CropKit

Specialty Plan Nutrition Management Guide

Table Grape

Juan Francisco Palma Mendoza

The author wishes to convey its appreciation for the technical support given by SQM in making this manual possible.

Thanks are also given to advisors, consultants, and Chilean researchers, for contributing and sharing their valuable experiences and photographs on table grape production, which have been of paramount importance in producing these Guide, among them:

- Advisors and consultant agronomists: Jose Antonio Soza, Martin Silva, Luis Cariola, Humberto Mendoza, and Dragomir Ljubetic.
- Profesor Dr. Carlos del Solar, Universidad Católica de Valparaíso, Chile.
- Dr. Rodrigo Callejas, Dr. Alexis Vega, Dr. Tomas Fichet e Ing. Agr. Bruno Razeto (M. Sc), research center (CEVID) of Universidad de Chile, Chile.
- Dr. Gabriel Selles, Instituto de Investigaciones Agropecuarias (INIA), La Platina Experimental Research Station, Santiago.

Special thanks to Empresa Exportadora Subsole, S. A., especially to its directing staff and producers: Alfonso Prohens, Oscar Prohens and Jaime Prohens.

And finally, special thanks to Dr. Roberto F. Soza, for his valuable advice in the review and editing of this manuscript.

Table Grape Nutritional Guide
Prepared by: Juan Francisco Palma Mendoza
Development Market Manager for Specialty Plant Nutrition (SPN)
SQM

Foreword

SQM is one of the largest world suppliers of specialty plant nutrition, and service provider to distributors and agricultural producers.

As part of a commitment to the agricultural community, the company has developed an integral series of plant nutritional manual for an array of crops.

Technical information derived from SQM and contract research studies, and on-farm practical experiences of company specialists around the world, have been assembled and offered to producers and fertilizer dealers.

This guide on Table Grapes summarizes the main markets requirements and the recommended fertilization technical procedures aimed at the high quality production recommendations needed to meet client's demands.

Index

Introduction

Nutritional balance means to provide plants all the 13 mineral elements needed to thrive, that is: nitrogen (N); phosphorous (P); potassium (K), calcium (Ca); magnesium (Mg); sulfur (S), iron (Fe); manganese (Mn); zinc (Zn); copper (Cu); boron (B); chlorine (Cl) and molybdenum (Mo). Since they carry vital and crucial functions, they receive the denomination of essential elements. The first six of them constitute the macro-elements, since they are taken in large quantities by the plants, while the rest of them, because are required in much smaller quantities, are known as micro-elements. A nutritional balance should provide each one of these elements in the right amount, following the absorption curves corresponding to each phenological stage, in order to optimize their potentials. Daily fertigation (ferti-irrigation) with small quantities of nutrient will prevent saline stress situations at the rhyzosphere or crop's root zone.

The objective of this nutritional guide, which is addressed to **SQM** partners - such as distributors, producers, agronomists, and technical advisors - is to widen their knowledge and management information, and to provide the minimum tools necessary to learn about the world's grape situation, including markets and related subjects. In the first chapter, this guide depicts the fundamental bases on how a nutritional management may improve yield and quality, aimed to produce maximum economic returns to the farmers. Chapter 2 presents a general crop description of subjects such as taxonomy, morpho-anatomy, world production, market requirements, climate, soils, pH, organic matter, salinity, irrigation, management, phenology, physiological disorders, diseases, insect pests, weeds, and crop monitoring. Chapter 3 gives a general overview on the importance of nutrients, with emphasis on potassium and calcium. Chapter 4 gives a sort of guide of concepts aiming at facilitating the nutritional level management, while chapter 5 consists of a photo gallery of visual nutrient deficiency and excess imbalances (physiological disorders) is presented. Chapter 6 shows **Specialty Plant Nutrition** (SPN) product characteristics regarding imbalance rectification effectiveness. Chapter 7 explains the basis of crop nutrition practices and fertilization principles (when, how much, how, which) through plant nutrition practices and effective programmes aimed at increasing yield, quality and profitability. Research results demonstrating the necessity of a nutritional balance is given in Chapter 8, while Chapter 9 summarizes the economic results drawn from **SQM** demonstration field trials, in which a traditional nutritional program based on raw materials is compared with the use of the soluble specialty product "**Ultrasol**™". The demonstrations have been carried out in the Metropolitan area, Chilean Central Valley, with the export variety Thompson Seedless "Sultanina", and in grape seedlings in the VI Region (Marchigue, Chile). An overview of cited literature is shown in Chapter 10.

1 Nutritional Vineyard Status and Relationship with its Productive Behavior

This chapter, which describes the nutritional management of vineyards, will show how to optimize the productive behavior (yield, quality), in order to maximize profitability. The basic considerations are:

Plant behavior, in terms of generating healthy plants, depends on the nutritional level in the different plant tissues. Nutrients must be well balanced in every stage of the plant's development. In case an unbalance occurs, either due to a deficient or nutritional excess, the plant will respond negatively. In the event of a general depletion of mineral nutrients from the productive sites, either caused by harvests, leaching, and runoff, it will be necessary to replenish nutrients with adequate fertilizers, applied in the correct proportion, at the right time.

An ideal fertilization programme should be the one, which permits that the nutritional balance is maintained through the production cycle. The information provided by this guide was based and obtained from specific research activities can be use to facilitate, nutritional balance management. This information may consider standards and norms regarding leaves sampling methods at specific stages of development. It is hoped that this information will be useful in determining the incorporation of nutrients in the right amount and relative proportion for the different growing parts of the plants to maintain balance.

Soil characteristic and nutritional status are also useful. The information provided herein is derived from the knowledge about superior plants.

Fertilizers either applied on the soil surface or incorporated, and complementary foliar applications must be sought as a tool for a good nutritional balance. Fertilizers may differ in their capacity for maintaining a nutritional balance, since some of them are more effective than other competitive products.

Plant responses are related with yield and quality. Quality is regulated by the destination markets, and is related to consumer's requirements. The information contained in this guide should be aimed at obtaining the highest benefits from better plants, able to satisfy target markets needs.

2 Crop Description

This chapter describes the cultivation of table grape in relation to its origin, taxonomy, morpho-anatomy, world production, market requirements, climate, soils, pH, organic matter, salinity, irrigation, orchard monitoring, phenology, crop management (referred to establishment and production), physiologic disorders, diseases, insects and weeds.

2.1 History and Origin

Grape originated in the southern regions of the Caspian Sea. In Europe, wild grapes are found in the Caucasian and Sardinian woods. Their spread of grape seeds and species dispersal is attributed to birds.

2.2 Taxonomy

Grape belongs to the **Ampelidacea** family, genus and species is **Vitis vinifera L**.

2.3 Morpho-Anatomy

The grape plant is a vine bush, in which the braches (canes) have tendrils to support the grapevine as it grows.

In the **root system**, it is convenient to distinguish the real roots, which produce abundant food, from the adventitious roots located at the base of the soil surface, which provide the fructification favoring sap.

The **stem** is tortuous and covered by an exfoliating bark. If vineyards are maintained short- stemmed, the trunk is known as **cepa**.

The **branches** are knotted and flexible; the year old branches, known as canes, are the only ones capable of bearing fruitful buds. The grapevine produces fruits only on new wood (**wood of the year**). Thus, the cane bears (shoots and fruits).

The **shoots** arising from the buds have a thick floppy pith, which is always a part of the lower bud, and is separated from the upper buds by a piece of a woody stem known as diaphragm. For this reason, the pruner always cuts above the immediately upper bud in relation with to the one he wants to keep, precisely in the diaphragm. This pruning cut receives the name of "franc bud".

Buds are arranged along the cane, and are seldom on old wood. Shoots arise from the **fruiting buds** (which, while remain herbaceous, are also known as small bunch "pompano", and give rise to fruits in the opposite side of the third leaf.

Genus **Vitis** encompass several species of agricultural interest, which up to certain extent, differ on their morpho-anatomy, partly due to the genotypic evolution suffered because of agro-climatic changes in its center of origin.

The basic **growth phases of the grapevine** plant are: growth of the primary and the secondary stem and roots, and the fruit development (the reproductive growth is programmed in the meristematic tissues).

The induction and differentiation of the buds coincide with the last stage of the fruit growth, which in turn produces a competition for carbohydrates and nutrients.
In grapevines, the **overwintering bud** correspond to the basal bud called "**feminela**" (that then apside , leaving a scar), which originate in the leaf axillary bud or shoot near bud (cane). These buds have a good vascular connection with the cane. The overwintering bud consist of:

a) Primary buds (inflorescence primordium).
b) Secondary buds (without differentiated floral structures).
c) Scales and stipulae primordia and bracts, which protect the apical meristem, leaves, and the inflorescence primordia.
d) Tomentum (wooliness) or scale trycoms, which provide mechanical and thermal protection.

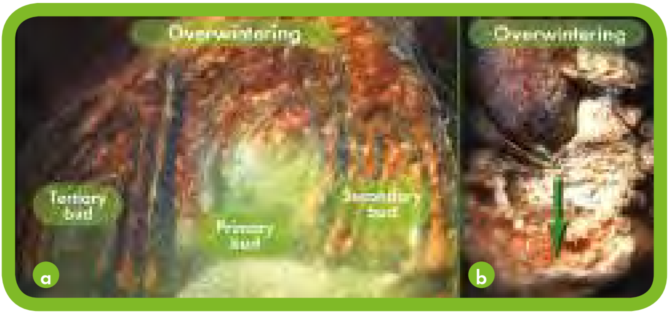


Figure 1. *Parts of the overwintering bud (a and b) (Vega, 2003).*

The apical meristem of the primary overwintering bud differentiates leaf primordium, stipulae, inflorescences, and bract primordia, before beginning dormancy. The inflorescence primordium may either reach an intermediate phase, known as tendril, or get to a final stage (Figure 2).

