(R – 1) Table of Important Equations, Relationships and Concepts used in IWM

Irrigation planning:

$Fc = ECe_{(ct)}/ECiw$ (calculates the ratio of the soil salinity to irrigation water salinity). Is needed to calculate the Leaching Fraction (LF)).

$LF = 0.3086/Fc^{1.702}$ (calculates the LF for conventional irrigation). Accounts for extra water needed for salt mgmt.

$NIR = ETc/(1 - LF)$ (calculates the Net Irrigation Requirement (NIR)). Used to plan & design irrigation systems & IWM Plan.

Ea = Irr. needed/Irr. applied (calculates the Irrigation Application Efficiency (Ea)). Used to evaluate irrigation system efficiency & IWM Plan.

$Fg = NIR/Ea$ (to calculate Gross Irrigation Application needed (Fg)). Used in the planning & design of irrigation systems and IWM Plans.

$Q = DA/T$ (to calculate the amount of flow (cfs) needed per border/field). Used in the planning and design of irrigation systems and evaluation of IWM Plans.

Water Quality:

$SAR = Na/\sqrt{(Ca + Mg)/2}$ (calculates the Sodium Absorption Ratio). Used to evaluate potential infiltration problems (SAR & ECiw are used together in this evaluation).

TDS (ppm) = ECiw (dS/m) x 640 (for ECiw between 0.1 & 5.0 dS/m; calculates Total Dissolved Solids). Used to assess salt load in irrigation water.

TDS (ppm) = ECiw (dS/m) x 800 (for ECiw > 5.0 dS/m; i.e., irrigation waters with high salt content).

Soils:

$D_b = g/cm^3$ (calculates the soil bulk density). Used to assess soil compaction, available water & soil porosity as they relate to soil texture & structure.

CEC = meq/100 g (is based on % clay & % OM). Is used as an indicator of the soils capacity to retain nutrients and its buffering capacity).

AWH (inches/foot): is based predominantly on soil texture. Used in the development, implementation & monitoring of an IWM Plan.

Definitions:

Fc = Ratio of soil salinity to irrigation water salinity

$ECe_{(ct)}$ = Electrical Conductivity of soil saturation extract (i.e., the Crop Threshold Salinity in dS/m)

ECiw = Electrical Conductivity of the Irrigation Water (dS/m)

LF = Leaching Fraction. A $LF = 0.1794/Fc^{3.0417}$ is used for High Frequency Irrigations

NIR = Net Irrigation Requirement

ETc = Crop Evapotranspiration (crop consumptive use)

IWM = Irrigation Water Mgmt.

Ea = Irrigation Application Efficiency

Fg = Gross Irrigation Application

Q = DA/T: Where Q = cubic feet per second (cfs); D = inches applied; A = area in acres & T = time in hours

SAR = Sodium Absorption Ratio

TDS = Total Dissolved Solids (the amount of solid minerals dissolved in water)

ppm = parts per million

dS/m = decisiemens/meter (electrical conductivity)

D_b = Soil bulk density in grams per centimeter cubed (g/cm^3)

CEC = Cation Exchange Capacity in milliequivalents per 100 grams (meq/100 g) of soil, on a dry weight basis

AWH = Available Water-Holding Capacity in inches of available water per acre-foot of soil

(R – 2) Why Salinity Management is Important

Salinity: The major solutes comprising the dissolved salts are the cations (ions with a positive charge) of calcium, magnesium & sodium (potassium exist in very small amounts). The anions (ions with a negative charge) include sulfate, chloride, & bicarbonate (minor amounts of anions include: carbonate, nitrate, fluoride, phosphate, borate & silicate). All combined, the proportion of each of these dissolved mineral solute determines the suitability of water for irrigation.

There are four rules regarding irrigation and salinity that need to be understood[1/]:

- Rule #1: All waters used for irrigation contain salts of some kind in some varying amounts
- Rule #2: Salinization of soil and water is inevitable to some extent
- Rule # 3: An irrigated agroecosystem cannot be sustained without some drainage, either natural or artificial
- Rule # 4: Rules 1 though 3 can't be changed

Major reasons & strategies for salinity management:

- Sustainability of irrigated agriculture
- Protect surface and ground water quality
- Water conservation requires it
- Increased energy cost to pump water requires efficient irrigation systems that can leach salts to acceptable levels
- To prevent salinization
- Increased costs of soil amendments demand their judicious use
- Water resources (quantity and quality) are becoming more limited
- Increased irrigation efficiencies require greater salt management
- To prevent soil erosion and protect and improve soil quality
- Significant portions of the world's irrigated land are affected by salinity
- Lands degraded by salinity must be restored and reclaimed in order to increase crop productivity & quality
- Is a major component of an IWM Plan (i.e., leaching requirement)
- Salinity levels must be monitored to ensure that IWM practices are providing an optimal crop growing environment
- Planting & tillage strategies can be developed to prevent excessive salinity accumulation in the root zone
- Crops are most affected at the germinate and young seedling stage (Critical to manage at this stage)
- Depending on water quality, foliar injury (salt burn) is caused by leaf absorption of excess concentrations of sodium and chloride
- Needed to plan, design and manage irrigation systems to meet crop consumptive use & salinity leaching requirements
- IWM Plan must account for the crops unique salt tolerance
- To use appropriate reclamation strategies & amendments for reclaiming Saline, Sodic & Saline-Sodic soils
- To select suitable salt tolerant crops that are appropriate for existing water quality/quantity and irrigation systems
- To ensure a suitable drainage requirement for given water quality, crop salt tolerance and leaching requirement (e.g., depth to water table, soil texture/structure, etc.)
- To ensure that leaching is not required until accumulated soil salinity surpasses the salt tolerance threshold for the crop

1/ NRCS Salinity Management for Soil & Water (pg. 1.28); Additional Ref.: NRCS Conservation Practice (610): Toxic salt reduction

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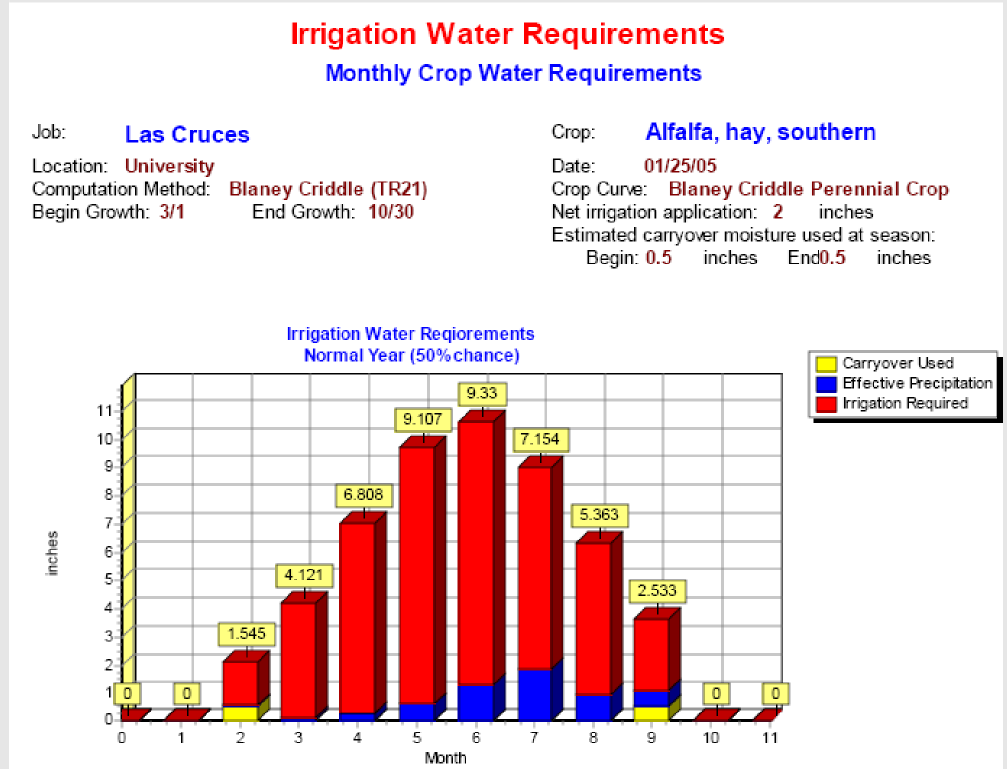
(R – 3) How to access New Mexico Crop Consumptive Use Requirements

