply wells and should be located on an impervious surface above the 100-year flood plain, unless adequate flood proofing structures are provided.
- Runoff from manure storage sites should be diverted away from surface waters and be applied to cropland or pasture.
- Avoid mechanical disturbance of the manure-soil seal when cleaning feedlots.

- Feedlots or manure storage sites should be scraped down to bare earth and revegetated when abandoned.

Irrigation Management

Over irrigation may cause leaching or runoff. To reduce non-point source pollution caused by leaching and runoff, irrigation systems should be managed so that the timing and amount of applied water match crop water needs and soil water holding capacity.

Proper irrigation management can conserve water, lower irrigation costs, minimize deep percolation and produce higher crop yields, resulting in increased net returns.

This information should be used by irrigators to select irrigation methods and BMPs to conserve water and decrease leaching and/or runoff. All BMPs are not appropriate for every field and irrigation system.

Center-pivot sprinkler irrigation of a potato field in bloom.

Best Management Practices for Irrigation Management

Guidance Principle: Manage irrigation to minimize transport of chemicals, nutrients, or sediment from the field surface and active root zone to conserve water quality.

- Schedule irrigation according to crop evapotranspiration (ET) and soil water depletion. Apply only enough irrigation water to fill the effective crop root zone at the current crop growth stage. Be sure to adjust irrigation application for rainfall received. Avoid unnecessary late season irrigation.
- Monitor soil moisture by the feel method and use tensiometers, resistance blocks, a hand probe, or other acceptable methods before and after irrigation.
- Irrigate based on management allowed depletion (MAD) rates considering soil type and crop rooting depth. For MAD rates on specific crops and growth stages contact CSUCE.
- Monitor the water content in the soil profile to check if the irrigation water is moving beyond the root zone.
- Evaluate the efficiency of the total irrigation system from the pump or diversion to return flow or tail water. Upgrade irrigation equipment to improve delivery and application efficiency to reduce leaching and runoff.
- In situations where surface loss or leaching is highly probable, select pesticides that have shorter half-lives and low leaching potential and use biological pest control alternatives whenever possible.
- Analyze irrigation water periodically and credit NO_3-N contributions to the nitrogen budget.
- Time leaching of soluble salts to coincide with periods of low residual soil nitrate.
- Irrigation water used to recharge underground aquifers should be applied only on areas where no N fertilizer or pesticides have been applied within the last 12 months.
- If you need assistance, contact a qualified crop consultant or irrigation technician to help schedule irrigation and determine the application efficiency of your system.

Flood or Furrow Irrigation

- Minimize deep percolation and surface runoff by installing gated pipe, surge flow, or other more efficient systems where feasible.

N Credit From Irrigation Water

NO_3 - N Conc. in Water	Water applied (inches)					
	6	12	18	24	30	36
ppm	-lb. N/Ac-					
1	1	2	4	5	7	8
2	3	5	8	11	14	16
3	4	8	12	16	20	24
4	5	11	16	22	27	33
5	7	14	20	27	34	41
6	8	16	24	32	41	49
7	9	19	28	38	47	57
8	11	22	32	43	54	65
9	12	24	36	49	61	73
10	13	27	40	54	67	81
12	16	30	45	60	75	90
14	19	38	57	76	95	113
16	22	43	65	86	108	130
18	23	49	73	97	122	146
20	27	54	81	108	135	162

- Reuse tail water by storing irrigation runoff in tail water recovery ponds, where feasible.
- Use different combinations of furrow stream size and set-time to achieve the most uniform water application. Use the maximum furrow stream size that does not cause significant erosion.
- Adjust irrigation run distance to optimize irrigation efficiency. For example, length of irrigation run on level fields with <.5% slope should ideally not exceed 600 feet on sandy soils or about 1300 feet on fine textured soil.
- Line irrigation delivery ditches to reduce seepage losses and install pipelines to convey irrigation water where feasible.
- Adjust border width and flow rate to optimize efficiency in border irrigation.

