ROP Extension Training Series
Section 4: Nutrition and Water

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USAID
FROM THE AMERICAN PEOPLE

ROOTS OF PEACE

Agenda

- Plant Nutrition
  - Essential nutrients
  - Inorganic and organic sources
- Water Relations
  - Supply
  - Demand
  - Scheduling

What makes a nutrient essential?

- Plant must need it to complete lifecycle.
- Must not be able to be replaced by another element.
- Must exert its effect directly on growth or metabolism

Essential Plant Nutrients

Essential	Carbon, hydrogen, oxygen
Primary	Nitrogen, phosphorus, potassium
Secondary	Calcium, magnesium, zinc
Minor	Boron, chloride, coper, manganese, zinc, iron, nickel, molybdenum

Grapes in California

- Commonly need
  - Nitrogen, Potassium, Zinc, and Boron
- Less commonly need
  - Iron, Magnesium, and Manganese
- Sometimes have in excess
  - Nitrogen, Chlorine, and Boron

Soil Testing

Soil tests are good for:

- pH
- Ec (for salts)
- P
- K
- Zn
- Too much B

Soil tests are <u>not good</u> for most other elements

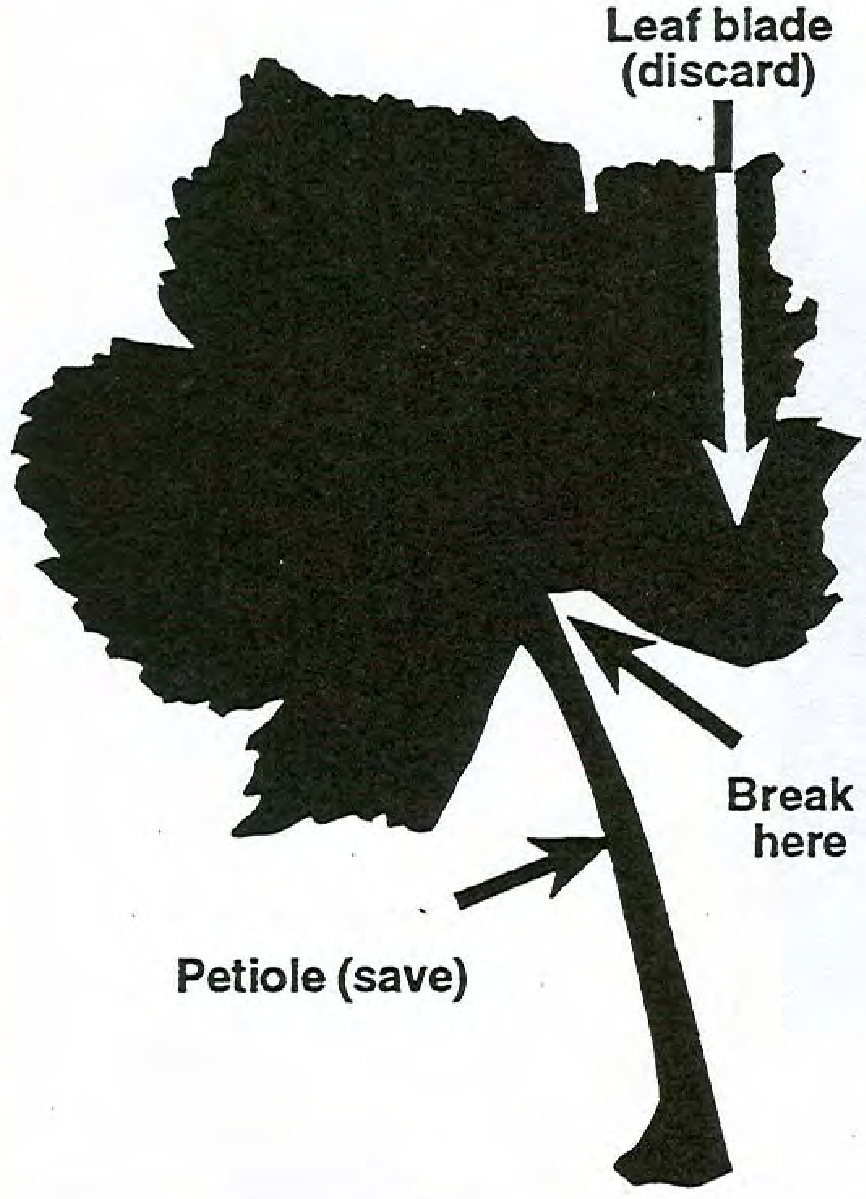
Tissue Tests

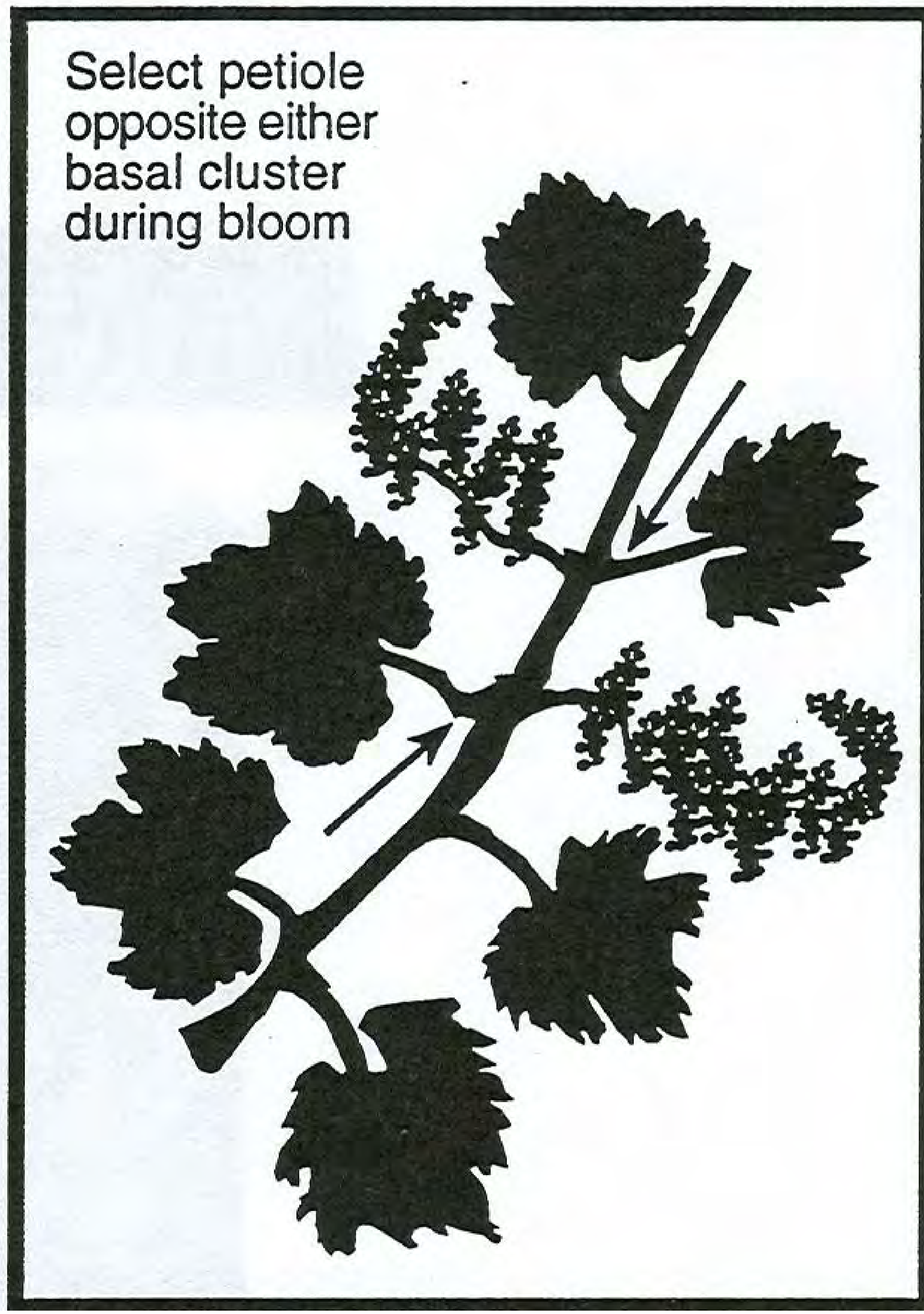
- Reflect what's in the plant
- When interpreting tissue tests, remember
  - **Look only at the most limiting factor first**
  - Often numbers of other elements will be **larger** than normal when something else is deficient
    - Other nutrients may accumulate to higher than normal numbers