Step 1	**Enter the following website:** **http://www.nm.nrcs.uasd.gov/**
Step 2	**Under Quick Access (left-hand side of screen), <u>click on</u>:** **Field Office Technical Guide**
Step 3	**Under Section I – General Resource References, <u>click on</u>:** **Reference List**
Step 4	**Under Environmental Assessment, <u>click on</u>:** **Irrigation Guide for New Mexico**
Step 5	**Under Irrigation Guide, click on:** **Consumptive Use Requirements**
Step 6	**Under Consumptive Use Crops, <u>click on</u> your Location of interest:** **Example: Las Cruces**
Step 7	**Under Irrigation Water Requirements (Crop Data Summary), <u>scroll down</u> to your crop of interest:** **Example: Alfalfa, hay, southern**
Step 8	**You're Done!!!**



Crop Consumptive Use Requirements are used by NRCS in the planning and design of irrigation systems. This information is also used in understanding and properly implementing an Irrigation Water Management (IWM) Plan.

Additional Engineering and Irrigation Resources

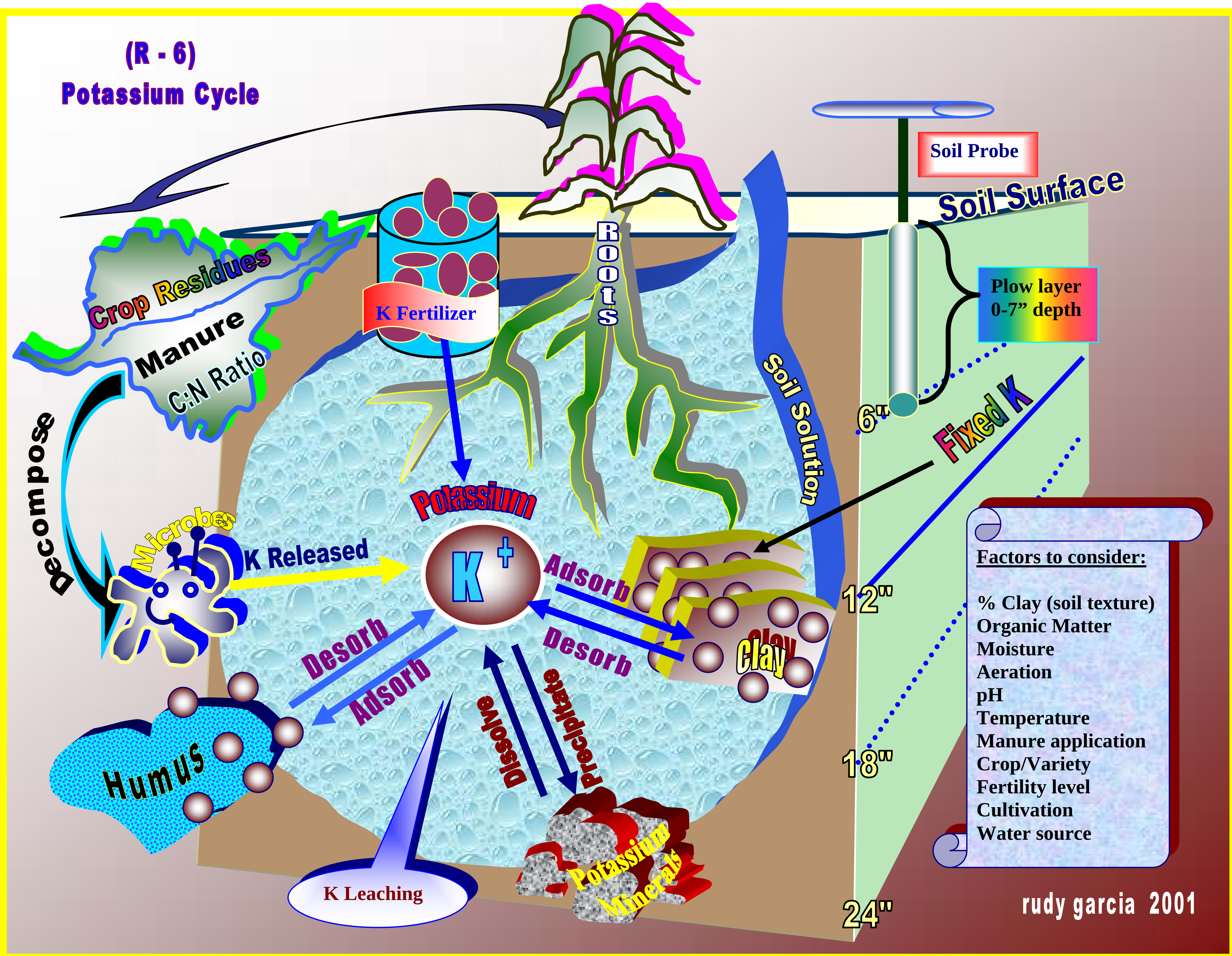
Various references and resources are available that could be used to expand upon the contents of this IWM Field Guide to include the following:

1. **National Engineering Handbook, Part 652, Irrigation Guide, http://www.info.usda.gov/CED/**
2. **National Engineering Handbook, Section 15, Chapters 1 to 9 & 12, http://www.info.usda.gov/CED/**
3. **National Engineering Handbook, Part 623 Irrigation, Chapter 4, Surface Irrigation, http://www.info.usda.gov/CED/,**
4. **New Mexico NRCS Field Office Technical Guide, Section IV, Standards and Specifications, http://www.nm.nrcs.usda.gov/technical/fotg/section-4/std-specs.html**
5. **NRCS Irrigation Training Tool Box, http://www.wsi.nrcs.usda.gov/products/W2Q/water_mgt/Irrigation/irrig-training-toolbox.html**
6. **The New Mexico Irrigator's Pocket Guide - 2005**
7. **Western Fertilizer Handbook, 9th edition, 2002, California Plant Health Association. Interstate Publishers, Inc., Danville, IL.**
8. **Irrigation Principles and Practices; Hansen, Israelsen, Stringham**
9. **OHIO**
10. **SIMenu**

Where there is no counsel, the people fall, but in the multitude of counselors, there is safety.

(R – 5) Using IWM to achieve Energy Conservation

A Holistic IWM Plan integrates various agronomic practices to achieve energy conservation through the proper mgmt. of all inputs				
INPUTS	**Integration of IWM Plan with other Mgmt. Practices**	**Benefits of IWM**	**Para-meter**	**% of total cost**
Irrigation Water	Irrigation is based on crop consumptive use, soil water holding capacity, irrigation scheduling & monitoring.	Higher irrigation efficiencies (reduced pumping costs); reduced water use; acceptable salt management; higher yields and crop quality.	Pumping	
Irrigation Technology & Labor	Irrigation technology and its management are designed to meet the unique crop, water quality/quantity, economics & site-specific conditions.	Substantial reduction in labor requirements; increased irrigation efficiencies; protection of surface & ground water quality; higher yields and crop quality.	Irrigation System & Labor	
Nitrogen	Split-applications of N (based on soil test & NMSU fertilizer recommendations), with tissue test to assess fertility program.	Substantial reductions in N losses through leaching, volatilization and denitrification; protection of surface & ground water quality; reduced N inputs; higher yields & quality.	Units of N/acre	
Phosphorus	Applications of P are based on soil test & NMSU fertilizer recommendations & the NRCS Phosphorus Index	Protection of surface & ground water quality; achieve nutrient balance; reduced P inputs; higher yields; proper use of manure/effluent.	Units of P_2O_5/acre	
Potassium	Applications of K are based on soil test & NMSU fertilizer recommendations; plant tissue test monitors effectiveness of fertility program.	Significant reduction in K inputs; attainment of nutrient balance; protection of surface & water quality; higher yields & quality.	Units of K_2O/acre	
Soil Amendments	Application of soil amendments are based on water quality, soil test & NMSU recommendations (and are correlated to soil texture & structure)	Prevents and/or remediates sodic and saline-sodic soils; substantial reduction in amendment use & cost; protects surface and ground water quality.	Lbs./acre	
Pesticides	Applied according to NRCS Conservation Practice Standard 595; uses pest scouting techniques.	Protects surface and ground water quality; breaks pest and disease cycles; higher yields and quality.	Oz./acre (a.i.)	
Herbicides	Crop rotations, tillage operations & other agronomic practices are used with herbicides to manage weeds.	Protects surface and ground water quality; reduces weed pressures; higher yields and quality.	Oz./acre (a.i.)	
Tillage Operations	Tillage is based on achieving a positive Soil Conditioning Index.	Reductions in fuel cost; higher soil organic matter (improved soil structure and quality).	Gal. (fuel) /acre	