Figures 2. *Apical meristem of the overwintering bud (a and b) (Vega, 2003).*

During dormancy, the **overwintering** buds show different types of damage, such as necrosis of the main bud (a), and the browning of apical primordiums (b) that limit sprouting (Figures 3).

Figure 3. *Overwintering buds damage (Vega, 2003).*

The **overwintering** gives origin to a mixed shoot, in which each axillary bud (prompt bud) sprouts when the node is in position 4 – 6 from the apex. The prompt bud gives origin to the feminela, a bud that then apside, leaving only its basal bud, the one that will become the new overwintering bud (Figure 4).

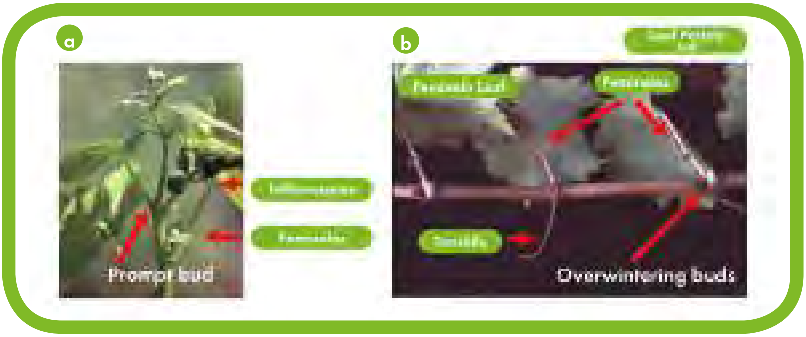


Figure 4. *Overwintering bud, which originates a mixed bud (a). The prompt bud produces the feminela, which in many cases, serve for production purposes (b) (Vega, 2003).*

In **stem** during the secondary growth xyleme vessels are relatively larger that those found in other species. The ritidoma is a group of thin bark dead tissues, with "felema" and cork prevalence, and few phloematic cells (Figure 5).

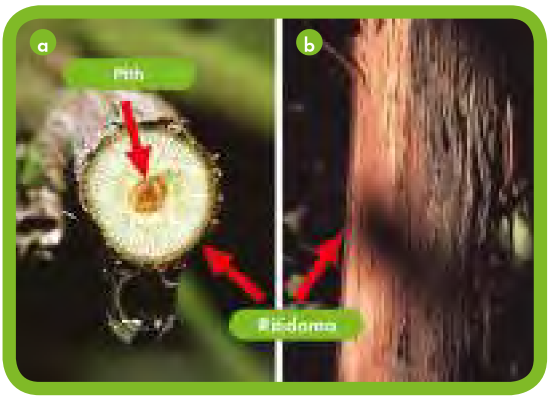


Figure 5. *Cross cut of a cane where the pith is observed (a) (Dr. Jemery Burgess/Science Photo Library, cited by Vega, 2003) and the ritidoma (b), the same to grapevine trunk (Vega, 2003).*

Grapevine **leaves** are distich, whole, tri or penta-globulated, with a typical pattern of C3 species, with a glabrous, waxy epidermis (upper face) and tomentose, with trycomes (inferior face), distinguishing (Figure 6):

a) Cuticle.
b) Epidermis.
c) Palisade parenchyma.
d) Spongy parenchyma.

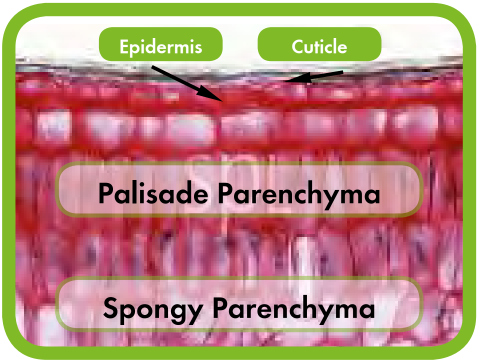


Figure 6. *Cross cut of a grapevine leaf (Vega, 2003).*

Stomata are of fundamental importance for gases exchange. Leaves have a genetically determined abscission zone, which is gradually formed in response to environmental factors. When stresses affect the leaves, the abscission zone may not be completely formed, in which case the leaves may remain attached to the plant (Figure 7).

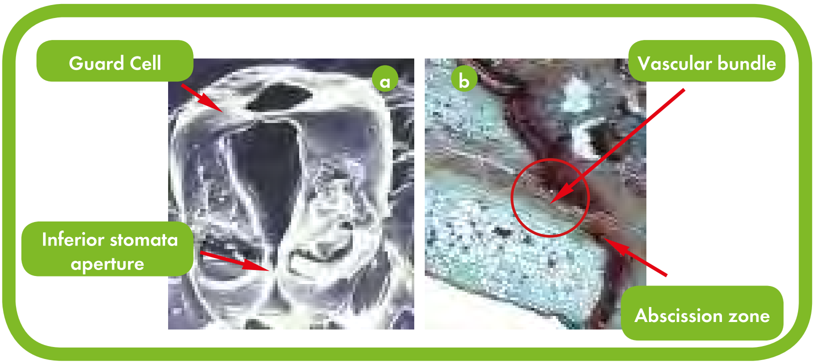


Figure 7. *Stomata cavity (a) and abscission zone in leaves (b) (Vega, 2003).*

Flowers are small, greenish, and hermaphrodite, with small calyx, quinquelentado, corolla bearing five petals, welded to each other at the tip. The ovary (upper and bicarpelar), has two locules, with two ovules (Figure 8).

Figure 8. *Flower (a), and ovary of a superior plant (b) (Vega, 2003).*

The **fruit** is a berry which parts are shown in Figure 9.

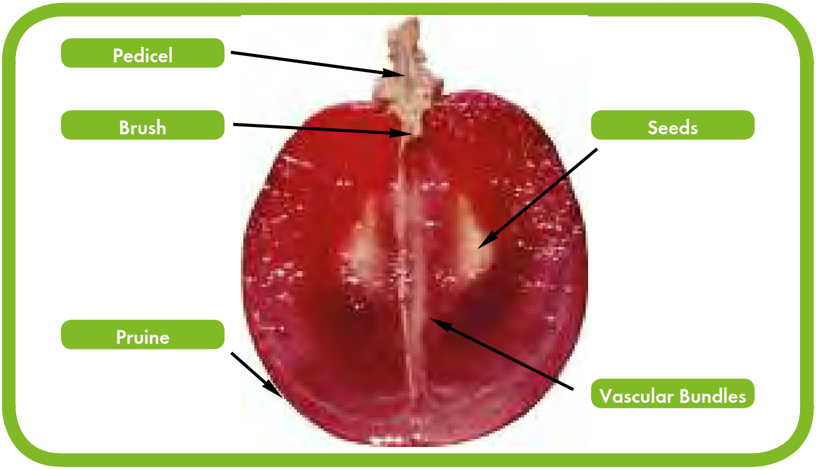
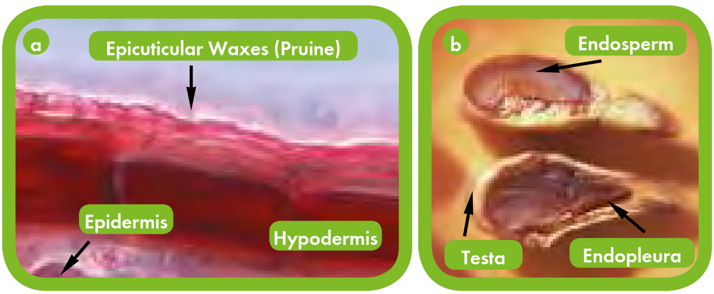


Figure 9. *Cross section of a grape berry (Vega, 2003).*

Epicuticular wax (pruine) is observed in the **fruit epidermis**. The epidermis and the hypodermis concentrate coloring substances (Figure 10a).

In the **seeds**, the endosperm occupies most of the locule (Figure 10b).



Figures 10. *Cross section of a berry (a), and parts of the grape seed (b) (Vega, 2003).*

2.4 World Grape Production

In 2002, the total world grape production reached 61 million ton, produced on 7.4 million ha cultivated in 60 different countries. In 2004, nearly 13 million ton corresponded to table grape. Approximately, half of this production was for local consumption in the original markets, 25% for export (2.3 million ton), and the remaining 25% was processed. The main table grape producing countries are China, Turkey, and Italy, standing out the United States in the Northern Hemisphere, and Chile and South Africa in the Southern Hemisphere (Yara, 2004)

Chile is the most important table grape exporting country in the world (750.000 ton), followed by Italy, (390.000 ton) and the USA (346.000 ton), in the Northern Hemisphere (Figure 11). China –although being the largest producer-, reveals a rather small export volume.