Sprinkler Irrigation

- Minimize deep percolation on sprinkler irrigated fields by applying only the amount required to replace water used by crop ET.
- Minimize surface runoff on sprinkler irrigated fields by adjusting depth of application, increasing surface residue, utilizing conservation tillage, or changing nozzle configuration, height, and droplet size as appropriate.
- Annually, calibrate sprinklers for depth of application, rate of flow, pressure, uniformity, and timer accuracy.
- Use drop nozzles and low pressures to increase efficiency.

Chemigation

- Always read and follow the chemical label prior to chemigation.
- Sprinkler applications of fertilizers or pesticides should be made in accordance with the rules of the Colorado Chemigation Act. Chemigation is not recommended with any low efficiency systems and is discouraged with conventional flood or furrow systems.
- Reduce water application rate to minimize runoff and deep percolation
- Avoid chemigation application when excessive wind speed may cause drift beyond target field.
- Inspect chemigation equipment and safety devices frequently to determine proper function and replace all worn or nonfunctional components immediately.
- Upgrade well design or condition to reduce the possibility of point source contamination at the wellhead. Handle chemicals carefully around the wellhead and chemigation site. Clean up any fertilizer or pesticide spills immediately to avoid well contamination.

Manure and Organic Waste Utilization

Livestock manure is rich in plant available nutrients which can be valuable assets to crop producers. However, it also can be a source of both ground and surface water contamination if improperly handled.

In Colorado, the Confined Animal Feeding Operations Control Regulation prohibits any direct discharge of manure or animal wastewater to either surface or groundwater. Animal feeding operations are directed to employ BMPs, when or where appropriate, to protect state waters.

Best Management Practices for Manure Utilization

Guidance Principle: Analyze manure and similar organic materials for nutrient content. Base application on crop needs and nutrient availability from the manure.

- Sufficient land area needs to be available for manure application in relation to the amount of manure generated by the animal feeding operation.
- When calculating long term manure loading rates, a reasonable estimate is that 50% of total N from applied manure is available in the first cropping season. The remaining N will become available slowly over time. Use soil test and manure test data to help determine available nutrients after repeated manure applications.
- Test well water near livestock operations and land where manure is applied regularly for nitrate and bacterial contamination to determine if management practices are sufficiently conserving water quality. Properly seal unused wells and repair poorly sealed operating wells.
- Manure application rates should be based upon a site-specific nutrient management plan that includes:
    - Credit of all plant available nutrients from manure, irrigation water, crop residues, residual soil nutrients, and soil organic matter. These factors should be based upon laboratory analysis of soil, water, and manure.
    - Appropriate manure application rates based upon crop yield goal and plant available nutrients.
    - Factors such as handling, application method, tillage, irrigation regime, cropping and grazing pattern and site factors such as soil texture and slope.
- Incorporate manure as soon as possible after application to prevent losses due to wind erosion, surface runoff and NH_3 volatilization. Avoid application of manure to soils subject to excessive surface runoff.
- Apply manure on coarse textured soils near planting time to enhance crop uptake and minimize nitrate leaching. Multiple applications are better than a single heavy annual application.
- Manage manure application to minimize stress on seedlings such as nitrogen burn or salt buildup in soils.
- Apply manure uniformly with properly calibrated equipment.
- Reduce nitrate leaching potential by delaying fall application on low surface residue sites until soil temperatures are below 50 degrees F. Application of manure to frozen or saturated soils should be limited to lands not subject to excessive surface runoff.
- Create a buffer area around water wells and surface water bodies where no manure is applied to prevent the possibility of water contamination.
- Operators of animal feeding operations, as defined by Colorado law, should establish adequate manure storage capacity based upon manure, wastewater and runoff production.

Other Best Management Practices to Improve Nutrient and Irrigation Management

Guidance Principle: In order to be current regarding technological advancement in BMP systems, participate in farm demonstrations and local meetings, where new methods and advances are presented annually by prominent researchers.