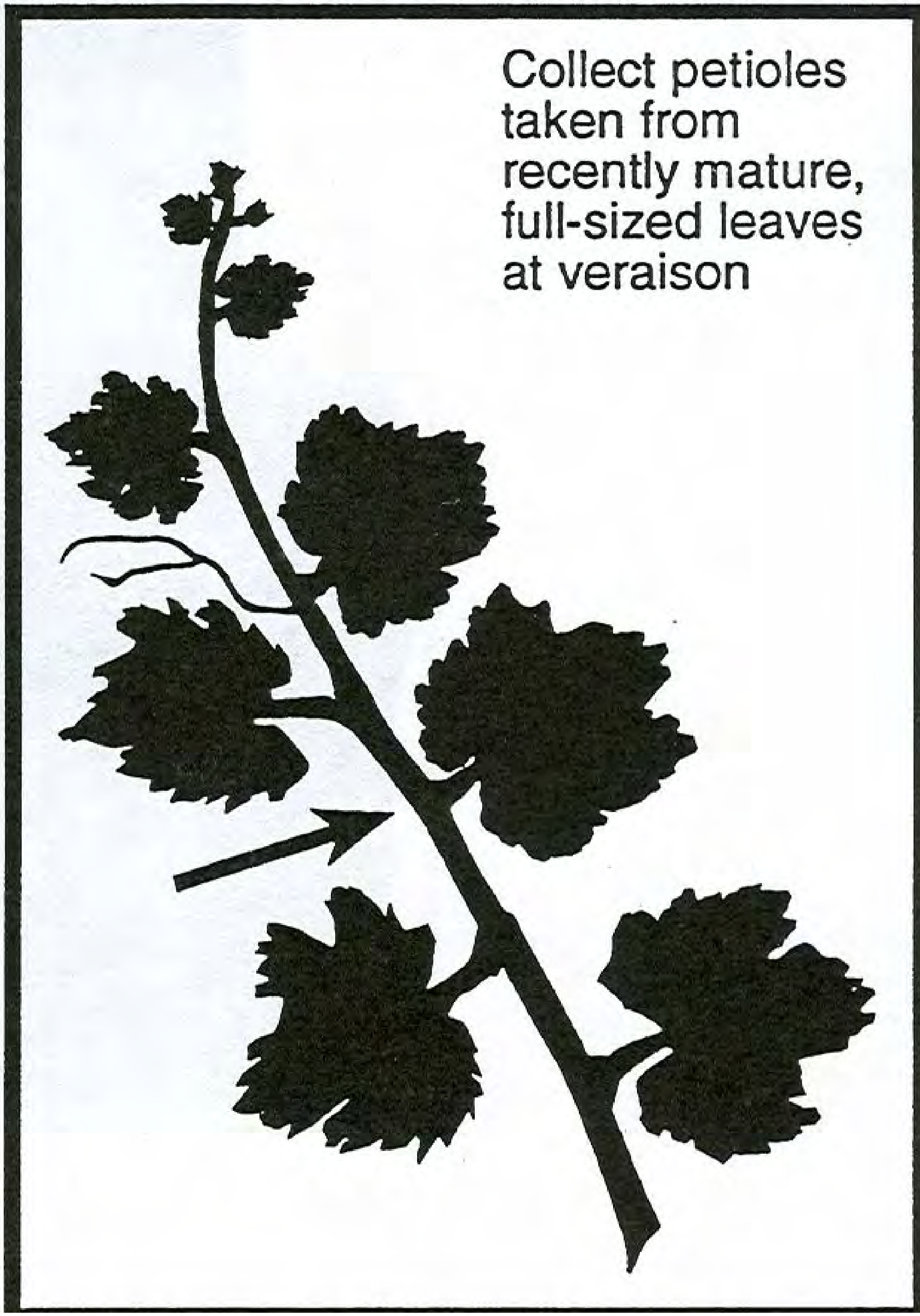
Diagnostics to Use

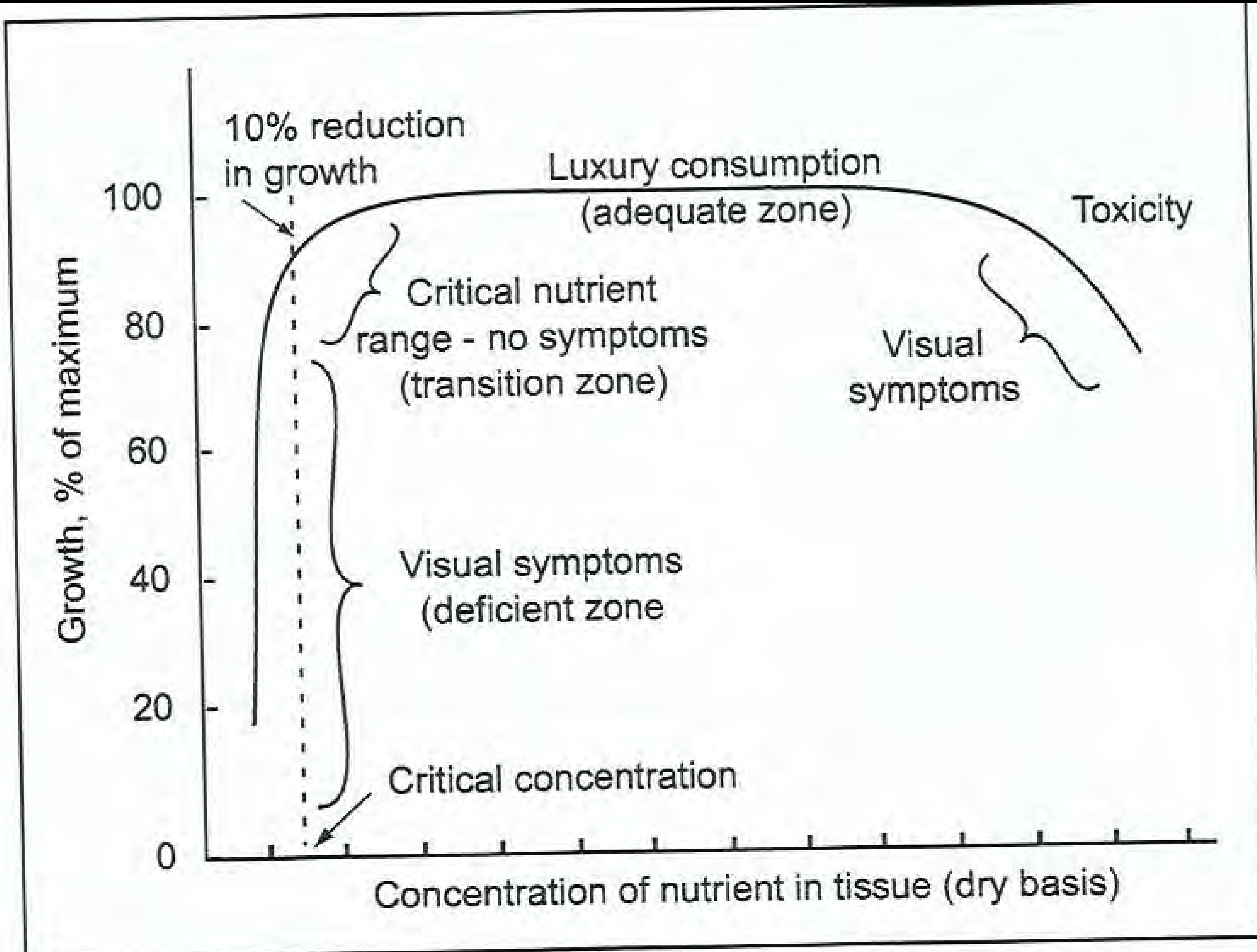
- Soil
  - pH
  - Ec (for salts)
  - Phosphorus
  - Potassium
  - Zn
  - Too much B
- Tissue
  - Nitrogen
  - Phosphorus
  - Potassium
  - Boron
  - Zinc
  - Manganese
  - Magnesium

Collect petioles and discard the blade for nutrient analysis




Select petiole
opposite either
basal cluster
during bloom


Collect petioles
taken from
recently mature,
full-sized leaves
at veraison



10% reduction
in growth
Luxury consumption
(adequate zone)
Toxicity
Critical nutrient
range - no symptoms
(transition zone)
Visual
symptoms
Visual symptoms
(deficient zone
Critical concentration
Growth, % of maximum
100
80
60
40
20
0
Concentration of nutrient in tissue (dry basis)

Table 1. Interpretive Guide for Grape Tissue Analysis at Bloom and Veraison

Nutrient	Deficient (below)	Adequate (above)	Excessive[2] (above)	Toxic[3] (above)
NO_3-N, ppm	350[1]	500	2,000	8,000
P (total), %	0.10 (0.08)[4]	0.15 (0.12)[4]		
K (total), %	1.0 (0.5)[4]	1.5 (0.8)[4]		
Mg (total), %	0.2	0.3		
Zn (total), ppm	15	26		
Mn (total), ppm	20	25	300	1,200
B (total), ppm	25	30	100	150 300 in blades
Na (total), %				0.5 0.3 in blades
Cl (total), %			0.5-1.0	1.5 0.5 in blades

[1]Critical NO_3-N levels are based on Thompson Seedless data only. Some laboratories report as % NO_3. Multiply % NO_3 by 2258 for ppm NO_3-N (i.e. 1.0% NO_3 = 2258 ppm NO_3-N).

[2]Excessive levels may be cautionary rather than indicating known effects on vine performance.

[3]Critical toxicity values are not well defined due to variety, growing condition, and seasonal differences.

[4]Veraison (berry softening) petiole values are in parenthesis.

Table 2. Ranking of Grape Varieties by Their Comparative Bloomtime Petiole NO_3-N Levels When Grown on Own Roots.

High	High-medium	Medium	Low-medium	Low