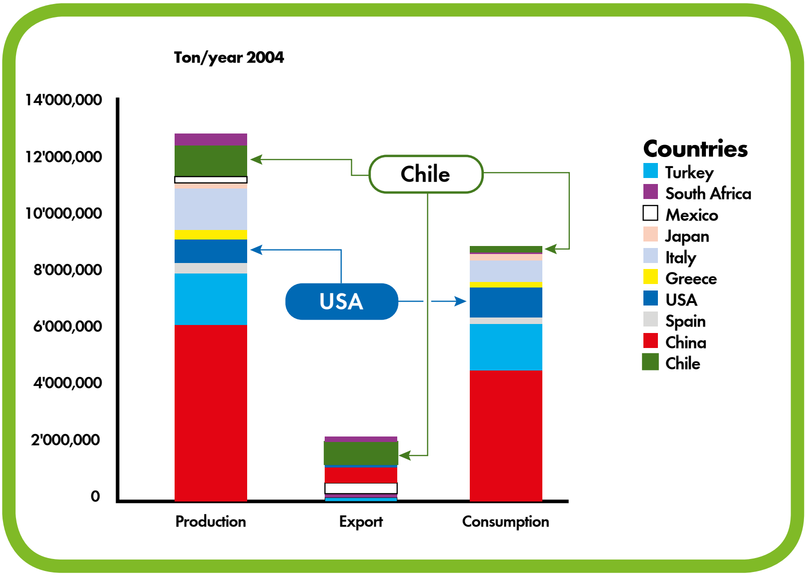


Figure 11. *Main table grape exporting countries (Colombo, 2005.)*

The main commercial table grape varieties for export in Chile appear in Table 1, being Red Globe, Thompson Seedless, Flame Seedless, and Crimson Seedless the most important ones.

2.5 World Market Requirements

The quality demanded parameters vary, depending on countries; thus, it is important to mention precisely the USA requirements (Chile exports largely to this country) as well as those of the European market.

2.5.1 Chilean Market Quality Requirement for Fresh Fruit Export (USA):

- Size and color are fundamental parameters according destiny market, besides flavor, shape, appearance, organoleptic characteristics, presence, or absence of seeds, and easiness of peeling fruits, are the preferred attributes requested by fresh fruit consumers.

- It is important to detect the physiological maturity before harvests, to avoid the internal browning of immature fruits at the port of destiny. The total soluble solids determine this maturity (TSS), and is expressed as Brix degrees (0Brix), and the acidity (determined by titration with Sodium Hydroxide 0.1 N). In addition, is important to know the relation between both (SS/acidity) which should register a minimum 20:1 ratio, and a minimum TSS level at harvest.

Table 1. *Fresh fruit–minimum berry maturity and diameter at harvest in Chile (Asoexport, 2005).*

Soluble Solids Requirements and Berry Diameter in Table Grapes

Varieties	Soluble Solids		Berry Diameter (mm)		
	Minimum	Threshold	Extra Large	Large	Medium
Beauty Seedless	15.5	15.0	> 19	17.5 - 18.9	16.0 - 17.4
Black Seedless	15.5	14.5	> 19	17.5 - 18.9	16.0 - 17.4
Christmas Rose	16.5	16.0	> 22	19.0 - 21.9	17.0 - 18.9
Crimson Seedless	16.5	15.5	> 19	17.5 - 18.9	16.0 - 17.4
Dawn Seedlees	16.0	15.5	> 19	17.5 - 18.9	16.0 - 17.4
Flame Seedless	16.0	15.0	> 20	18.0 - 19.9	17.0 - 17.9
Moscatel	17.0	16.5	> 19	17.5 - 18.9	16.0 - 17.4
Perlette	15.5	14.5	> 19	17.5 - 18.9	16.0 - 17.4
Red Seedless	14.5	14.0	> 19	17.5 - 18.9	16.0 - 17.4
Ribier	16.0	15.5	> 24	22.0 - 23.9	21.0 - 21.9
Ruby Seedless	16.0	15.0	>19	17.5 - 18.9	16.0 - 17.4
Sugraone	16.0	15.0	> 20	18.0 - 19.9	17.0 - 17.9
Thompson Seedless	16.5	15.5	>19	17.5 - 18.9	16.0 - 17.4
Red Globe	16.0	15.5	> 28	25.0 - 27.9	23.0 - 24.9

Tables 2, 3 and 4. *Fresh fruit–minimum bunch's berry coloration, weight and threshing, in Chile (Asoexport, 2005).*

- Color: (% coverage).

Color	%
White	100
Black	90
Red or Pink	80

- Weight: (Bunches, in grams).

Varieties	Minimum weight (g)	Maximum weight (g)
Perlette	200	600
Sugraone	200	800
Ribier	300	900
Red Globe	400	1000

- Threshing: In berries, is defined as serious; specific tolerance is set within the range of 2 and 4%, based on box weight, depending on varieties.

Varieties	%
Seedless	4
With Seeds	2

Bunch shape: according to variety, the market requires a well-formed bunch. Those which do not fit the norm, are considered as deformed bunches.

- **Tolerances** in the Chilean export fresh fruit market - **quality defects.** A maximum of one bunch with these characteristics is accepted per box, or the equivalent to 10% weight basis:
  - Low caliber bunch.
  - Deformed bunch.
  - Light colored bunch.
  - Defective berries in bunch.
  - Low weight or overweight bunch.
  - Sun-scorched bunch.
  - Yellow berries in bunch.

- **Tolerances** in the Chilean export fresh fruit market - **condition defects** are defined as Very serious category, which corresponds to non-admitted defects, whatsoever.
  - Chemical products residues.
  - Presence of insects or diseases.
  - Botrytis.

- **Severe category affecting berries:** the individual tolerance is of 15% based on weight, except pedicelar laceration that reaches to 2%. The total sum of defects cannot be higher than 2%.
  - Burst berries.
  - Watery berries.
  - Pedicel laceration.

- **Severe category affecting bunches**:
  - Bunches with bunch stem necrosis.
  - Weak or crystalline bunches.
  - Soiled bunches.

2.5.2 European Fresh Fruit Export Market Requirements: Regulation (EC) N0 2137/2002 (Only For Fresh Fruit Consumption)

– Minimum quality requirements (after conditioning and packing):

- Pigmentation due to sun damage is not a shortcoming.
- Bunches must be carefully harvested.
- Berries juice should fulfill sugar indexes such as:
  - 12° Brix for varieties Alfonso Lavallée (Ribier), Cardinal, and Victoria.
  - 13° Brix for the rest of varieties bearing seeds.
  - 14° Brix for all the seedless.
- All varieties should satisfactorily complete the sugar/acidity ratio levels.

Table 5. *Fresh fruit classification into classes "Extra "; Class I and Class II.*

	Extra	Class I	Class II
Quality	**Superior**	**Good**	
Defects	None.	Some russet, malformed, colorless are permitted.	Some malformed, russet colorless, bruises, skin deffects.
Berry	**Firm**	**Firm**	
	Firmly attached.	Firmly attached.	
	Evenly spaced	**Evenly attached but less**	**Evenly attached but less near rachis than class I**
	Flowering virtually intact, without floral remains and good fruit set.	Flowering virtually intact, without floral remains and good fruit set.	Presence of floral remains and lack of fruit set.

Source: *CONSLEG: 1999R2789. 2003. Office for official publications of the European Communities; Yara, 2004.*

As far as caliber is concerned, it is determined according to bunch weight (Table 6).

Table 6. *Size classification and classes, according to weight.*

	Grapevine development	**Growth in the open field**	
	under glass/plastic cover	All varieties, except those charactized by small berries.	Small berry varieties, except those listed in the appendix.
Categories	Grams per bunch	Grams per bunch	Grams per bunch
Extra class	300	200	150
Class I	250	150	100
Class II	150	100	75

Source: *CONSLEG: 1999R2789. 2003. Office for official publications of the European Communities.; Yara, 2004.*

Tolerances in fresh fruit, European export market - **quality defects**:
- Class Extra: when **the weight of 5% bunches** does not meet the requirements for this class, although satisfy those for class I or exceptionally, fall within the tolerance for this class.
- Class I: When **the weight of 10% bunches**, do not meet the requirements for this class, but satisfy those for class II or exceptionally, fall within the tolerance for this class.
- Class II: When **the weight of 10% bunches**, do not meet the requirements for this class, nor the minimum required, with the exception of production affected by rotting or any other type of worsening which makes the product unsuitable for consumption.

Tolerances in fresh fruit, European export market - **size defects**:
- Class "Extra" and class I: when **the weight of 10% of clusters**, does not satisfy the size or caliber required for this class, but meets the requirements for the class immediately below.
- Class II: when **the weight of 10%** of clusters does not satisfy the requirements for this class but their weight is not less than 75 g.
- Class "Extra '', Classes I and II: In each container that do not exceed 1 kg net weight, one bunch weighing less than 75 g per box is allowed for adjusting weight, provided that the bunch meets all other requirements for the specific class (Source: CONSLEG: 1999R2789. 003. Office for official publications of the European Communities).

2.6 Climate

2.6.1 Temperatures

Grapevines require a warm and dry climate; they are affected by fast drops in temperature and by cold winds, and suffer from frosts, and lingering rains. **Frost control equipments** are used to protect the orchard from low temperatures, since frost affects the early sprouting in the season (Figure 12).

Figure 12. *The use of frost control equipment, also contributes to homogenize sprouting, VI Region, Chile (Soza, 2004).*

Humid weather delays maturity and produces watery grapes, with reduced flavor; somewhat dry weather produces grapes, which may be kept for longer time in storage, whereas dry weather produces sugary berries, with low acidity, and very tasty grapes.

White varieties are less demanding than the red ones, since the latter present some requirements for the veraison.