(R - 6)
Potassium Cycle
Soil Probe
Soil Surface
Plow layer
0-7” depth
Crop Residues
Manure
C:N Ratio
K Fertilizer
Roots
Soil Solution
Decompose
Microbes
K Released
Potassium
K+
Adsorb
Desorb
Fixed K
Clay
Desorb
Adsorb
Dissolve
Precipitate
Humus
K Leaching
Potassium Minerals
6"
12"
18"
24"
Factors to consider:
% Clay (soil texture)
Organic Matter
Moisture
Aeration
pH
Temperature
Manure application
Crop/Variety
Fertility level
Cultivation
Water source
rudy garcia 2001

(R – 7) **Runoff Class Based on Field Slope and Permeability Class**[1]

Slope %	Very Rapid >20 (in/hr)	Rapid 20-6 (in/hr)	Moderately Rapid 6-2 (in/hr)	Moderate 2-0.6 (in/hr)	Moderately Slow 0.6-0.2 (in/hr)	Slow 0.2-0.06 (in/hr)	Very Slow 0.06-0.0015 (in/hr)	Impermeable <0.0015 (in/hr)
Level or Concave	N	N	N	N	N	N	N	VH
>0 to 1	N	N	N	N	L	M	H	VH
1 to <5	N	N	VL	L	M	H	VH	VH
5-<10	VL	VL	L	M	H	VH	VH	VH
10-<20	VL	VL	L	M	H	VH	VH	VH
>20	L	L	M	H	VH	VH	VH	VH

Note: Adapted from the National Soil Survey Handbook.

[1]Based on the most restrictive horizon above 20 inches. If the most restrictive horizon is between 20 and 40 inches, the runoff estimate should be reduced by one class (e.g., medium to low). If the most restrictive layer in the soil is below 40 inches, use the lowers class that occurs above 40 inches.

Runoff Classes: N-negligible, VL-very low, L-low, M-medium, H-high, VH-very high

Special Rule 1 - A soil horizon that has a seasonal water table is assumed to have very slow permeability.

Special Rule 2 - Runoff is rated as "negligible" (N) if the soil is in a depression, regardless of the permeability.

Assumptions:
1. Soil Permeability based on bare soil surface.
2. Low water retention due to ground surface irregularities.
3. Steady ponded infiltration rate.
4. Bulk density of upper 10" is within normal range for the soil.

(R – 8) Measurement of soluble Salts

EC Plant Response
ds/m-1 or mmho/cm or ms/cm

SOIL	EC	SAR	pH
➢ Normal	<4	<13	
➢ Saline	>4	<13	< 8.5
➢ Sodic	<4	>13	> 8.5
➢ Saline-sodic	>4	>13	7.8 – 8.5

Three types of soils with salt problems

1.

- **Saline soils** - Saline soils contain large quantities of neutral salts which interfere with plant growth. The salts present may include bicarbonates, carbonates, borates, chlorides, or sulfates of calcium, magnesium, potassium, or sodium.
- SAR < 13
- EC > 4 mmho/cm
- pH < 8.5
- Sometimes called **white alkali soils**

2.

- **Sodic soils** - Sodic soils contain large amounts of exchangeable sodium (Na+)
- SAR = > 13
- EC = < 4 mmho/cm
- pH > 8.5

3.

- **Saline-sodic soils –**
- Saline-sodic soils contain appreciable quantities of both neutral salts and sodium
- SAR > 13
- EC > 4 mmho/cm
- pH 7.8 to 8.5 usually

Measurement of soluble Salts by EC

EC Plant Response
ds/m-1 or mmho/cm or ms/cm

- 0 - 2 No or negligible salt effects
- 2 – 4 Yield reduction possible in salt-sensitive crops
- 4 - 8 Yield of many crops reduced
- 8 -16 Yield satisfactory only in salt-tolerant crops
- > 16 Yield satisfactory only in few very salt-tolerant crops

The conversion factor from PPM to mmho/cm is 640

(R – 9) - GLOSSARY

Acequia: Historical community ditch, found throughout the state but predominantly in the mountainous areas of Northern New Mexico.

Agronomy: The science of utilizing plants for food, fuel, feed, and fiber.

Anion: Negatively-charged particle.

Application efficiency (E_a): The ratio of the average depth of irrigation water infiltrated and stored in the root zone to the average depth of water applied, expressed as a percentage - also referred to as AE.

Application rate: Term generally used in sprinkler irrigation to describe the rate at water is applied to a given area - usually expressed in inches per hour.

Available soil water: The difference between actual water content of a soil and the water held by the soil at permanent wilting point.

Available water capacity (AWC): The portion of water in the soil profile that can be readily absorbed by plant roots of most crops, expressed in inches per inch, inches per foot, or total inches for the specified soil depth. It is the amount of water stored in the soil between field capacity (FC) and permanent wilting point (WP). It also called available water holding capacity (AWHC).

Blaney-Criddle Method: An air temperature based method to estimate crop Evapotranspiration.

Bulk density: Mass of dry soil per unit volume, determined by drying to a constant weight at 105^o C, usually expressed as gm/cc or lb/ft^3.

Cation exchange capacity (CEC): The sum of exchangeable cations (usually Ca, Mg, K, Na, Al, H) that the soil constituent or other material can absorb at a specific pH. Usually expressed in milli equivalents (meq) per 100 grams of soil at neutrality (pH=7.0).

Cation: Positively charged particle.

Chemigation: Application of chemicals to crops through an irrigation system by mixing them with irrigation water.

Conservation crop rotation: Growing crops in a recurring rotation on the same field to maintain or improve soil organic matter, reduce water and wind erosion, select crops for irrigation water management or salinity management, manage nutrients and pests, provide food for domestic livestock, and provide food and cover for wildlife.

Conservation management system: A system which addresses soil, water, air, plant, and animal resource concerns.

Consumptive use: See Evapotranspiration.

Crop coefficient (K_c): A factor used to modify potential evapotranspiration as follows: (1) Ratio between crop evapotranspiration (Et_c) and the reference crop (ET_o) when the crop is grown in large fields under optimum growing conditions ($Et_c = K_c \times ET_o$), or (2) the ration of the actual crop Evapotranspiration to its potential Evapotranspiration.

Denitrification: Process occurring naturally in soil, where bacteria break down nitrates to give nitrogen gas, which returns to the atmosphere.

Distribution uniformity (DU): The measure of the uniformity of irrigation water over a field. NRCS typically uses DU of the lower one-quarter which is the ration of the average of the lowest one-fourth of measurements of irrigation water infiltrated to the average depth of water infiltrated, expressed as a decimal. Each value represents and equal area.

Electrical conductivity (EC): A measure of the ability of the soil water to transfer an electrical charge. It is used as an indicator for the estimation of salt concentration, measured in mmhos/cm (dS/m at 77^{o}F (25^{o}C).

Electrical resistance blocks: A block made of various material containing electrical contact wires that is placed in the soils at selected depths to measure soil moisture content. Electrical resistance, as affected by moisture in the block, is read with a meter.

Energy: The capacity of a physical system to perform work.