Malbec	Petite Sirah	Pinot noir	Barbera	Sylvaner
Merlot	Chenin blanc	Semillon	French Colombard	Salvador
Grenache	Emerald Riesling	Cabernet Sauvignon	Gerwurztraminer	Ribier
Tinta Madeira	Muscat of Alexandria	Rubired	Tokay	Flame Seedless
White Reisling	Emperor	Ruby Cabernet		Perlette
Sauvignon blanc	Christmas Rose	Chardonnay		
Black Corinth		Zinfandel		
Redglobe		Carignane		
		Thompson Seedless		
		Ruby Seedless		
		Calmeria		
		Exotic		
		Italia		

[1]Based on data of L. P. Christensen, W. M. Kliewer, and J. A. Cook, UC Davis.

TABLE 1. NITROGEN RATE GUIDELINES

Suggested rates (actual N)	Soil and vine characteristics
lb./acre	
Mature vineyards	
0 - 40	Deep, fine sandy loam soils, especially those planted to high-vigor grape varieties. Higher rates may be justified where heavier foliage is desirable, as for Thompson Seedless table grapes on a large trellis or for late market. Fruit color may be delayed with excess N rates in colored table grape varieties, such as Emperor. Repeated applications of over 60 lb N annually can lead to excess N levels in such soils. It may be desirable to stop N applications entirely for several years or more where high vine N levels are encountered.
50 - 60	Sandy loam soils; vines of medium or normal vigor.
60 - 100	Sand and loamy sand soils; old or marginal vineyards where higher rates are used to maintain vine growth, such as in old Emperor vines.
Young vineyards (first and second growing season)	
0 - 20	Sandy loam to loam soils with a crop history of N application, such as cotton, orchard, or alfalfa, usually do not require N for at least several years. For questionable areas use 20 lb N per acre.
25 - 30	Loamy sand soils.
40 - 50	Coarse, sandy soils. This rate should be split into two separate applications of 20 to 25 lb, preferably one early in the growing season and the second by early July.