The minimum daily temperatures differ for the different phenological stages, in such a way that 10.5° C are needed for bud break, 18.4° C for flowering and 22.5° C to reach maturity.

As far as accumulation of degree-days is concerned, (which considers temperatures above 7° C) they affect production since they control the vineyard phenology. Thus, from the beginning of bud break to full maturity, between 3.200 and 4.000 degree-days are needed during a 180-200 day-period. In general, for a good growth, the grape plant prefers dry and warm summers and cold winters.

2.6.2 Rainfall

Rains occurring during key phenological stages, such as flowering and fruit set, can considerably reduce production. The same effect is produced when coincides with veraison and harvest, since humid conditions and temperature are of fundamental importance for a late infestation with Botrytis cinerea (gray mold).

2.6.3 Wind

Excessive wind affects young vineyards mechanically or chemically (saline winds), by producing damage to berries, stems and leaves. The use of windbreakers is basic for the protection of newly planted vineyards; otherwise, the beginning of production may be delayed (Figure 13).

Figure 13. *The use of windbreakers in newly planted vineyards, III Region, Copiapo, Chile (Palma, 2004).*

2.6.4 Luminosity

The higher the illumination, the better will be the cane maturation, which is essential for the production in the following year. In such varieties as Sultanina (Thompson Seedless), the bud infertility is partly due to a lack of luminosity (far-infrared light) to the bud. The canopy management is fundamental for an adequate light infiltration and vineyard aeration, as to avoid later infections by pathogens such as Botrytis.

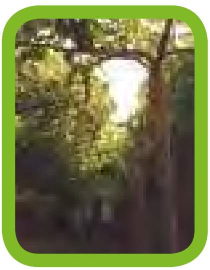


Figure 14. *Deficient light produces excessive vigor, which is associated with low quality fruit (lack of color), and poor condition (fruit decay) (Cariola, 2004).*

2.7 Soils

Grapevines can grow under a variety of soil textures, from heavy clays to light sands, but the latter are preferred by the plants (Figure15).

Figure 15. *Different soils in Chile, (a and b) in the North, and (c) in the South (Palma, 2004 field visit).*

A good and deep drainage is essential to avoid early grape maturation.

- Soil pits are recommended for checking the plant root system (Figure 16).
  - Rhyzosphere.
  - Drainage.
  - Chlorosis.

Figure 16. *A soil pit is examined for monitoring root system in Chile (a, b, c and d) (Palma, 2004).*

Ridges are frequently used for protecting the root system from diseases, which affect the roots and the trunk at the ground level, and for preventing waterlogging and a consequent lack of oxygen at the rhyzosphere level (Figure 17).

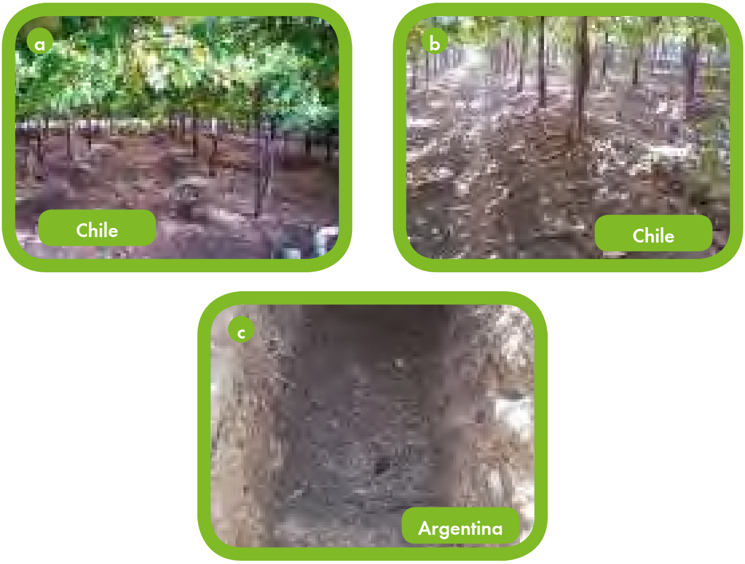


Figure 17. *Ridges in Spanish vineyards (a and b), and rhyzosphere waterlogging effect (c) (Soza, 2004).*

Cover crops are also frequently used as a way of protecting the soil from erosion and, at the same time, improve the organic matter content, improve the water retention capacity, increase iron element availability in the soil, and avoid excessive evapotranspiration. (Figure 18).

Figure 18. *The use of cover crops within rows (a) to protect the soil from erosion, and improve water infiltration, and (b) for stimulating root growth in the inter-row space, thus improving water and nutrient absorption (Bull, 2004).*

2.8 pH

Grapevines can grow within a pH range of 4.5 at 8.5 (Figure 19). At a pH > 6.5, the metal micronutrients (Fe, Zn, Mn, Cu, P and B) become less available for plant uptake. The same situation occurs if the pH is < 5.5, in which case molybdenum becomes non-available. Consequently, the control of soil pH corrects these situations, by balancing the essential nutrients at a right amount, according to the crop phenology as to optimize a quality factor, which influences growth and productivity.

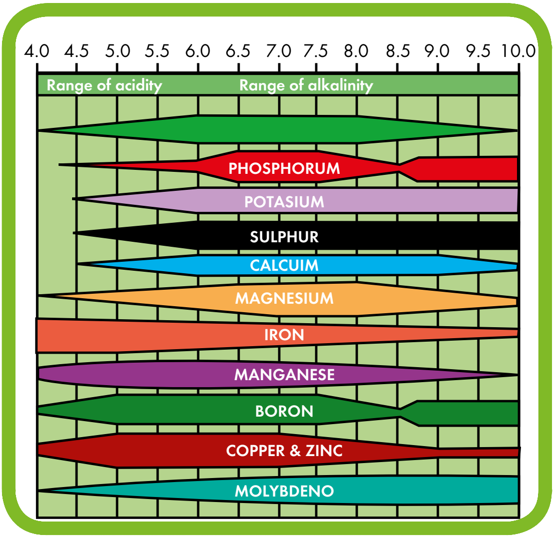


Figure 19. *Soil pH influence on the availability of available nutrients (Yara, 2004).*

2.9 Organic Matter

Organic matter is applied to increase the soil interchange capacity. Besides, as the soil structure and microbiological activity improve, the soil is able to hold more moisture and nutrients. Organic matter contains a significant amount of nutrients. Therefore, the fertilizer rate should be reduced in accordance with the excess of nutrients in the root zone (rhyzosphere), to avoid the risk of increasing soil salinity.

The application of organic matter at the rate of 10 to 15 ton/ha contributes with an important part of the total nutrient demand. Dry organic matter coming from chicken is more concentrated than dry organic matter coming from the cow (Table 7). With 10 MT/ha of large animals manure or chicken manure supplies 134 kg/ha of N is applied. The application of 50 MT/ha of cow manure provides, approximately, 5.5 kg of N-total/MT of manure is applied = 275 kg N-total/ha will be given (Table 8).

Table 7. *The average nutrient contribution in dry chicken manure.*

		Dry	Org.	Total N	P_2O_5	K_2O	MgO	Na_2O	Density
		matter	matter	In kg per 1000 kg organic matter					Kg/m^3
Chicken (dry)	1	530	350	15,8	20	11	4,4	3,5	600
Application (MT/ha)	10			158	200	110	44	35	

Source: *Handbock MeststofferNMI, 1995.*

Table 8. *The average nutrient contribution in dry cow manure*

		Dry	Org.	Total N	P_2O_5	K_2O	MgO	Na_2O	Density
		matter	matter	In kg per 1000 kg organic matter					Kg/m^3
Cow (dry)	1	215	140	5,5	3,8	3,5	1,5	1	900
Application (MT/ha)	10			55	38	35	15	10	

Source: *Handbock MeststofferNMI 1995. p. 29. ISBN 90 5439 023 9.*

Most of the nitrogen is organically bound and will be released during the growing season as a consequence of microbiological activity. This will lead to a high release of nitrogen later in the growing season, when the table grape is already in its generative phase, possibly it may cause a delay in the coloring and fruit maturation, which is associated to low flavor and short post-harvest life.

Frequent "in situ compost" soil incorporations aimed at promoting new roots growth, also tend to stabilize fruit production (yield), and favors water infiltration and soil structure improvement. For these reasons, it is of basic importance to incorporate large amounts of stabilized organic matter in the form of compost. Vineyard canes resulted from pruning, are the raw materials used for composting. It takes not less than three growing cycles to realize its effects on quality and fruit yield. Following this line, two years after mulch was applied, Soza et al (2003) achieved production stability in Chile, while doubled the production from 1,500 to almost 3,500 boxes/ha (Figure 20).