- Divide fields into areas of like soil types to increase irrigation water and nutrient use efficiency.
- Use precision agriculture technology that incorporates data from soil analysis, yield monitors and similar sources to make site-specific nutrient recommendations.
- Computer decision support systems such as the Nitrate Leaching and Economic Analysis Package (NLEAP) or Cropflex should be used to assist in nutrient and irrigation water management.
- Use field tests such as chlorophyll meters, plant and soil nutrient monitors, nitrate test strips, and other tests to evaluate nutrient levels in your operation.
- Use remote sensing technology, such as satellite imagery and aerial photography if economically feasible to help detect problem areas.

NITROGEN MANAGEMENT RECORD SHEET

Field description:

Previous crop: ______________________ Yield: ______________________

Soil tested by: ______________________ Water tested by: ______________________

Crop Season: ______________________

1. Crop and variety planted: ______________________
2. Expected crop yield: ______________________
3. Total N needed to achieve expected yield: ______________________ lbs N/A
   (expected yield x crop factor/Efficiency factor)
4. Residual soil NO_3: ______________________ lbs N/A
5. Irrigation water NO_3-N credit: ______________________ lbs N/A
   (ppm NO_3-N x 2.7 =lbs/A ft. water)
6. Soil organic matter credit: ______________________ lbs N/A
   (10 lbs/1 percent organic matter)
7. Manure credit: ______________________ lbs N/A
   (10 lbs N/ton manure for the first year after application if analysis not performed)
8. Nitrogen available from previous legume crop: ______________________ lbs N/A
9. Total N available to crops: (sum of lines 4,5,6,7, and 8) ______________________ lbs N/A
10. Nitrogen fertilizer requirement: ______________________ lbs N/A
    (line 3 minus line 9)

Total Nitrogen applied: ______________________ lbs N/A Actual Yield: ______________________

Application dates and amounts: ______________________

Form of N used: ______________________ Total irrigation water applied: ______________________ in/A

N Placement: ______________________

References

Colorado State University Cooperative Extension Fact Sheets:

Center pivot irrigation systems	*4.704*
Controlling soil erosion from wind	*0.518*
Crop water use and growth stages	*4.715*
Estimating soil moisture	*4.700*
Fertigation through surge valves	*0.508*
Fertigation	*0.512*
Fertilizer cost calculations	*0.548*
Fertilizer practices and efficiency	*0.553*
Fertilizing alfalfa and grasses	*0.537*
Fertilizing irrigated meadows	*0.701*
Fertilizing mountain meadows	*0.535*
Fertilizing potatoes	*0.541*
Fertilizing spring seeded small grains	*0.534*
Fertilizing winter wheat	*0.544*
Grain protein content and N needs	*0.555*
Irrigation of winter wheat	*0.556*
Irrigation pumping plant efficiency	*4.712*
Irrigation scheduling with atmometers	*4.706*
Irrigation scheduling	*4.708*
Irrigation scheduling: the water balance approach	*4.707*
Irrigation water quality criteria	*0.506*
Nitrogen and irrigation management	*0.514*
Nitrogen sources and transformations	*0.550*
Organic materials as nitrogen fertilizers	*0.546*
Soil sampling	*0.500*
Soil test explanation	*0.502*
Soil testing	*0.501*
Soil, water and plant testing	*0.507*
Use of manure in crop production	*0.549*

Colorado State University Cooperative Extension Publications:

Best Management Practices for:	
Irrigation Management	*XCM173*
Manure Utilization	*XCM174*
Nitrogen Fertilization	*XCM172*
Phosphorus Fertilization	*XCM175*
Surge Irrigation Guide	*543A*

Colorado Irrigation Guide USDA Soil Conservation Service

Innovative Management Alternatives to Increase Nitrogen Use efficiency and Water and Soil Quality Protection Under Potato or Vegetable - Small Grains System: II. Cropping System Evaluations. J. Delgado, R. Riggenbach, R. Sparks, M. Dillon, L. Kawanabe, and R. Ristau, USDA Agricultural Research Service - Soil Plant Nutrient Research Unit, Fort Collins, CO 80522 (This poster and associated publications are available from the main author.)

For more information about nutrient and irrigation management in the San Luis Valley, contact Colorado State University Cooperative Extension the Natural Resources Conservation Service, or a qualified crop consultant. They have publications, programs and specialists available to help answer your questions about water quality.