Evapotranspiration (ET): The combination of water transpired from vegetation and evaporated from soil and plant surfaces - sometimes called consumptive use (CU).

Field capacity: The amount of water retained by a soil after it has been saturated and has drained freely by gravity. It can be expressed as inches, inches per inch, bars suction, or percent of total available water.

Flood irrigation, wild flooding: A surface irrigation system where water is applied to the soil surface without flow controls, such as furrows, borders (including dikes), or corrugations.

Furrow irrigation: A surface irrigation system where water is applied to small channels or furrows to guide water down slope and prevent cross flow - called rill or corrugation irrigation in some areas.

Gravitational water: Soil water that moves into, through, or out of the soil under the influence of gravity.

Hiflow turnout: A field turnout structure that delivers a high rate of water, typically up to 20 cfs. The idea is to deliver water across the field in the minimum amount of time in order to have similar opportunity time across the entire filed. Laser leveled fields are essential.

Infiltration, infiltration rate: The downward flow of water into the soil at the air-soil interface. The rate at which water enters soil is called intake rate or infiltration rate.

Irrigation efficiency (E_i): The ration of the average depth of irrigation water beneficially used to the average depth applied, expressed as a percentage. It includes satisfying the soil water deficit, leaching requirement for salinity control, and meeting other plant needs - generally used to express overall field or farm efficiency, or seasonal irrigation efficiency.

Irrigation water management (IWM): Managing water resources (precipitation, applied irrigation water, humidity) to optimize water use by the plant. Soil and plant resources must be considered.

Laser leveling: Shaping of the surface of the soil to planned elevations and grades with the use of laser controlled leveling equipment.

Leaching fraction: The ratio of the depth of subsurface drainage water (deep percolation) to the depth of infiltrated irrigation water - determined by the leaching requirement.

Legume: A legume is any of the thousands of plant species in the legume family, *Leguminosae*. Legumes have seed pods that, when ripe, split along both sides. Beans, lentils, peanuts, peas, and soybeans are some of the common legumes consumed by humans

LEPA: Low energy precision application. A soil, water, and plant management regime where precision down-in-crop application of water is made on the soil surface at the point of use. Application devices are located in the crop canopy on drop tubes mounted on low pressure center pivot or linear move sprinkler irrigation systems - generally limited to circular plantings on less than 1% slopes and no translocation of applied water. Furrow dikes, good soil condition, and crop residue are usually required to control water translocation.

LPIC: A low pressure in-canopy system that may or may not include a complete soil, water, and plant management regime as required by LEPA. Application devices are located in the crop canopy with drop tubes mounted on low pressure center pivot or linear move systems. Limited water translocation within the field and some minor non-uniformity of water application usually exists.

MAD: Management allowed depletion is the planned soil moisture deficit at the time of irrigation. It can be expressed as the percentage of available soil water capacity or as a depth of water that has been depleted from the root zone.

Measuring: The process of determining the amount of water used with the focus being on managing the use.

Metering: The process of measuring water with the legal implications of reporting use.

Microirrigation: The frequent application of small quantities of water as drops, tiny streams, or miniature spray through emitters or applicators place along a water delivery line (tubing). The microirrigaiton method encompasses a number of systems or concepts, such as bubbler, drip, trickle, line source, mist, or spray.

Net irrigation: The actual amount of applied water stored in the soil for plant use or moved through the soil for leaching salts. Also includes water applied for crop quality and temperature modification. Application losses, such as evaporation, runoff, and deep percolation are not included - generally measured in inches of water depth applied.

Nutrient management: Managing the application rate, method, and timing of fertilizers and soil amendments, including manure, to optimize crop use and reduce pollution of ground and surface water.

Organic Matter: Soil organic matter consists of a variety of components. These include, in varying proportions and many intermediate stages: raw plant residues and microorganisms (1 to 10 per cent), "active" organic traction (10 to 40 per cent), and resistant or stable organic matter (40 to 60 per cent) also referred to as humus.

Pan coefficient: A factor to relate actual evapotranspiration of a crop to the rate water evaporates from a free water surface in a shallow pan. The coefficient usually changes by crop growth stage.

Pest Management: Utilizing environmentally sensitive prevention, avoidance, monitoring and suppression strategies, to manage weeds, insects, diseases, animals, and other organisms, that directly or indirectly cause damage or annoyance.

Petiole: The stalk of a leaf, attaching the blade to the stem.

pH: A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The pH scale commonly in use ranges from 0 to 14.

Power: The time rate at which work is done or energy is transferred.

PPM: Parts per million

PWP: Permanent wilting point. The moisture percentage, on a dry weight basis, at which a plant can no longer obtain sufficient moisture from the soil to satisfy water requirements resulting in a dead plant. Classically, 15 atmospheres soil moisture tension is used to estimate PWP.

Replogle flume: Also known as a ramp flume. A modified broad-crested weir located in a short flume, lined ditch, or pipeline that causes a drop in the hydraulic grade line, for measuring water flow rates. With open channel flow, there is one critical surface, which is level. Very little head loss is required to accurately measure water.

Root zone: Depth of soil that plant roots readily penetrate and in which predominant root activity occurs.

Saline soil: A non-sodic soil containing sufficient soluble salts to impair its productivity for growing most crops. The electrical conductivity (EC_e) of the saturation extract is greater than 4 mmhos/cm. and the exchangeable sodium percentage (ESP) is less than 15; i.e., non-sodic. The principle ions are chloride, sulfate, small amounts of bicarbonate, and occasionally some nitrate. Sensitive plants are affected at lower salinity and tolerant plants are not affected until the salinity is higher.

Saline-sodic soil: Soil containing both sufficient soluble salts and exchangeable sodium to interfere with the growth of most crops. The electrical conductivity (EC_e) of the saturation extract is greater than 4 mmhos/cm. and the exchangeable sodium percentage (ESP) is greater than or equal to 15. This soil is difficult to leach because the clay colloids are dispersed.

Salinity: The concentration of dissolved mineral salt in water and soil on a unit volume or weight basis.

SAR: Sodium adsorption ratio. A relation between soluble sodium and soluble divalent cations that can be used to predict the exchangeable sodium percentage (ESP) of soil equilibrated with a given solution defined as follows: $SAR = Na / ((Ca + Mg) / 2)^{1/2}$. Na is sodium, Ca is calcium, and Mg is magnesium. Concentrations are expressed in moles per liter.

SAR, adjusted: Also shown as “Adj. RNa”. The sodium adsorption ratio of water adjusted for the precipitation or dissolution of Ca^{2+} and Mg^{2+} that is expected to occur where water reacts with alkaline earth carbonates within a soil. Numerically, it is obtained by multiplying the sodium adsorption ration by the value ($1 + 8.4 – pH_c*$), where pH_c is the theoretical calculation of the pH of the water in contact with lime and in equilibrium with soil CO_2.

SDI: Subsurface drip irrigation. Applying irrigation water below the ground surface by using a buried perforated or porous pipe system that discharges water directly into the plant root zone. It is the predominant form of trickle/drip irrigation in New Mexico.

Sprinkle irrigation: Method of irrigation in which water is sprayed or sprinkled through the air to plant or ground surface. Various systems exist to include: Periodic move, fixed/solid-set, continuous/self-move, boom, center pivot, corner pivot, gun type, lateral move / linear move, portable hand move, side move, side roll, solid set / fixed set, towed, and traveler.

Stress irrigation: Management of irrigation water to apply less than enough water to satisfy the soil-water deficiency in the entire root zone. Preferred term is limited irrigation or deficit irrigation.

TDS: Total dissolved solids. The total dissolved mineral constituents of water.

Tensiometer: instrument, consisting of a porous cup filled with water and connected to a manometer of vacuum gauge to measure the soil-water metric potential.

Transmissivity: A measure of the capability of the entire thickness of an aquifer to transmit water.

Transpiration: The process of plant water uptake and use, beginning with absorption through the roots and ending with transpiration at the leaf surfaces.

Trickle irrigation: a microirrigation system (low pressure and low volume) wherein water is applied to the soil surface as drops or small streams through emitters. Preferred term is drip irrigation.