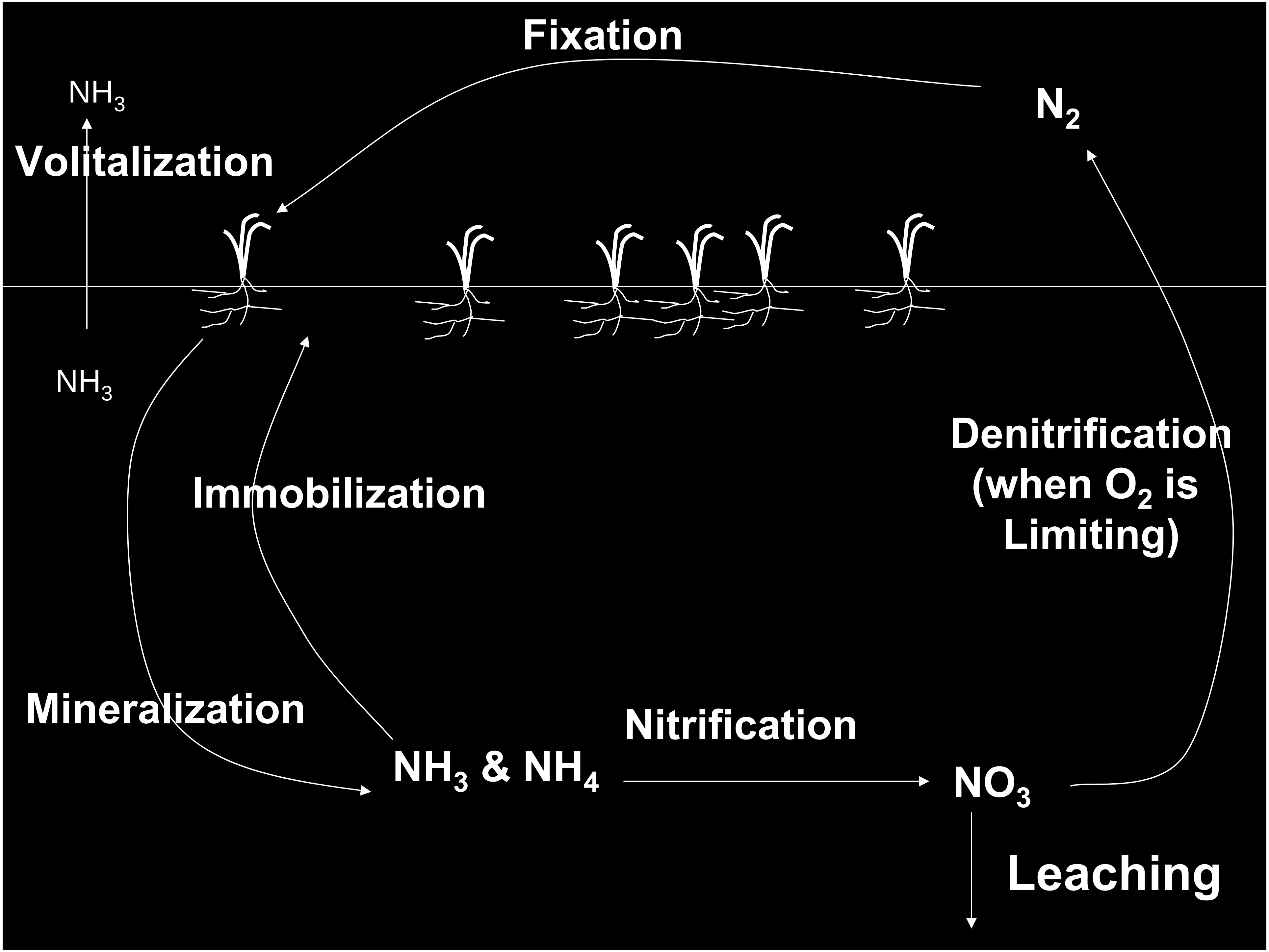

Fixation
N_2
NH_3
Volitalization
NH_3
Immobilization
Denitrification (when O_2 is Limiting)
Mineralization
Nitrification
NH_3 & NH_4
NO_3
Leaching

Table 3-5. Ratios of C:N for selected organic materials.

Material	C:N ratio
Undisturbed top soil	10:1
Alfalfa	13:1
Rotted barnyard manure	20:1
Corn stalks	60:1
Small grain straw	80:1
Coal and shale oil	124:1
Oak	200:1
Spruce	1000:1

Table 3.2 Plant Nutrient Content (Dry Basis) of Selected Manures and Composts.

Description	Total N	Ammonium N	P_2O_5	K_2O	S
	lbs per ton				
Non-composted poultry					
Turkey/rice hull litter	35	4	53	37	6
Fresh broiler/rice hull	78	6	51	53	9
Fresh layer	79	8	125	67	16
Aged layer	43	9	164	79	14
Non-composted dairy/steer					
Fresh dairy separator solids	43	1	17	12	10
Fresh dairy corral scrapings	47	2	26	141	12
Aged dairy separator solids	41	1	13	8	9
Aged steer corral scrapings	26	5	31	66	8
Composts					
Broiler/rice hull compost	38	2	86	50	11
Dairy	27	1	27	57	9
Dairy/gin trash	31	1	22	57	14
Dairy/steer	33	0	17	51	9
Dairy/poultry	34	2	39	66	10
Gin trash	47	0	18	75	29

All materials collected from commercial sources in California during 1990. Ammonium run on KCl extract of undried samples. All other analyses run on dried, ground samples.

Source: Pettygrove, unpublished laboratory analyses.