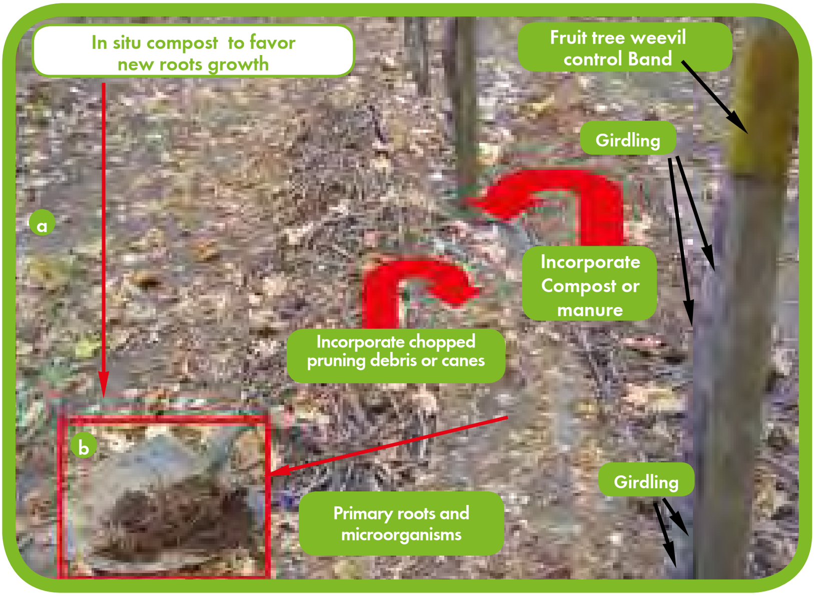


Figure 20. *In situ mulch incorporation (a) to promote new roots growth as well as soil microorganisms (b) (Soza, 2003).*

Trials carried out in Chile, using this type of mulch on soils with low organic matter content, produced significant annual yield increases in vineyards (Figure 21).

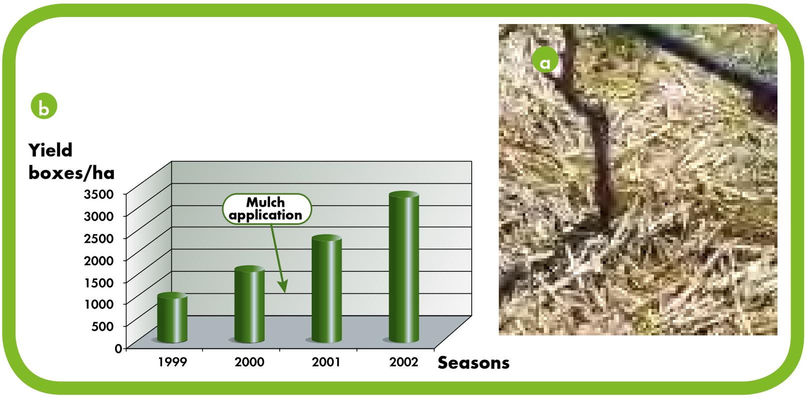


Figura 21. *Use of Cane mulching (a) increase grape yield (b) (Soza, J. 2003; cited in Yara (2004)*

2.10 Salinity

Salinity results from the accumulation of all salts in the rooting zone at such a level that it limits the potential yield in grapes. For instance, salinity can be caused by wrong may fertilizer management, lack of water (water stress) to keep the soil moist or lack of rainfall to flush the soil, and/or irrigation with water holding a high electric conductivity (E.C.). One way to restrain the increase in E.C. in soils, consists in not exaggerate the use of non-stabilized organic matter and/or avoid the use of fertilizers with high chlorine content (KCl) in order to not increase a higher E.C in the soil.

Table grape tolerance to E.C. occurs when the E.C. from soil extract < 1.5 mS/cm (Table 9). In order to preclude a reduction in the productive potential, it is necessary to increase the amount of irrigation water to produce the necessary lixiviation of excessive salts. In this way, a soil extracted E.C. = 2.5 reduce the potential yield by 10%.

Table 9. *Reduction in potential yield in table grapes caused by salinity*

%	Sat. Soil Ext. (E.C)	E.C Irrigation water	Neccesary leaching %
0	<1,5	1	4
10	2,5	1,7	7
25	4,1	2,7	11
50	6,7	4,5	19

Source: *SQM. 2002. Libro Azul, 3a edición. p 67.*

2.11 Irrigation

2.11.1 Overview

Drip irrigation is the most widely irrigation system used in vineyards. This is required for exploiting the maximum production potential of the new rootstock-variety combinations.

The irrigation programming consists of timely replenishing in the correct amount, the water required by the plants for their development, keeping in mind the production maximization or the production of berries of a given quality.

Thus, for example, in fruit orchards, the objective of the irrigation program is to maintain a water supply to the plants in such a manner that it will not impair its growth and development, and will stimulate the production of fruit of a given size for the destination market (either fresh or for industrial use). The irrigation programming must be divided in two stages: one predictive, which is related to the programming itself and an stage of control that correspond to the quantification of the soil moisture and/or the hydric condition of the plants (Sellés, 2003).

For an adequate functioning of the programme, several factors are considered, mainly:

- Climatic circumstances, which determine the evaporation demand of the atmosphere or the referential evapotranspiration (potential).
- Characteristics, which are inherent to the crop, such as the stage of development, the phenological stage, and the root distribution.
- Characteristics, which are inherent to the soil, among others, the water holding capacity, aeration, soil depth, and spatial variability.
- In the case of localized irrigation equipments, is important to know the real precipitation rate or the amount of water applied to each plant.

The evaporative atmospheric demand can be determined from the **referential evapotranspiración (Eto)**. This is defined as the quantity of water required to satisfy the demand of a short and dense crop that covers the whole surface of the land (grasses), The referential evapotranspiración reflexes the climatic effects upon the water demand (formerly referred as to potential evapotranspitration), which is affected by the solar radiation, which in turn depends of the latitude, elevation, time in the year, cloudiness and time of the day. On the other hand, it also depends on the wind condition, temperature and the air relative humidity. Consequently, Eto is independent of the characteristics of a particular crop. Eto can be determined by various methods. One of them is by using physical models, such as the Penman-Monteith's equation. This method requires measurements of solar radiation, wind, relative humidity and temperature, and the help of some coefficients. Because of the considerable amount of information needed, this method has seldom been use for many years, for irrigation programming. However, now a days due to advancements in electronics, automated weather stations have been set up (Figure 22a) at a reasonable cost, permitting the measurements of these parameters in real time, facilitating Eto calculations by means of computers.
(Sellés, 2003: Vera 2003)

Another form of estimating Eto, at present in Chile and in many other countries –among them Israel- uses class A pan evaporimeter (Figure 22a). It is necessary to point out that the use and installation of the evaporation pan is internationally standardized. For this reason, these norms must be followed in order to obtain appropriate readings and perform a correct interpretation of the measured values (Sellés, 2003).

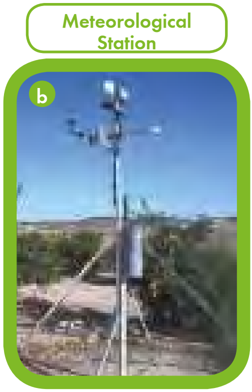


Figure 22. *Meteorological station (b) and evaporimeter tray (a) (Sellés, 2003).*

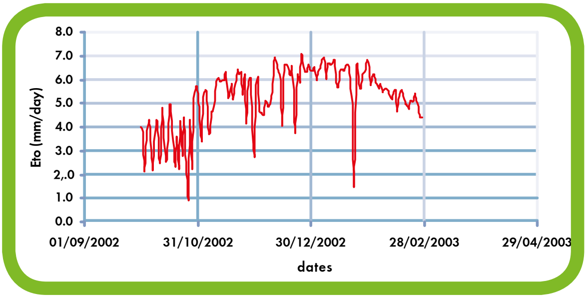


Figure 23. *Example of the daily Eto evolution measured in real time, in an automatic meteorological station (Sellés, 2003).*

The tray provides an integrated measure of the radiation effects, wind, temperature, and humidity on the evaporation of a surface of water. However, the estimate that is carried out doesn't represent precisely the Eto; for this reason it is necessary to correct the reading, using a coefficient (kp) that takes into account the characteristics of the pan location, plus particular wind condition and relative humidity in such a way that:

$$Eto = kp \times Eb$$

Where:

- kp = tray coefficient (tray class A)
- Eb = tray evaporation (mm/day)

Under general field conditions, the kp values may vary within the range of 0.6 and 0.8.

Under arid climates and windy conditions, to 0.6 kp value is recommended. According to Sellés (2003), it must be kept in mind that there are other factor which affect the tray readings, such as water turbidity (algae), tray deterioration (lack of paint) and –obviously- bypassing the installation, and proper use procedures.

The maximum crop evaporation which takes place without hydric restrictions is known as maximum evapoperspiration (Etm), its magnitude depending on Eto (climatic conditions) and crop characteristics (stomata structure and resistance) and the stage of development. These factors, which are lump together in an adimentional coefficient known as crop coefficient (kc), in such a way that the Etm of a given crop can be estimated according to the following expression:

$$Etm = Eto * kc$$

Where:

- Eto = evaporation demand of the atmosphere or referential evapotranspiration.
- Kc = is an adimentional referred to as crop coefficient.

Crop coefficient (Kc) is an adimentional coefficient which includes the crop characteristics (stomata structure and resistance), and the phenological stages of development, especially those concerning the degree of foliar coverage. The crop coefficient (kc) reflects the difference in water consumption between a given crop (Etm) and the referential Eto (a short plant grass species), so that different crops would have a different kc.

Table 10. *Crop coefficients (kc) for different varieties, throughout several phenological stages (Selles, 2003).*

Phenological stage	Thompson seedless; Red Globe	Flame, Superior y Dawn seedless
Before bud break	0.15	0.15
Bud break initation	0.20	0.20
Shoot 40cm	0.25	0.20
Shoot 80cm	0.30	0.20
Flowering initation	0.60	0.30
Berry, 6mm	0.80	0.60
Berry, 8mm		0.80
Berry, 10mm	0.90	
Close bunch	0.90	0.90
Veraison initation	0.95	0.90
Harvest initation	0.80	0.70
End export harvest	0.60	0.50
End internal market harvest	0.50	0.50
Leaf fall	0.15	0.15

Source: *Sellés, 2003.*

Crop coefficients have been obtained at experimental stations of several countries, many times under agronomic conditions quite different than those present in the fields in which the are to be applied, which simply means that they are just mere approximations. Thus, over estimations or sub estimations of the real Etm from the crop may result. Therefore, as indicated in the next paragraphs, it is necessary to make a programming "control" of the utilized parameters.