Valve: A device installed in conjunction with a pipeline to control flow that includes: Air relief, air vacuum / air relief, backflow prevention, ball, butterfly, check, drain, float, gate, globe, pressure relief, solenoid, vacuum relief, alfalfa, orchard, and surge.

Volatilization: The conversion of a chemical substance from a liquid or solid state to a gaseous or vapor state.

WHC: Water holding capacity. Total amount of water held in the soil between field capacity (FC) and oven dry moisture level, expressed in inches per inch, inches per foot, or total inches for a specified depth.

Water Quality: The biological, chemical and physical characteristics of water and its general composition. These attributes affect water's ability to sustain life and its suitability for consumption and other designated uses.

Water table: The upper surface of a saturated zone below the soil surface where the water is at atmospheric pressure.

Wilting point: See PWP or Permanent wilting point.

R-10	COMPARING IRRIGATION SYSTEMS														
	Surface					**Sprinkler**						**Micro**			
									CenterPivot, Linear						
SYSTEM SUB-TYPE	Flood, Uncontrolled	Furrow, Graded	Furrow, Contour	Border, Graded	Border, Level Basin	Big Gun	Side Roll	Solid Set	Over Pipe, Impact	Low Pressure Drops	LEPA	Mini-Sprinkler	Continuous tape	Point Source Emitter	Subsurface Drip Irrigation (SDI)
Description	Water is diverted into a field with no method to contain the water in any part of the field.	Small channels on a continuous somewhat uniform slope in the direction of irrigation.	Similar to Graded Furrow except that the nearly level furrows carry water across a sloping field. One method of delivering water is with gated pipe.	A form of controlled surface flooding, where the field is divided by parallel ridges on a slope in the direction of irrigation.	A form of controlled surface flooding on land that is leveled flat or nearly flat and the water is confined by borders all around. Most of these have been laser leveled.	A high capacity sprinkler mounted on a self-powered chassis and fed with water from a flexible hose	Similar to a hand move system with the lateral lines mounted on a large wheel. The system is periodically moved typically by a small gas engine	A fixed sprinkler system that covers the entire field	The "classic" original center pivot system.	A short pipe connected to the supply line that positions the outlet at a pre-determined elevation above or within the crop canopy or to a drag hose on the ground. See LEPA, LESA, LPIC, & MESA	Low Energy Precision Application. Discharge is via a drag sock or hose or through a bubble shield or pad nozzle less than or equal to 18" above ground. Only used in a row crop or bed scenario where water is applied only within the row.	Spray or spinners, generally less than 45 gallons per hour (0.75 gpm)	"Classic" Drip Irrigation with either a tortuous path or holes burned or cut into the tubing.	Individual emitters inserted or tapped into tubing (generally less than or equal to 2 gph) or bubblers (generally less than or equal to 60 gph)	Variation of drip irrigation where the tubing and emitters are buried beneath the soil surface rather than laid on the surface or suspended from wires.
Potential Irrigation Efficiency (%)	45	70	70	70	80	55	65	75	70	80	90	85	90	90	90
Applicability	Not recommended	Sloping terrain such as in Tucumcari and parts of the Deming area.	Uneven sloping terrain such as mountainous valleys throughout the state.	Sloping terrain such as the mountainous valleys throughout the state.	Used widely in flatter terrain such as in Las Cruces, Carlsbad, and Fort Sumner	Relatively flat terrain. Often used to apply liquid ag waste.	Various terrain	Various terrain	Various terrain	Various terrain	Relatively flat terrain	Various terrain	Relatively flat terrain	Various terrain	Relatively flat terrain
Crops	Pasture	All Row Crops	All Row Crops	Pasture and Hay	Pasture and Hay	Pasture and Hay	Pasture, Hay, and Low Growing Row Crops	Pasture, Hay, and Most Row Crops	Pasture, Hay, and Most Row Crops	Pasture, Hay, and Most Row Crops	All Row Crops	All Row Crops and orchards	All Row Crops	All Row Crops, Orchards, and Vineyards	All Row Crops, Alfalfa, and orchards
Head or Pressure	Very Low	Very Low	Very Low	Very Low	Very Low	60+ PSI	50 PSI	50 PSI	50 PSI	30 PSI	30 PSI	30 PSI	25 PSI	25 PSI	25 PSI
Operation	Very High labor requirement	High labor requirement	High labor requirement	High labor requirement	Medium labor requirement	High labor requirement	High labor requirement	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled	Low labor requirement, but must be highly skilled
Maintenance	Annual touchup of ditches, turnouts, and borders.					Electrical and mechanical requirements						Electrical and mechanical requirements			
Restrictions	Need large "head" of water.					Water quality is very important due to the potential for leaf burn.						Filtration is essential.			
						Need a more continuous supply of water.						Need a continuous supply of water			
System Cost	Minimal	Low	Low	Low	Medium	High	High	Very High	High	Very High	Very High	Very High	Very High	Very High	Very High
Other Considerations	The minimum application under the very best designed and operated surface systems is about two inches					Very high energy cost	Higher energy cost than other sprinkler systems			Additional energy cost when compared to surface methods.		Additional energy cost when compared to surface methods.			
	Production may be substantially reduced due to moisture stress.					Production may be slightly reduced due to moisture stress.						Production can be optimized due to operation flexibility			

TECHNICAL NOTES

U.S. DEPARTMENT OF AGRICULTURE NATURAL RESOURCES CONSERVATION SERVICE
NEW MEXICO October, 2004

AGRONOMY TECHNICAL NOTE NO. 71

(R – 11) FERTILIZER "JAR TEST"

Before you inject a new fertilizer solution into your drip system, always perform a "jar test". This will help you avoid annoying and unnecessary line or emitter clogging due to fertilizer incompatibility.

Whether you begin with water-soluble or liquid fertilizers, dissolved chemicals such as phosphates, calcium, and magnesium can react together or with the irrigation water. This can lead to insoluble chemical combinations precipitating in the water. These precipitates can clog the emitters. There are also fertilizer compatibility charts available, such as the one below. However, they may not list the fertilizers you are considering to use.

The "jar test" is easy. If you can prepare a half-decent shaken-not-stirred-Bond martini, you are well on your way. The key is to approximate the dilution rate that you expect to be injecting through the drip system. This jar test method comes from the Irrigation Training and Research Centre fertigation manual

To get started you will need:

1. the injection rate (gal per hr)
2. the drip system delivery rate (gal per hr)
3. the stock fertilizer or fertilizer combinations that you will be using (stock solution to water applied ratio)
4. a jar with a sealing lid
5. the water that you use for irrigating (use the buffer (6.5pH) irrigation water)

For example, a fertilizer stock solution is injected at a rate of 30 gallons per hour and delivered at a rate of 1200 gallons per minute.

Step one:

Convert system delivery rate from gallons per minute to gallons per hour.

1200 gallons per minute X 60 minutes = 72,000 gallons per hour.

Step two:

Calculate the dilution ratio. This is ratio of the injection rate to the delivery rate.

30 gallons per hour: 72,000 gallons per hour = 1:2,400 (72,000 divided by 30 = 2,400)

Step three:

Add fertilizer stock solution and irrigation water into the jar at the same dilution ratio, 1:2400. Do this by adding 1 mL of fertilizer stock solution to 2400 mL or 2.41- of the irrigation water. Hopefully your jar wasn't too small. Always wear protective clothing and safety glasses when performing any jar test.

Step four:

Tighten the lid and shake it up!

Step five:

Watch what happens. Does any precipitate form on the bottom of the jar? Does the water become milky or cloudy? If this happens within one or two hours after mixing, there is a chance that the fertilizer solution or combination of fertilizers could cause line or emitter plugging.

Whether you begin with liquid or dissolved water-soluble fertilizers, you need to be aware of fertilizer compatibility. So before you mix it up, give it a shake.