Nitrification

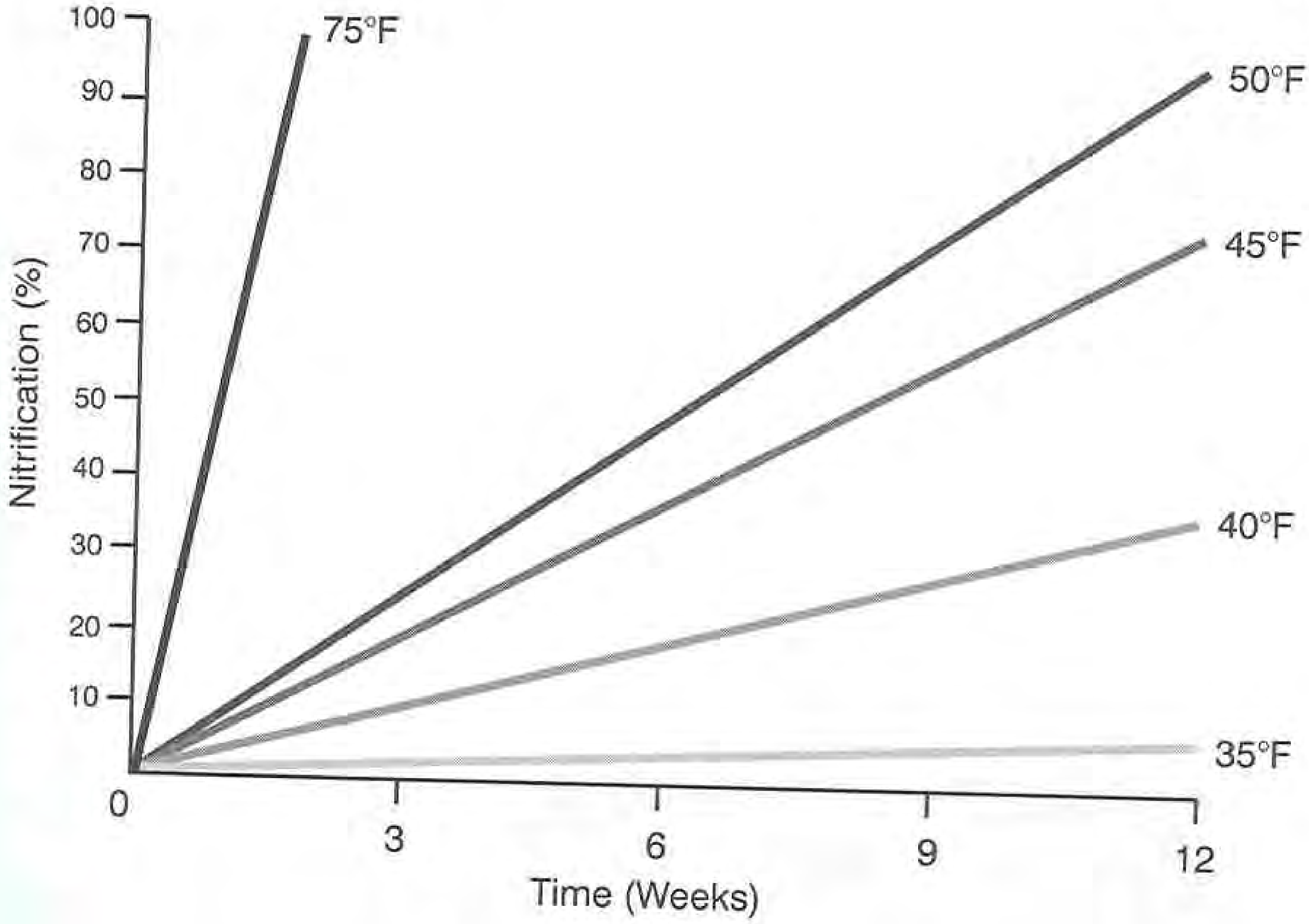


FIGURE 4–2. Generalized nitrification rates at various soil temperatures.

Denitrification takes place under anaerobic (no oxygen) conditions and Nitrogen is lost to the atmosphere

$$NO_3^- \rightarrow NO_2^- \rightarrow NO \rightarrow N_2O \rightarrow N_2$$

nitrate → nitrite → nitric oxide → nitrous oxide → dinitrogen

Nitrate is also lost downward with leaching

More factors causing nitrogen loss

Ammonium losses direct to atmosphere

- Happens on high pH soils, less on acid soils
- Incorporate fertilizer on high pH soils

pH measures the acidity or alkalinity (basic) of a soil

- Related to soil minerals and drainage history
- Affects availability of nutrients
- Can be changed by
  - Sulfur and many N fertilizers – lowers pH
  - Lime – raises pH to close to neutral
- The ideal pH ranges from 6.0 to 7.5
  - An exception is alfalfa where over 6.2 is desired
- Over 6.0 is desirable
- Over 8.2 can indicate a sodium problem

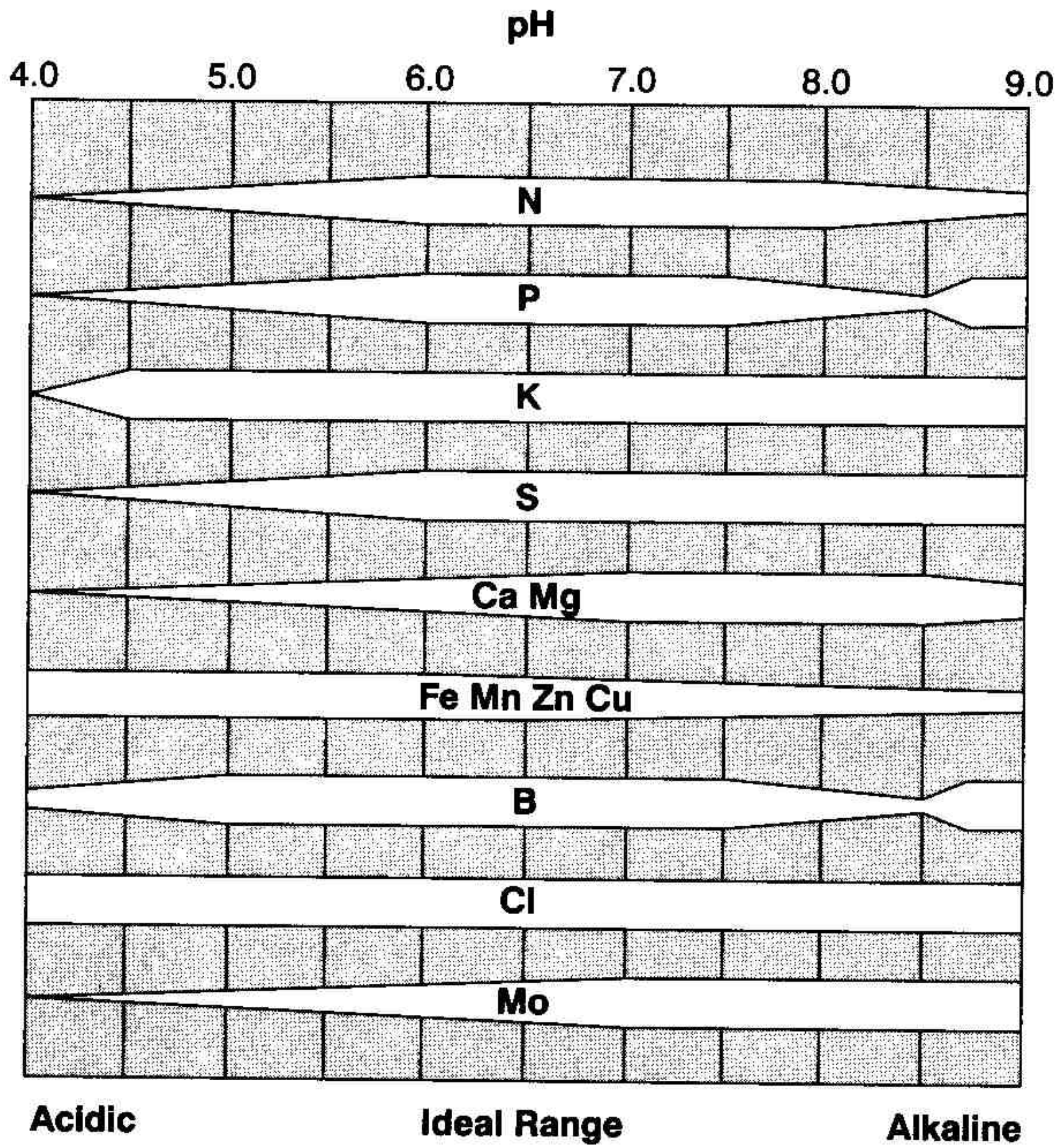


FIGURE 1–8. Relative nutrient availability as affected by soil pH.