Regarding the water distribution based on the total water (%) requirement during the crop cycle of cultivation, decisions can be made in the following way:

- Bud break (2 to 7%): excess of water causes yellowing symptoms in the leaves.
- Flowering to fruit set (10%): water stress causes poor fruit set, while in excess, produces an over vigor and excessive berries pruning (Thompson and Superior Seedless).
- Fruit set to veraison (43%): cell divisions during 40 days after seed set determines the fruit caliber. Enough water is needed for growth; otherwise, detrimental irreversible effects will occur.
- Veraison to maturity (44%): sugar development will be retarded if water becomes insufficient. However, excessive irrigation may cause over vigor and delay in maturity and harvest.
- Post-harvest to dormancy: excess of water causes re-bud break (in early production geographical areas). On the other hand, drought conditions affect bud break.

The hydric demand of export table grapes in the Copiapo valley in northern Chile is estimated as 123 irrigations, equivalent to 1.506,4 mm or 15.064 m_3/ha during the annual cycle of the cultivation, as shown in Table 11.

Table 11. *Proposed irrigation scheme for the 2004-2005 cycle for a mature parronal, north of Copiapo, Chile, based on tray evapotranspiration.*

Phenological stages	# irrigations	Hydric contribution (mm)	Hydric demand (m^3/ha)	% hydric demand
Bud break/flowering	12	140,7	1.407,0	9,3
Flowering-fruit set-veraison	41	524,7	5.427,0	34,8
Veraison-harvest	28	261,0	2.610,0	17,3
During harvest	8	90,0	900,0	6,0
Post harvest	34	490,0	4.900,0	32,5
Total	123	1.506,4	15.064,0	100,0

Source: *Silva, 2004. Field visit technical report. Subsole Exporting.*

2.11.2 Controlled Deficit Irrigation (CDI)

It should be pointed out that in low water availability areas, especially in parts of Europe like Murcia (Spain), a **Controlled Deficit Irrigation (CDI)** system is used, which consists of producing a monitored controlled water stress during the grape plant cycle. These drought periods in grapevines, even short ones, tend to affect the crop.

- **Positive CDI effects** upon abscisic acid, proline and solutes, which accumulate before harvest (Ferreira et al, 1998).

- **Negative CDI effect** on productivity, since the time span from sprouting till a week prior to flowering, when foliar area and transpiration increase, is the most critical one. Every deficit causes a reduction in cellular elongation. CDI is negatively correlated with the trunk perimeter. Besides, the levels of cytokinins affect photosynthesis, the stomata aperture, respiration, prochlorophill formation, cell wall synthesis, proteins and cellular growth.

The critical periods and the effect of hydric deficits in irrigation programming and also, the physiological and phenological aspects of different species, should be considered. Not all plant basic physiologic processes show the same response to hydric deficit, since some of them are more susceptible than others, which permit certain flexibility in water management, depending on the farmer's production objectives. For this reason, it is important to know the critical periods of different species (Table 12) in order to know at which growth stage is important not to provoke water deficits.

Table 12. *Critical periods, in different fruit species, in which there should be no water shortage*

Species	Critical periods
Citrus	Flowering – fruit set.
Olive	Pre-flowering to final fruit development.
Apple and Pear	Fruit set to just before harvest.
Peach	Fast fruit development stage (Phases I and III).
Apricot	Fast fruit development stage (Phases I and III).
Cherry	Fast fruit development stage – just before harvest.
Walnut and Almond	Fruit growth and seed development stage.
Grape	Sprouting to flowering (fruit set); fruit veraison.
Kiwi	Fruit set to just before maturation.

Source : *(Sellés, 2003).*

2.12 Monitoring of a Table Grape Orchard

Once irrigation and fertilization programmes are defined for a vineyard, it becomes necessary to perform the following monitoring:

- Soil and water analyses (Tables 13, 14 and 15).
- Soil conductivity analysis and moisture percentage and temperature determinations (Figure 24).
- Moisture measurements using FDR Capacitance probes (Figure 25a) (PRISM-CMP system) and TDR (Figure 25b).
- Nutrition measurements with extractometers or porcelane capsule probes (Figure 26).
- Moisture detection front and nutrition (Cziro type) (Figure 27).
- Nutrition measurements with electrode equipment (Cardy), (Figure 28a), reflectometry (reflectoquant–Merck) and Photometers (Merck spectrum) (Figure 28b).

2.12.1 Water Monitoring: Irrigation Water Quality

It is essential to know the irrigation water chemical and physical qualities, since their effect in plants can be extremely detrimental when factors such as salinity, permeability and specific toxicity are not taken into consideration (Table 13).

Table 13. *Interpretation of water analyses in vineyard irrigation.*

Month	Without risk	With increasing risk	With severe risk
Salinity			
Electric Conductivity (EC) mmhos/cm	1.1	1.1 - 3.0	More than 3.0
Permeability			
Conductivity (EC) mmhos/cm	More than 0.5	0.5 - 0.2	Less than 0.2
Adjusted SAR (Sodium absorption ratio)	Less than 6.0	6.0 - 15.0	More than 15.0
Specific Ionic Toxicity			
Sodium; flood irrigation (meq Na/l)	Less than 3.0	3.0 - 9.0	More than 9.0
Sodium; sprinkle irrigation (meq Na/l)	Less than 3.0	More than 3.0	
Chlorine; flood irrigation (meq Na/l)	Less than 5.0	5.0 - 10.0	More than 10.0
Chlorine; sprinkle irrigation (meq Na/l)	Less than 3.0	More than 3.0	
Boron (B) mew/l	Less than 0.3	0.3 - 2.0	More than 2.0
Other Defects			
Bicarbonates (CO H-)sprinkle irrigation (meq/l)	Less than 1.5	1.5 - 8.5	More than 8.5

Source: *Amorós, 1997.*

2.12.2 Soil Monitoring: Analyses and their Interpretation

Soils can be classified according with the relation existing between electrical conductivity levels in a saturated soil extract (E.C) (mmhos/cm; dS/m) and the Exchangeable Sodium Percentage (ESP). Possible water infiltration problems are also detected from their sodium adsorption ratio (SAR) (Tables 14 and 15).

Table 14. *Soil classification.*

SOIL TYPE	EC (dS/M)	ESP(%)
Normal	<2.0	<15.0
Slightly saline	2.1 - 3.9	<15.0
Saline	>4.0	<15.0
Saline	<4.0	>15.0
Saline sodic (saline-alkaline)	>4.0	>15.0

Source: *INIA Technical Bulletin. Intihuasi Research Experimental Station, (La Serena, Chile).*

Table 15. *Possible infiltration water problems according to the relation with sodium adsorption (SAR).*

SAR	INFILTRATION PROBLEMS
0 - 5.0	Without problem
5 - 10.0	Increasing problem
15.0	Severe problem

Source: *INIA Technical Bulletin. Intihuasi Research Experimental Station, (La Serena, Chile).*

2.12.3 Monitoring During Crop Growth

Monitoring of various soil parameters such as pH, conductivity, temperature, humidity and nutrition, should be carried out. Plant nutrition monitoring is performed in different ways: through suction probes or porous porcelain capsules or by soil saturation extract. Both methods allow sample extraction for their immediate in situ analyses using portable electrode equipments, reflectometers, photometers or index paper.

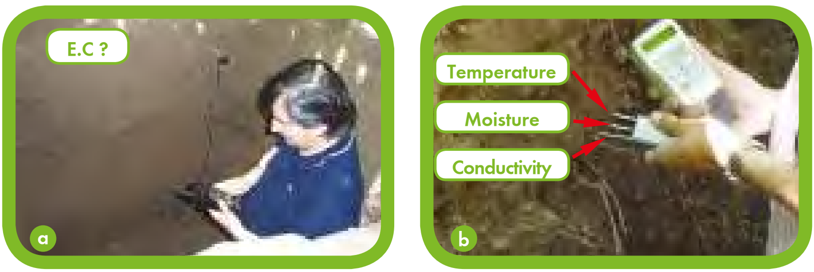


Figure 24. *Monitoring electrical conductivity (a), and moisture and temperature testing (b) (Palma, 2003. Technical Assistance SQMC, Chile; Callejas, 2004, field visits. Copiapo, Chile).*

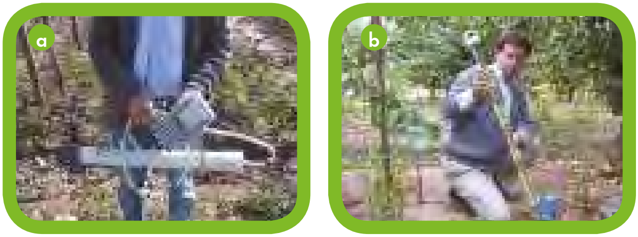


Figure 25. *Monitoring moisture with different systems. FDR (a) and TDR (b) (Field Assistance, Adcom and Atec S.A. companies in Chile, Palma 2004).*

Figure 26. *Nutritional Monitoring, using probes or porous capsule extractometers of different types: left picture (a) shows two types of extractometers: the one of a larger diameter (white) corresponds to the Spanish exclusive extractometer distributed by Agriquem Chile S. A.; the one marked with a yellow circle is of Israeli origin, which is similar to a tensiometer but carries a hose for suctioning the solution. Picture (b) depicts four measurement stations at different depths: 30, 60, 90 and 120 cm (Israeli system) (Palma, 2004. Field visit, SQMC Chile).*

Figure 27. *Front moisture and nutrient detector (a, b, c and d) (lysimeter), measuring with Merck paper strips (d) (Journal Chile Riego, N ° 21, May 2005; web site: cziro. Com; Bay and Bornman, 2003, Kynoch technical team, Yara, South Africa).*

Figure 28. *Nutritional monitoring with extractometer with an electrode equipment (Habira brand (a and b), Cardy), and irrigation bulb by means of measurable saturation extract with a Reflectoquant RQ-Flex Plus (Merck) (Palma, 2003. Field visit, Chile and Colombia).*

2.13 Phenology

2.13.1 Root Growth in Grapevines

- Preferably a deep root system.
- Roots have two growth peaks: at flowering and at post-harvest.
- Root monitoring by rhyzotron is usually perform.