Fertilizer compatibility chart (B.C. Trickle Irrigation Manual, 1999)

	urea	Ammonium nitrate	Ammonium sulphate	Calcium nitrate	Potassium nitrate	Potassium chloride	Potassium sulphate
urea							
Ammonium nitrate							
Ammonium sulphate							
Calcium nitrate			**XX**				
Potassium, nitrate							
Potassium chloride							
Potassium sulphate			**X**	**XX**		**X**	
Ammonium phosphate				**XX**			
Iron, zinc, copper, manganese sulphate				**XX**			**X**
Iron, zinc, copper, manganese, chelate				**X**			
Magnesium sulphate				**XX**			**X**
Phosphoric acid				**XX**			
Sulphuric_acid				**XX**			**X**
Nitric acid							

Fully compatible - y
Reduced solubility - X
Incompatible - XX

Fertilizer compatibility chart (B.C. Trickle Irrigation Manual, 1999)

	Ammonium phosphate	Iron, zinc, copper, manganese sulphate	Iron, zinc, copper, manganese chelate	Magnesium sulphate	Phosphoric acid	Sulphuric acid	Nitric acid
urea							
Ammonium nitrate							
Ammonium sulphate							
Calcium nitrate							
Potassium nitrate							
Potassium chloride							
Potassium sulphate							
Ammonium phosphate							
Iron, zinc, copper, manganese sulphate	**XX**						
Iron, zinc, copper, manganese chelate	**X**						
Magnesium sulphate	**XX**						
Phosphoric acid			**X**				
Sulphuric acid							
Nitric acid			**XX**				

Fully compatible - y
Reduced solubility - X
Incompatible - XX

(R – 12) HOW TO COLLECT AND INTERPRET PLANT TISSUE SAMPLES

Compiled by Linda Scheffe, 2008, http://www.nm.nrcs.usda.gov/technical/handbooks/iwm/nmiwm.html

WHY ANALYZE PLANT SAMPLES FOR NUTRIENTS?

- **A plant analysis is often recommended to evaluate fertility status and plant uptake during the growing season.**
- **It is also used to monitor micronutrient levels and to develop a foliar application spray rate of selected micronutrients.**
- **Fertilizer efficiencies can be monitored.**
- **A database for future planning can also be developed based on plant analysis.**

Sampling Plant Tissue

- **Plant analysis is the laboratory determination of several elements on a single sample of plant tissue. This technique is most commonly used to diagnose nutritional problems related to soil fertility or to monitor the effectiveness of fertilizer practices on growing crops.**
- **Plant analysis is not a substitute for soil testing, but is most effective when used in conjunction with a regular soil testing program.**
- **The number of elements that are measured depends on the laboratory to which the samples are sent for analysis. The most common elements analyzed in the sample are nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (M), sulfur (S), sodium (Na), iron (Fe), manganese (Mn), boron (B), copper (Cu), zinc (Zn), and aluminum (Al). Others that may be measured either routinely or upon request include molybdenum (Mo), chloride (Cl), cobalt (Co), silicon (Si), cadmium (Cd), nickel (Ni), lead (Pb), chromium (Cr), arsenic (As), barium (Ba), and selenium (Se). Although some of these are not essential for plant growth, the results may be used to identify elemental toxicities.**
- **In order for plant analysis to be effective, considerable care must be given to collecting, preparing and sending plant tissue to the laboratory for analysis.**

What to Sample

- **Proper sampling requires that a specific plant part be taken such as a particular leaf, group of leaves or portion of the plant. Instructions also include number of individual parts, as well as the number of plants to sample. This will ensure that a sufficient quantity of plant tissue is submitted for analysis and that the collected sample is statistically representative of the area under study.**
- **When sampling mixed stands, particularly forages and pastures, separate plant species. Similarly, the sample should be of only leaves or petioles or whole tops**

and not mixtures. The enclosed table provides plant tissue collection guidelines for many of the crops grown in New Mexico.

- **When no specific sampling instructions are given for a particular crop, the general rule of thumb is to sample the uppermost recently mature leaves.**
- **Young emerging leaves, older mature leaves and seed are not usually suitable plant tissues for analysis since they do not ordinarily reflect the general nutrient status of the whole plant.**
- **The recommended time to sample usually occurs just prior to the beginning of the reproductive stage for many plants. However, sampling earlier or even later than the specified time may be recommended for specific plants or circumstances.**
- **Sample plants that are showing a suspected nutrient deficiency symptom at the time or shortly after the visual symptoms appear. Do not sample or include in a sample plants under a nutrient stress for an extended period of time, dead plant tissue or plants or tissue mechanically injured, diseased, or insect-damaged.**

Multiple Sampling

- **When a nutrient deficiency is suspected at time other than specified for sampling, also collect similar plant parts from normal plants growing in the immediate or adjacent areas. Take care to ensure that the two sets of plants are at approximately the same stage of growth and have been treated the same. Comparative analyses are questionable when the two sets of plants are not at the same stage of growth, have not received the same treatment or are not the same variety or hybrid. If the soil type varies between the two sites, tissue analyses would not be comparable. If all the proper conditions have been met, then a comparison of results between two sets of plant tissue samples can be invaluable to the interpreter. Do not mix or place the collected tissues in the same mailing kit. When soil test data are available, take soil samples from both areas.**

Washing to Remove Contaminants

- **Avoid dusty or soil-covered leaves and plants whenever possible. When leaves are dusty, brush or wipe with a damp cloth to remove the contaminants. If this is not effective or when leaves are covered with spray materials, wash in a mild detergent solution (0.30 percent) and rinse in running water to remove attached substances. Do not prolong the washing procedures or allow the plant material to stand in either the washing or rinsing baths. Wash and rinse briskly. Wash leaves which have been sprayed with nutrient solutions while they are still fresh. If iron is of primary interest, wash leaves regardless of their outward appearance. Wash whole plants sampled shortly after emergence to remove soil particles that are frequently attached to the new tissue.**

What Not to Sample

- **Do not include diseased or dead plant material in a sample. Do not sample or include plants or leaf tissue that have been damaged by insects or mechanically injured in a sample. When whole plants are sampled, remove the roots and wash the upper portion to remove soil particles. Do not sample plants, which have been stressed extensively by cold, heat, moisture deficiency, or by excess moisture. Examine both the below ground as well as the above ground portion of the plant. The presence of nematodes or roots damaged by other insects or diseases should preclude the need to sample.**

Packaging Plant Tissue

- **Air-dry plant tissue samples before shipment to the laboratory. Package samples in clean paper bags or envelopes for mailing to the laboratory. Never place fresh samples in a plastic bag.**

Plant Analysis Interpretation

- **The use of plant analysis is an effective management strategy for a sustainable soil fertility program because it provides a direct measure of nutrient concentrations and balance within the plant.**
- **Principles and procedures used for plant analyses have evolved over many years and changed as knowledge increased about each element that is essential for a plant to complete its life cycle. As such, use of plant analyses has become an integral part of most agronomic research and a tool for crop consultants and fertilizer dealers to monitor production fields.**
- **The enclosed table provides plant tissue analysis interpretation guidelines for most crops grown in New Mexico.**
- **The effects of time of sampling, variety or hybrid and environmental factors, such as soil moisture, temperature, light quality and intensity may significantly affect the relationship between nutrient concentration and plant response.**
- **A defined sufficiency range may not apply to all situations or environments, nutrient uptake and internal mobility, as well as dry matter changes, can affect the nutrient concentrations in plant tissues. Concentration and dilution occur due to the difference between plant growth and nutrient absorption as well as movement of the nutrients within and between plant parts.**
- **Under normal growing conditions, nutrient absorption, and plant growth closely parallel each other during most of the vegetative growth period. Exceptions occur during the very early growth period shortly after germination, after seed set and at the beginning of senescence. However, if the normal rate of growth is interrupted, nutrient accumulation or dilution can occur.**