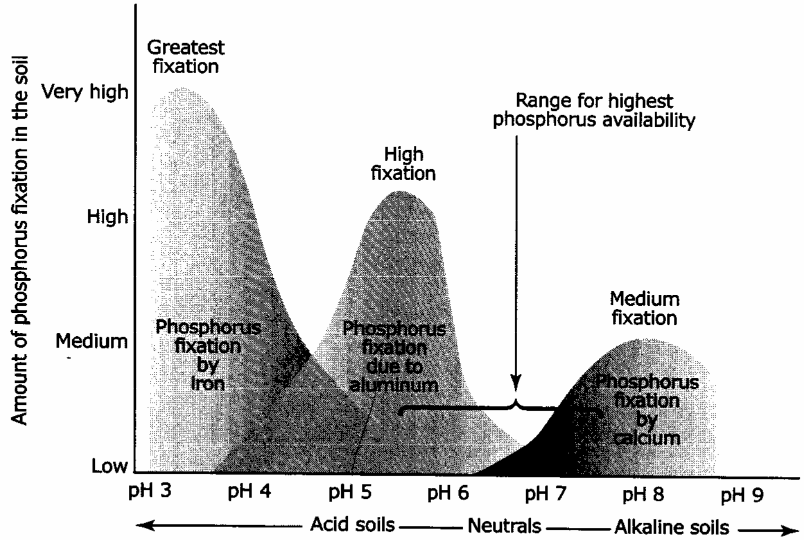
Table 7-2. Best pH ranges for micronutrient availability.

Micronutrient	Symbol	pH range for maximum availability
Boron	B	5.0-7.5
Chloride	Cl	Not affected
Copper	Cu	5.0-7.0
Iron	Fe	4.0-6.5
Manganese	Mn	5.0-6.5
Molybdenum	Mo	7.0-8.5
Zinc	Zn	5.0-7.0

Production Concept 4-3

Availability of Phosphorus Varies with Soil pH

The Hills and Valleys of Phosphorus Fixation



Soil pH greatly influences the solubility of different P compounds in the soil. Solubility indicates how available the P is, or how fixed or tied up it becomes in the soil. In acid soils (decreasing pH), P reacts with Fe, Al, and Mn to form insoluble products, making P less available. In alkaline soils (increasing pH), Ca and Mg react with P to lessen P availability as pH increases above 7.5. The more soluble or available forms exist in the range of pH 5.5 to 7.5. This makes liming essential on very acid soils. Lowering the pH of alkaline soils specifically to improve P availability is not considered practical.

Phosphorus is most available from pH 5.5 to pH 7.5

Cation Exchange Capacity (CEC)

- Cations have the plus charge Ca^{++}, Mg^{++},K^{+}
  - Soil has a negative charge, so higher CEC soils can hang onto more cations
- Related to soil texture
  - Sandy soil – low CEC
  - Clay soil – high CEC
- Characterizes soils
  - Nutrient availability
    - higher, more
  - Leaching of Nitrogen and Potassium
    - lower, more

Production Concept 1-3

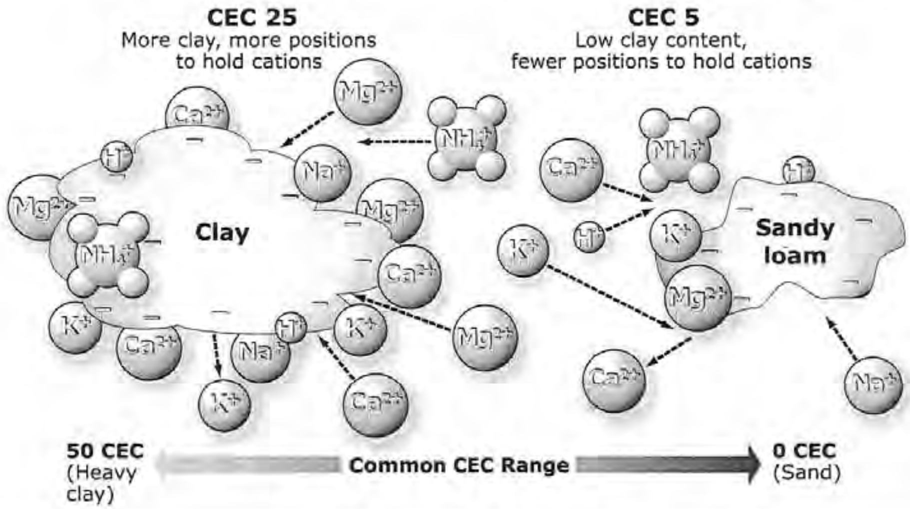
Cation Exchange Capacity:
An aid in soil management and nutrient addition

Cations are positively charged nutrient ions and molecules: calcium (Ca^{2+}), magnesium (Mg^{2+}), potassium (K^+), sodium (Na^+), hydrogen (H^+), and ammonium (NH_4^+).

Clay particles are the negatively charged constituents of soils. They attract, hold, and release positively charged nutrient particles (cations). Organic matter particles also have a negative charge to attract positively charged cations. Sand particles carry little or no charge and do not react.

Cation exchange capacity is the soil's capacity to hold and exchange cations. The strength of a cation's positive charge varies, enabling one cation to replace another on a negatively charged soil particle.