Figure 29. *Root system study with rhyzotron (a, b and c) (Ibacache (2001) cited in Libro Azul ,2002; Ruiz, 2001; Soza, 2004. Field visit, Chile).*

When digging a soil pit, if root vascular bundles show a reddish coloration, it means that they have been exposed to excess water for a long time and thus, suffered from lack of oxygen (Figure 30).

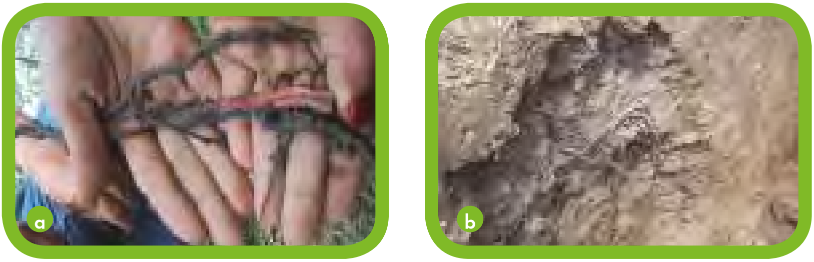


Figure 30. *Reddish root vascular bundles is an evidence that the root system has been subjected to periods of excess water, and lack of oxygen (Palma, 2005, field visit, Colombia).*

Figure 31 shows root growth periods in grapevine, variety Flame Seedless and their relation with shoot development and phenological stages. The information corresponds to studies carried out under the INIA-Vicuña and SQMC research agreement. Flame Seedless is an early harvest export variety grown in Chile. Growth of new roots occurred after plant sprouting. Two root growth periods have been identified: the first one, longer than the second, occurred from the time the first roots appear at sprouting, up to fruit set. The second took place after fruit harvest but before leaves fall. In repeated observations, it was observed that root growth periodicity depends largely on buds growth and on the amount of fruit produced by the plant. Competition for food between plant organs occurs by this way. When buds and fruit grow, they become larger competitors than the roots.

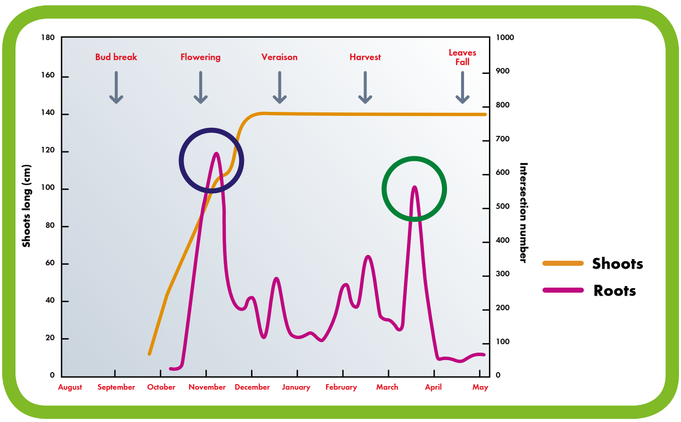


Figure 31. *Buds and roots growth cycles in Flame Seedless grapevine variety (Libro Azul, SQMC, 2002).*

It is basic to know the different grapevine phenological stages in order to underline a nutritional soil or foliage spraying programme, especially, through fertigation.

The growth and production cycles are classified into different phenological stages. Within each stage, specific physiological developments and processes may take place. In South Africa, six phenological stages are identified, totalizing nine events, depending on the geographical zone and problems, and the fine management tuning for the quality optimization for table grape production. (Du Préz, 2003).

- Stage 1 : Bud break to fruit stem separation.
- Stage 2a : Bunch separation, to beginning flowering.
- Stage 2b : Beginning to the end of flowering.
- Stage 3a : End of flowering, to berry pea size.
- Stage 3b : Berry pea size, to two weeks before veraison.
- Stage 3c : Two weeks before veraison, to veraison.
- Stage 4 : Veraison, to end of harvest.
- Stage 5 : End of harvest, to dormancy.
- Stage 6 : Dormancy to bud break.

During the first phase according to Du Préz (2003), it is important to feed the plant with a balanced nutrient solution, due to cold weather and cool soil, not all nutrient reservations are well translocated. Zinc and Boron are important to produce large leaves required for a good photosynthesis. Calcium is important to reduce cracking in berries. During the second stage, bunch growth, and fruit set and berry thinning, can be regulated. Fast growth with internodes lengthening may cause major cluster thinning. Good water and nutrients supplies are needed for fruit set. Stage 3 determines internal quality and fruit caliber. During fruit set to pea size, nitrogen is required for celular division (DNA). Calcium plays a major role during this stage for securing quality. At the end of stage 3, water and potassium are important for the production of large berries. Almost 60% of the final fruit size is reached at this stage. Stage 4 is also critical for producing berries of optimum size and for controlling unnecessary canopy growth and subsequent waist of energy. Potassium is important for the transport of sugars. During post-harvest (stage 5), is important to replenish the plant food reserves as soon as possible, for securing a right bunch and berry development for the following season. During dormancy (phase 6), the vineyard hardly needs nutrients, although is important to maintain plant cells turgency and root activity, since later on - as sprouting starts - the plants requires food. In table grape, the aim is to produce large berries of excellent internal quality, (without bunch stem necrosis, internal browning, cracked berries, or sugar or color problems) (Du Préz, 2003).

In Chile, the following phenological stages are described (Palma, 2003):

- Phase 1 : Bud break – flowering initiation.
- Phase 2 : Flowering initiation – fruit set – veraison.
- Phase 3 : Veraison – maturity – harvest.
- Phase 4 : Post harvest – leaf fall.
- Phase 5 : Dormancy (final leaf falls –sprouting initiation).

2.13.2 Phenological Stages

2.13.2.1 Bud Break - Flowering Initiation (Stage 1): all structures are formed from flowering and fruit set, high nitrogen is demanded, nearly 90% of the nutritional requirements are met by reserves accumulated during the past growing cycle, and flows from the trunk and roots. Spring Fever should be avoided (K deficiency and excess of putrescine) (Figure 32).

Figure 32. *Phenological stages in Chile to phase 1(a, b, c and d) (Neukirchen, 2003; Palma, 2003).*

2.13.2.2 Flowering Initiation – Fruit Set - Veraison (Stage 2): Yield is defined at this stage; levels of K, B and Zn should be checked. Supply NPKCaMg+M.E. This is an appropriate moment for performing two foliar analyses: the first one at flowering time (leaf blade or petiole opposite bunch), and the second, during veraison (leaf blade). The first root growth peak occurs, bringing up a high demand of phosphorous and calcium (Figure 33).

Figure 33. *Phenological stages in Chile to phase 2 (a, b, c, and e) (Palma, 2003; Silva, 2003; Soza, 2003).*

2.13.2.3 Veraison – Maturity – Harvest (Stage 3): Harvest delay should be avoided in this stage (excess N delays maturity). It is necessary to apply K to induce a fast size caliber berry gain. An adequate K supply for sugars translocation and production of varietal pigments (anthocyanine). Excess N, and low Ca and K induce disease susceptibility (Figure 34).

Figure 34. *Phenological stages in Chile to phase 3 (a, b, c and d) (Palma, 2003; Silva, 2003; Soza, 2003).*

2.13.2.4 Post Harvest – Leaf Fall Initiation (Stage 4): Accumulation of N reserves and movements of carbohydrates to roots by K. Second roots growth peak occurs, which requires phosphorous and Calcium. Zn and B deficiencies must be controlled in order to avoid phytotoxicities. Check fertility with soil analysis (Figure 35).

Figure 35. *Phenological stages in Chile to phase 4 (a, b and c). (; Bull 2004; Palma, 2003; Silva, 2003).*

2.13.2.5 Dormancy (Final Leaf Fall – Bud Break Initiation) (Stage 5): Dormant pruning. Hydrogen cyanamide (Dormex) application to homogenize shoots, and replace required winter chilling hours to stimulate bud break (Figure 36).