PLANT TISSUE ANALYSIS GUIDELINES

Crop	Time of Sampling	Plant Part	No. Plants to Sample	Nutrient	Deficient	Sufficient
Alfalfa	One-tenth bloom	Whole tops	45-50	Total N-%	-	4.5-5.0
				Total P-%	0.17	0.25-0.7
				Total K-%	0.80	1.5-3.5
				Total S-%	0.17	0.25-0.5
				B	-	30-80
				Cu	-	7-30
				Mn	-	31-100
				Zn	-	21-70
Alfalfa	Early growth	Petiole of young, mature leaf	30-35	N	5,000	7,000
				P	2,000	3,000
				K	4	6
Canola	Before seed set	Recently mature leaf	60-70	N (%)	-	4.0-6..4
				P(%)	-	0.42-0.69
				K (%)	-	3.5-5.1
Chile	Early fruit-set	Petiole of young, mature leaf	30-35	N	1,000	2,000
				P	1,500	2,500
				K	3	5
Chile	First square	The youngest fully mature leaves on the main stem. For "nitrate only" determination, sample only the petioles.	30-35	N	-	35,000-60,000
				P	-	2,200-7,000
				K	-	45,000-45,000
Corn, Silage	Prior to tasseling	First fully developed leaves from top	25-30	N-%	<2.7	2.7-3.5
				P-%	<0.23	0.25-0.4
				K-%	<1.7	1.7-2.5
				B	-	4-25
				Cu	-	6-20
				Fe	-	21-250
				Mn	-	20-150
				Zn	-	20-70
Cotton	First bloom		30-35	N	-	12,000-18,000
				P	-	1,500-2,000
				K	-	4.0-5.5
	Peak bloom		30-35	N	-	3,000-7,000
				P	-	1,200-1,500
				K	-	3.0-4.0
	First open boll		30-35	N	_	1,500-3,500
				P	_	1,000-1,200
				K	_	2.0-3.0
	Maturity		30-35	N	_	> 2,000
				P	_	800-1,000
				K	_	1.0-2.0

Unless otherwise noted, values are: N = NO_3-N, ppm; P = acetic acid-soluble PO_4-P, ppm; K = total K, %; S = SO_4-S, ppm; B, Cu, Fe, Mn, and Zn = ppm.

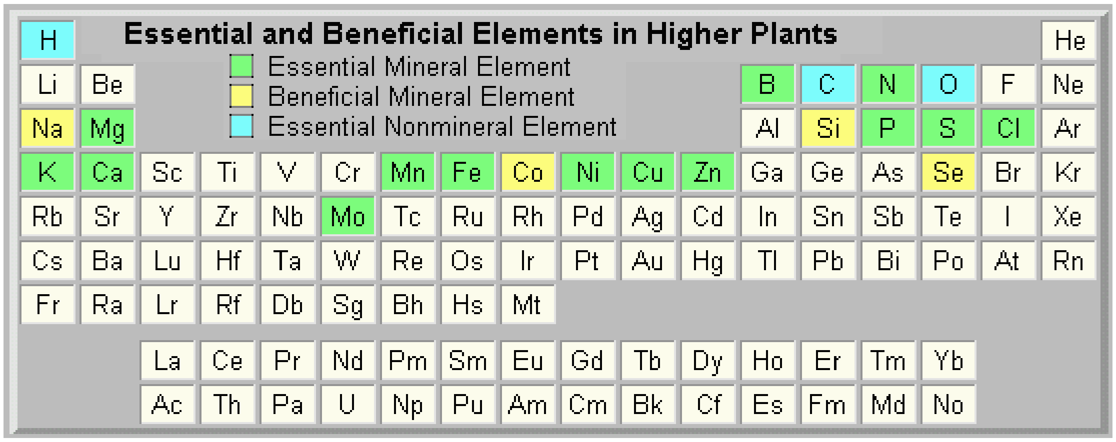
PLANT TISSUE ANALYSIS GUIDELINES

Crop	Time of Sampling	Plant Part	No. Plants to Sample	Nutrient	Deficient	Sufficient
Lettuce	At heading	Mid-rib of wrapper leaf	30-50	N P K	4,000 2,000 2	8,000 4,000 4
	At harvest	Mid-rib of wrapper leaf	30-50	N P K	3,000 1,500 1.5	6,000 2,500 2.5
Onion	Early Season	Tallest leaf	45-50	N-% P-% K-%	3.0 0.10 3.0	4.0 0.20 4.0
	Mid-season	Tallest leaf	45-50	N-% P-% K-%	2.5 0.10 2.5	3.0 0.20 4.0
	Late season	Tallest leaf	45-50	N-% P-% K-%	2.0 0.10 2.0	2.5 0.20 3.0
Peanuts	Before or at bloom	Recently mature leaves	40-50	N-% P-% K-% S-% B Cu Fe Mn Zn	_ _ _ _ _ _ _ _ _	3.5-4.5 0.2-0.35 1.7-3.0 0.2-0.3 20-50 10-50 100-350 100-350 20-50
Pecans	July or August	2 to 4 paired mid-leaflets on the mid-part of current season's growth taken from each of tree's four quadrants mid-way up the tree	80-100	N-% P-% K-%	_ _ _	2.5-2.9 0.12-0.30 0.75-0.95
Small grains	Before heading	4 uppermost leaf blades	25-40	N-% P-% K-%	- - -	1.7-3.0 0.20-0.50 1.5-3.0
Sorghum (milo)	Before or at heading	2nd leaf from top of plant	20-30	N-% P-% K-%	- - -	3.3-4.0 0.20-0.35 1.4-2.5

Unless otherwise noted, values are: N = NO_3-N, ppm; P = acetic acid-soluble PO_4-P, ppm; K = total K, %; S = SO_4-S, ppm; B, Cu, Fe, Mn, and Zn = ppm

Essential Elements for Plant Growth

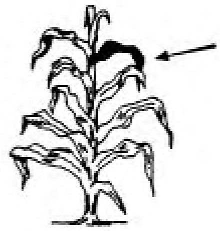
http://www.soils.wisc.edu/~barak/soilscience326/listofel.htm



General Symptoms of Nutrient Deficiency in Plants and Sampling Techniques

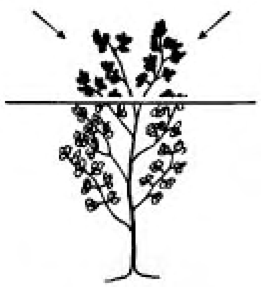
http://www.cahe.nmsu.edu/pubs/_a/a-123.html

Nitrogen: Plant light green, lower leaves yellow to light brown, stalks short and slender, plants stunted.	**Iron**: Young leaves are chlorotic, with principal veins typically green; stalks short and slender.
Phosphorus: Plants dark green, often developing red and purple pigments; lower leaves sometimes yellow; plants stunted.	**Zinc**: Leaf spots on older leaves, with spots rapidly enlarging and generally involving the area between the veins; thick leaves; stalks with shortened internodes.
Potassium: Spots of dead tissue, usually at the tips and between the veins; marked margins of leaves.	**Boron**: Young leaves of the terminal bud are light green at the base; the bud eventually dies.
Magnesium: Mottled or chlorotic leaves, which typically redden; leaf tips and margins turned or cupped upward.	**Copper**: Young leaves are permanently wilted, with spotty or marked chlorosis.
Calcium: Young leaves of terminal bud hooded; with severe deficiency, dying buds; dying back at the tips and margins of the leaf.	**Manganese**: Spots of dead tissue scattered over the leaf; smallest veins tend to remain green.
Sulfur: In young leaves, veins and tissue between veins are light green.	

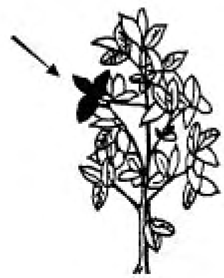


Corn...before tasseling

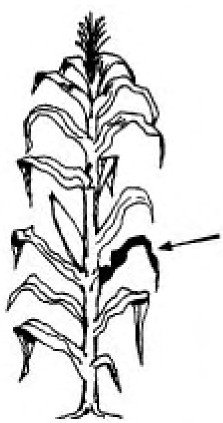
Collect the first fully developed leaves from the top of 15-20 plants. If the plant is less than 12 inches tall, collect all of the above-ground portion.