A Schematic Look at Cation Exchange



Some Practical Applications

Soils with CEC 11-50 range

- High clay content
- More aglime required to correct a given pH
- Greater capacity to hold nutrients in a given soil depth
- Physical ramifications of a soil with a high clay content
- High water-holding capacity

Soils with CEC 1-10 range

- High sand content
- Nitrogen and K leaching more likely
- Less aglime required to correct a given pH
- Physical ramifications of a soil with a high sand content
- Low water-holding capacity

TABLE 1–2
Typical CEC of Some Soil Textural Classes

Soil Texture	Typical CEC Range
	(meq/100 g)
Sand and loamy sand	2–6
Sandy loam	3–8
Loam	7–15
Silt loam	10–18
Clay and clay loam	15–30

Irrigation

Approaches to irrigation

- All approaches focus on crop need
  - Evapotranspiration – an estimate of evaporation from soil and transpiration from plants
  - Soil moisture depletion – the soil feel method to see how much water remains
- However, to replace the right amount of water, the water application rate is needed
  - Too much water, deep percolation
  - Too little water, plants are stressed before the next irrigation

The Water Balance of a Field

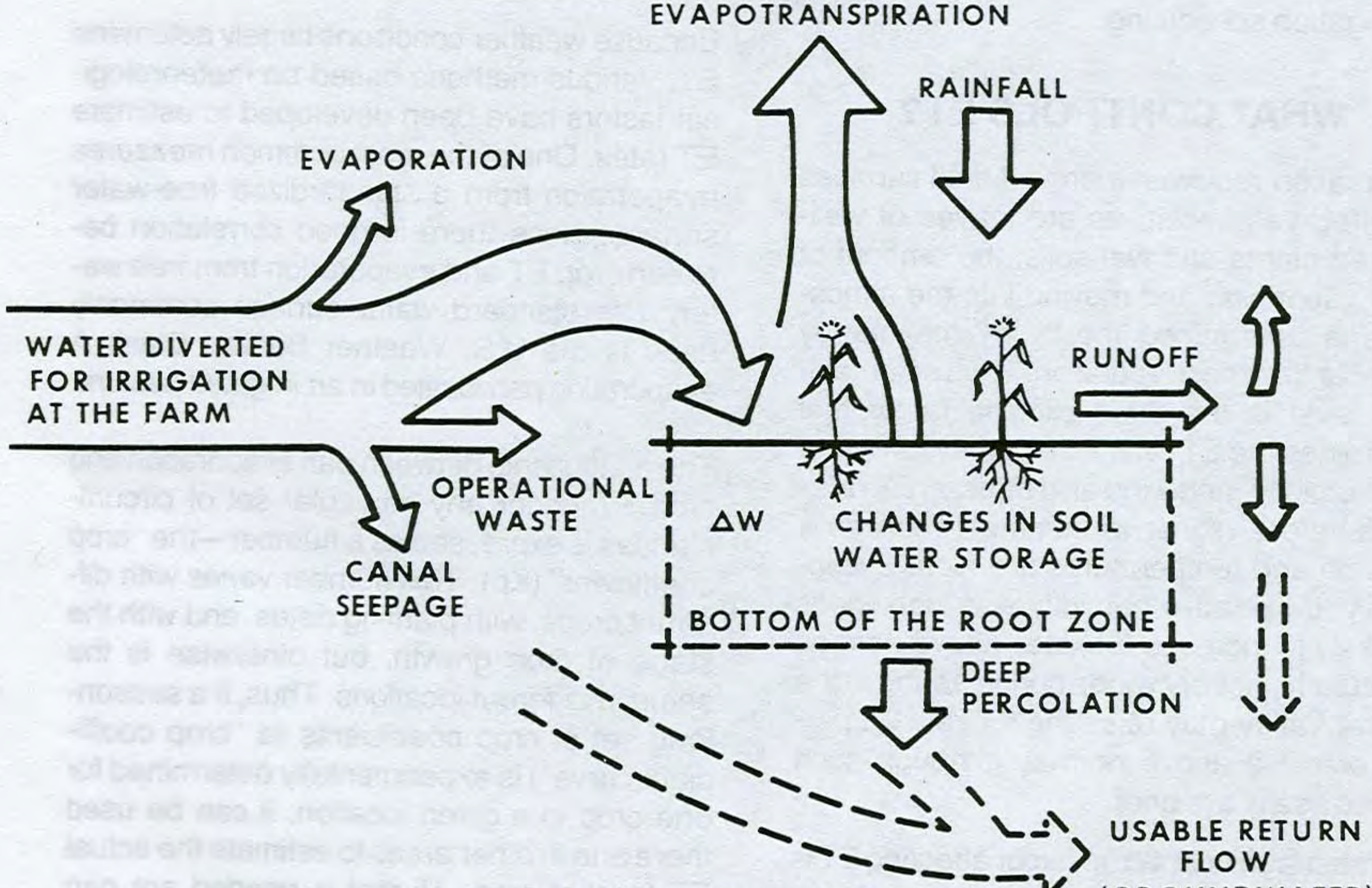
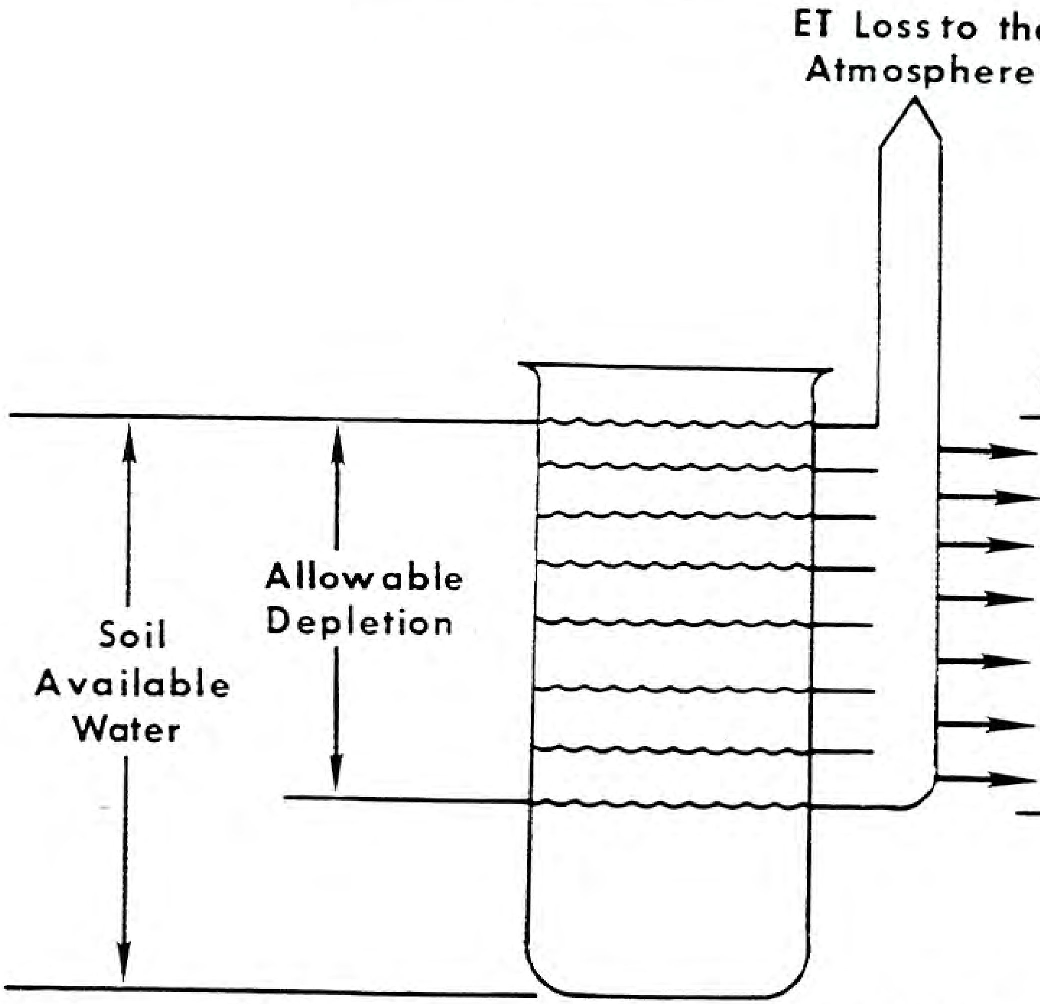


Fig. 1. Water balance of a field.

The Water Budget Method of Irrigation



ET inches/day	days
0.25	1
0.25	2
0.30	3
0.30	4
0.35	5
0.35	6
0.30	7
2.10	7

IRRIGATE

1. When?--------After 7 days
2. How much?-- Apply 2.10 inches of water + losses (Efficiency consideration)

Fig. 2. Water-budget method of irrigation.

Table 17.1 Approximate water use for a raisin vineyard during four seasonal irrigation stages*

Irrigation stage	Phenological events	Approximate dates	Days in irrigation stage	Vineyard water use during irrigation stage (*inches/acre*)†	
				Small canopy	Large canopy
Stage one‡	Budbreak to bloom	April 1 to May 10	40	2.0	2.5
Stage two§	Bloom to veraison	May 10 to July 1	51	5.6	7.5
Stage three¶	Veraison to harvest	July 1 to September 1	62	8.0	10.7
Stage four#	Harvest to leaf fall	September 1 to November 1	61	3.8	5.1
Total vineyard water use for season				19.4	25.8

*Based on the 'Thompson Seedless' variety

†To convert inches per acre to millimeters, multiply by 25.4.

‡Water requirement during irrigation stage one is supplied primarily by soil moisture stored from winter rains (except for vineyards on very sandy or shallow soils). It is difficult to stress vines during this stage. You may be able to help improve berry set by withholding irrigations.

§Do not stress vines during irrigation stage two: cell division and berry growth are occurring during this period and the fruit is very susceptible to sunburn.

¶Deficit irrigation during irrigation stage three (50 to 75% of ET) will have minimal or no effect on yield. Excessive irrigation can increase rot and delay fruit maturation.

#Apply enough water to maintain canopy during irrigation stage four. Avoid excessive growth or premature defoliation.

Table 17.2 Vine water use (drip irrigation schedule) for a small canopy vineyard or one using a single-wire trellis system in the San Joaquin Valley*

Date		Gallons per acre per day†	Date		Gallons per acre per day†
April	1–7	500	July	1–7	3,550
	8–14	750		8–14	3,700
	15–21	1,000		15–21	3,800
	22–30	1,200		22–31	3,750
May	1–7	1,550	August	1–7	3,650
	8–14	1,800		8–14	3,550
	15–21	2,050		15–21	3,400
	22–31	2,300		22–31	3,300
June	1–7	2,650	September	1–7	3,100
	8–14	2,900		8–14	2,850
	15–21	3,200		15–21	2,650
	22–30	3,350		22–30	2,400

*Vineyard canopy covers 50 to 60% of the land surface during summer months. When used to schedule drip irrigations, amounts must be increased according to the efficiency of the drip system.

†Divide values by number of vines per acre to determine gallons per vine per day. Divide values by 27,154 to calculate inches per day. Multiply values by 9.35 to calculate liters per hectare.

Table 1. Water use of Chardonnay grapevines grafted onto two rootstocks (5C and 110R) during and after vineyard establishment. Vine water use (ET_c) or potential ET (ET_o) amounts were obtained by summing data from the date of budbreak (or the day vines were planted in 1990) until the end of October each year.

Year	ET_c (inches)	ET_c (gal vine^{-1})	ET_o (inches)[a]
1990[b]	4.6	101	24
1991	6.9	150	39
1992	9.3	202	39
1993[c]	12.1	271	39
1994	18.1	396	40
1995	18.6	405	40
1996	19.5	425	39

[a] Potential ET (ET_o) data were obtained from a California Irrigation Management Information System (CIMIS) weather station located approximately 5 km (3 miles) from the vineyard from 1993 to 1996. ET_o data the first three years of the study were obtained from the Oakville CIMIS station. ET_o is the amount of water used by a short, green crop completely shading the ground and not water stressed. It is a measure of the evaporative demand of a particular region throughout the year.

[b] rootstocks were planted the last week of June in 1990 and fall chip budded. Vine and row spacings were 5 and 7 ft, respectively. A vertical wire trellis system was used.

[c] irrigations during this year were not initiated on schedule due to a broken water line. In addition, irrigations were interrupted for a three week period later in the season.

Improving efficiency

- Know how much is being applied
- Apply it directly to vines

Calculating the irrigation set time for a vineyard

- T = 449 **X** A **X** D/Q
  - T= irrigation set time in hours
  - A= acres irrigated per set
  - D = desired depth of water to be applied
  - Q= flow rate
- It's all dependent upon knowing the flow rate

TABLE 4 **Irrigation Application Efficiencies Under Good-to-Excellent Management**

System	Approximate Range of Application Efficiencies *(in percentage)*
Furrow	70-85
Basin	75-90
Sprinklers	70-85
Graded Border	70-85
Drip (Trickle)	80-90

Estimating irrigation water needs for grapes with ETo

- ETo is provide by FAO
- Plan on averaging 80% of ETo and using
  - Less early in the season
  - More at fruit ripening
  - Less late in the season

Climate Data Table

Country: Afghanistan Station: KANDAHAR Altitude: 1010 (m)

Month	Max Temp. (C)	Min Temp. (C)	Humidity (%)	WindSpeed (km/d)	SunShine (hours)	Solar Radiation (MJ/m2/d)	ETo (mm/d)
January	13.2	0.1	56.0	259.0	6.5	11.6	2.3
February	15.9	3.1	60.0	233.0	6.2	13.4	2.7
March	22.9	7.5	51.0	190.0	7.9	18.1	4.0
April	27.6	12.2	47.0	199.0	7.8	20.3	5.2
May	33.9	15.5	32.0	199.0	11.5	27.0	7.3
June	39.0	19.2	27.0	164.0	12.5	28.7	7.8
July	40.4	22.7	25.0	173.0	11.6	27.2	8.0
August	38.6	20.0	23.0	147.0	11.4	25.9	6.9
September	34.1	13.6	24.0	147.0	10.7	22.7	5.7
October	28.5	8.8	32.0	147.0	9.9	18.6	4.2
November	21.9	3.3	40.0	147.0	8.7	14.3	2.8
December	15.8	0.3	51.0	190.0	7.8	12.1	2.3
Average	27.6	10.5	39.0	182.9	9.4	20.0	4.9

Report... Close