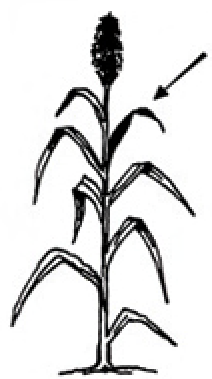
Alfalfa Collect the top 6 inches or upper third of the plant at early bloom.



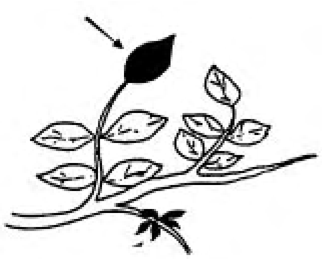
Soybeans Collect recently mature trifoliate leaves from the top of 20-30 plants before or during bloom. (In the seedling stage, collect all of the above-ground portion of the plant.)



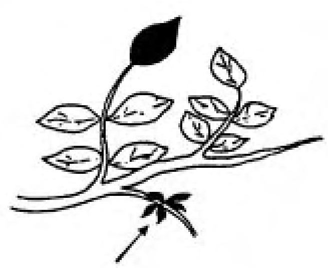
Corn...from tasseling to silking Collect the leaves below and opposite from the ear of 15-20 plants.



Sorghum Collect the second leaf from the top of 20-30 plants before or at heading.

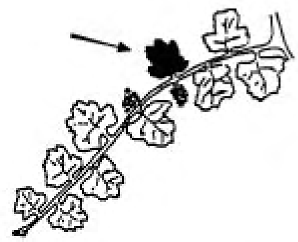


Pistachios and Walnuts Collect terminal leaflets/s from nonfruiting shoots at mid- to late season.



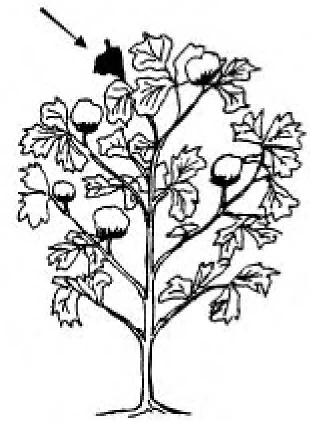
Apples, Pears, Almonds, Apricots, Cherries, Prunes, Plums Collect the leaves from the current season's nonfruiting, nonexpanding spurs at midseason.

Pecans, Peaches, and Nectarines Collect the midshoot leaflets/leaves at midseason.



Grapes Collect the petioles or leaves adjacent to basal clusters at bloom.

Small grains Collect the four uleaf blades from the top of 25-40 plants. Sample should equal 2 cups. (In the seedling stage, collect all of the above-ground portion.)



Cotton Collect recent from the main stem on 40 to 50 plants selected at random at full bloom.

(R-13) NITROGEN FERTILIZER GUIDE

FERTILIZER TYPE	CHEMICAL FORMULA & FERTILIZER GRADE(S):	Pounds of Nitrogen per 100 pounds of fertilizer		% N	% P_2O_5	% K_2O
Urea	$CO(NH_2)_2$ 45-0-0 to 46-0-0	45	46	45 to 46	0	0
Ammonium Nitrate	NH_4NO_3 33-0-0 to 34-0-0	33	34	33 to 34	0	0
URAN (Urea + Ammonium Nitrate)	$CO(NH_2)_2$ & NH_4NO_3 28-0-0 to 32-0-0	28	32	28 to 32	0	0
Ammonium Sulfate	$(NH_4)_2SO_4$ 21-0-0-24S	21		21	0	0
Ammonium Thiosulfate	$(NH_4)_2S_2O_3$ 12-0-0-26S	12		12	0	0
Monoammonium Phosphate	$NH_4H_2PO_4$ 11-48-0 to 11-52-0	11		11	48 to 52	0
Diammonium Phosphate	$(NH_4)_2HPO_4$ 18-46-0 to 21-53-0	18	21	18 to 21	46 to 53	0
Ammonium Polyphosphate	$(NH_4)_3HP_2O_7$ 10-34-0 to 11-37-0	10	11	10 to 11	34 to 37	0
Calcium Nitrate	$Ca(NO_3)_2$ 15-0-0-24Ca	15		15	0	0
Potassium Nitrate	KNO_3 13-0-44	13		13	0	44
Sodium Nitrate	$NaNO_3$ 16-0-0	16		16	0	0
Anhydrous Ammonia	NH_3 82-0-0	82		82	0	0
Aqua Ammonia	NH_4OH 20-0-0 to 25-0-0	20	25	20 to 25	0	0

NOTE: All major soil nitrogen transformations are mediated by various soil microorganisms. Also, the fate of **any** fertilizer nitrogen source will be subject to the following:

1) mineralization: conversion of organic nitrogen to inorganic nitrogen by microorganisms
2) nitrification: conversion of ammonia nitrogen into nitrate
3) denitrification: conversion of nitrate into a nitrogen gas
4) ammonia volatilization: loss of ammonia nitrogen as a gas
5) leaching of nitrates: caused by over-irrigation, especially in sandy soils
6) immobilization: conversion of inorganic nitrogen into an organic form
7) ammonium fixation on certain types of clays

Soil organic matter will mineralize about 20-40 pounds of nitrogen/acre/year. 95% or more of total N in surface soils is present as organic nitrogen. Under normal growing conditions, when soils are warm, moist, and well-aerated ammoniacal nitrogen (i.e., ammonium plus ammonia) converts to nitrate in 2-3 weeks, making nitrate the most abundant inorganic form of nitrogen.

NITROGEN FERTILIZERS	NITROGEN (**N**) CHEMICAL FORM (i.e., **UREA ($CO(NH_2)_2$), AMMONIUM ION (NH_4^+)**, **AMMONIA (NH_3)**, and **NITRATE (NO_3^-)**); handling properties, and other information:
Urea	**N** is 100% **$CO(NH_2)_2$**, which converts to ammonia in several days; is hygroscopic; quite soluble; good handling properties.
Ammonium Nitrate	**N** is 50% **NH_4^+** and 50% **NO_3^-**; is hygroscopic; highly soluble; explosive if mixed with hydrocarbons (fuel oil); care taken to prevent caking.
URAN (Urea + Ammonium Nitrate)	**N** is 50% **$CO(NH_2)_2$**, 25% **NH_4^+**, and 25% **NO_3^-**; nonpressure N solution; ease in handling and application. Can be applied through various irrigation systems.
Ammonium Sulfate	**N** is 100% **NH_4^+** ; S is 100% SO_4^{2-} ; safe and easy to store; quite soluble; low hygroscopicity; solid.
Ammonium Thiosulfate	**N** is 100% **NH_4^+** ; when applied to soil, ammonium thiosulfate forms colloidal S^0 and $(NH_4)_2SO_4$; S^0 must be oxidized; is a solution.
Monoammonium Phosphate	**N** is 100% **NH_4^+** ; 11-52-0 is the most common grade for monoammonium phosphate, and 18-46-0 is the most common grade for diammonium phosphate; both are granular & completely water-soluble; more important as a phosphorus source.
Diammonium Phosphate	
Ammonium Polyphosphate	**N** is 100% **NH_4^+** ; 10-34-0 is the most common grade; approximately 75% of P is polyphosphate and 25% is orthophosphate; liquid; easy handling.
Calcium Nitrate	**N** is 100% **NO_3^-** ; is highly soluble; strongly hygroscopic. Also provides a readily soluble/available calcium ions.
Potassium Nitrate	**N** is 100% **NO_3^-** ; also called salt peter. Also provides a readily soluble/available potassium ions.
Sodium Nitrate	**N** is 100% **NO_3^-** ; a naturally mined fertilizer. This is a very soluble fertilizer. Approved for organic farmer registration/ certification.
Anhydrous Ammonia	**N** is 100% **NH_3** ; is a liquid under pressure; must be injected 3 to 8" below the soil surface; stored in pressure tanks; <u>must</u> observe safety precautions.
Aqua Ammonia	**N** is 100% **NH_3** dissolved in water; usually injected in soils 2 to 4" depth; is composed of 25-29% NH_3 by weight; pressure of < 10 lb/in^2.