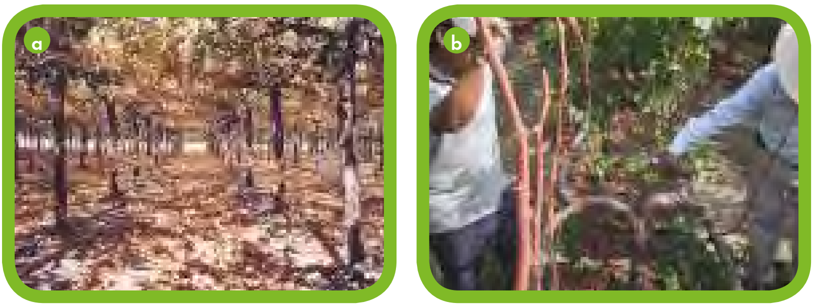


Figure 36. *Phenological stages in Chile to phase 5 (a and b) (Silva, 2003, Chile; Soza, 2005), Peru).*

2.14 Management Operations for the Establishment and Production of a Table Grape Orchard

Basic management operations in the establishment and production of a table grape orchard:

- Soil sampling and land preparation.
- Rootstock selection.
- Installation of a drip irrigation system (or other pressurized system).
- Plants selection, and grafting with a commercial variety.
- Plant formation pruning.
- Plant production pruning.
- Plant pruning for canopy formation.
- Hormones application (growth regulators) and amino acids.
- Girdling.
- Insects, diseases and weeds control.

2.14.1 Soil Sampling and Land Preparation

In some areas, before planting, specific soil salinity conditions should be determined. For this reason, the sodium adsorption ratio (SAR) or relation between elements such as Na, Ca and Mg has to be measured, and then, according to electric conductivity (EC), decide if it is necessary to perform a subsoil plowing in order to avoid consequent salinity problems, lack of aeration, poor infiltration and inadequate water movement in the soil profile (Figure 37).

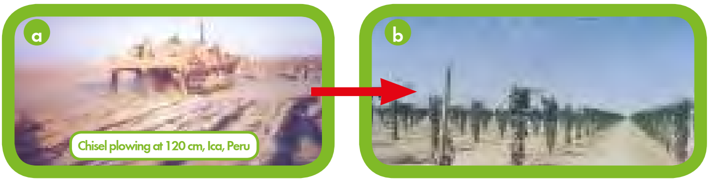


Figure 37. *Sub soiling to 120 cm prevents ulterior salinity problems, lack of aeration, while improves water movement in the profile (a and b) (Palma, (1998), Peru).*

2.14.2 Drip Irrigation System Installation

The higher efficiency of fertilizer materials when applied through a drip irrigation system, is basic for attaining high yields (Figure 38).

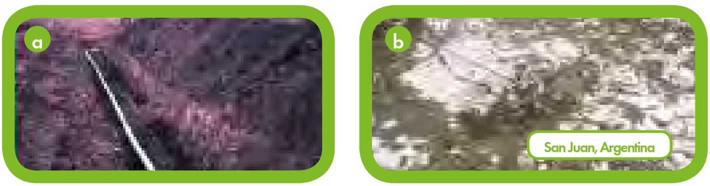


Figure 38. *Installation of a drip irrigation system in Chile (a) and Argentina (b) (Ljubetic, 2003; Palma, 2003, Argentina).*

2.14.3 Rootstock Selection

The relative diversity of available rootstocks gives farmers the possibility to find the rootstock-variety combination that adapts to the majority of the soils in different geographical areas. Grapevines reproduce by seed and multiply or propagate by buds, canes, mugron, and grafting, and by grafting a commercial variety on a rootstock. These rootstocks may be 3 or 12 month old and sold in bags, although they are also available as bare-root grapevines. The following rootstocks are commonly available in the market are Freedom; Harmony; Ramsey (Salt Creek); Paulsen 1103; 1613; SO4; Richter 99; Rugeris 140 and 101–14. These rootstocks are tolerant or solve soil salinity problems, soil pH, carbonates, drought and or suffocation, diseases such as Phytopthora spp., nematodes, phylloxera, replanting conditions, low fertility and soil conditions (Figure 39 and Tables 16, 17, 18, 19 and 20).

Table 16: *Grapevine rootstocks behavior at different soil circumstances.*

Rootstocks	Acidity	Salinity	Carbonates	Drought	Waterlogging
Ritchert 110	2	2	3	4	2*^/3
101-14	1	3	1	1	1*^/3
Ramsey	2	3	2	3	1*/4
Paulsen 1103	2	4*/1/2-3+	3	3*/2	2*/3
Ruggeri	4	4*/1-2	4	4	1
SO 4	1	1-2	4	1*/2	2*/3
3309	1	1*/1-2	2	1	1/2
5BB Teleki	1	1	4	1*/2#	1
Vitis Vinifera	2	1	3/4	2	2

Note: *1 = susceptible; 2 = average resistance; 3 = resistant; 4 = highly resistant*

Source: *Voor Groenberg SA, 2003; (+) Walker et al, 1993; (#) Hidalgo, 1993; (Δ) Archer, 2002; (*) Phylloxera and Grape Industry Board Australia, 2000, cited by Ljubetic, 2004.*

Table 17: *Behavior of grape rootstocks in Phylloxera control.*

	Phylloxera	
Rootstocks	**Resistant**	**Susceptible**
101-14 Mgt	X	
5BB	X	
3309C	X	
Freeedom	X	
Harmony	X	
1103 P	X	
SO_4	X	
St. George	X	X(3;6)
Ramsey	X	
1613	X	X(5)

(Sources: *Cirami, 1999 (1); Nicholas, 1992 (2); Ruhl and Walker, 1992 (3); Whiting and Gregory, 1992 (4); Hidalgo, 1999 (5); May (1994 (6), cited by Ljubetic, 2004.*

Table 18: *Grape rootstocks behavior in the Meloidogyne spp control.*

Meloidogyne spp.		
Rootstock	Voor Groenberg S.A. (Sud-africa, 2003)	Phylloxera & Grape Ind. Board Australia (2002)
Vitis vinifera	MS/S	MS/S
3309 C	S	S
Ruggeri 140	0 / S	0
Ritcher 110	0	0
Paulsen 1103	R/0	0
101-14	R	0
SO 4	R/MR	MR
Ramsey (Salt Creek)	MR	MR

Source: *McKenry, 1992; Hidalgo, 1993, cited by Ljubetic, 2004.*

Table 19. *Behavior of grape rootstocks in the control of Margarodes vitis.*

Rootstock	Margarodes Level	Survival (%)
Cabernet	High	91.7
Semillon	Medium	66.7
SO_4	Medium	50.0
St, George	Very high	55.6
Ramsey	High	60.0
1613 C	Medium	65.0
Teleki 5-A	High	44.4
Harmony	Very high	33.3

Source: *Zaviezo and Schmidt, 2003, cited by Ljubetic, 2004.*

Figure 39: *Table grape rootstock in the grapevine nursery (Soza, 2004).*

Table 20. *Effect of rootstock on Nutrients absorption.*

Rootstock	Nitrogen absorption	Phosphorous absorption	Potassium Lack resistance	Magnesium Lack resisntance	Zinc absorption
Richter 99			Low	Low	
Richter 110	Medium	High	High	Medium	Medium
Ruggeri 140	Medium		High	High	
SO4	Low		Medium to High	Low	
St. George	High	High	Low	High	
101 - 140 Mgt	Medium	Low		Medium to Low	Medium
Schwarzmann	Medium	Medium		Low	
Kober 5 BB	Medium	Medium	Medium	Low	Medium
1103 Paulsen	Medium	High	Low	Very High	Medium
3309 Couderc	Medium	Low	Low	Medium to High	Medium
Teleki 5C	Low	Medium	Medium to High	Low	Medium
Freedom	Very High	High	High	Medium	Low
Harmony	Low	High	High	High	Low
Ramsey	Very High	High	Low		Low

Souce: Ljubetic, D. 2007. Rootstock to table grapes. Presentation to Group of Chilean Advisors in Chile.
Rombolá et al. 2006. Nutritional Physiology in table grapes. Third international seminar in fertigation, organized by SQMC, Santiago, Chile.

Source: *Ljubetic, D. 2007. Rootstock of Table Grapes. Presentation to Group of Chilean Advisors in Chile; Rombolá et al. 2006. Nutritional Physiology in Tables Grapes. Third International Seminar in Fertigation organized by SQMC, Chile.*

Figure 40. *Rootstock effect - Harmony (a) upon Thompson Seedless variety, produces more vigor, and improve the leaf area, quality and yield, in contrast with grapevine plants franco produced from seed (b) (Palma, 2004).*

It must be determine if there is a variety/rootstock affinity since, when incompatibility occurs, an interruption in the vascular bundles will produce a poor graft, characterized by gall formations at the base of the plant, were the grafting took place (Figure 41).

Figure 41. *Incompatibility between the rootstock and a commercial variety (nutgall type)(a, b and c) (Ljubetic, 2004).*

2.14.4 Pruning

2.14.4.1 Plant Formation Pruning

During the first year it is necessary to cut bellow area to promote the rapid formation of 2 to 4 mother branches (Chilean case for plant formation in a Spanish system vineyard).

Figure 42. *Plant cut bellow in the first year (Spanish system vineyard).*

The following six steps are followed in the first year to form the four mother branches required to build the structure of a Spanish system orchard:

- Step 1: Promote vertical growth.
- Step 2: Set the number of buds in canes, according to variety.
- Step 3: Distribute mother branches.
- Step 4: Form four mother branches.
- Step 5: Tie the four mother branches.
- Step 6: Avoid competition by controlling weeds.

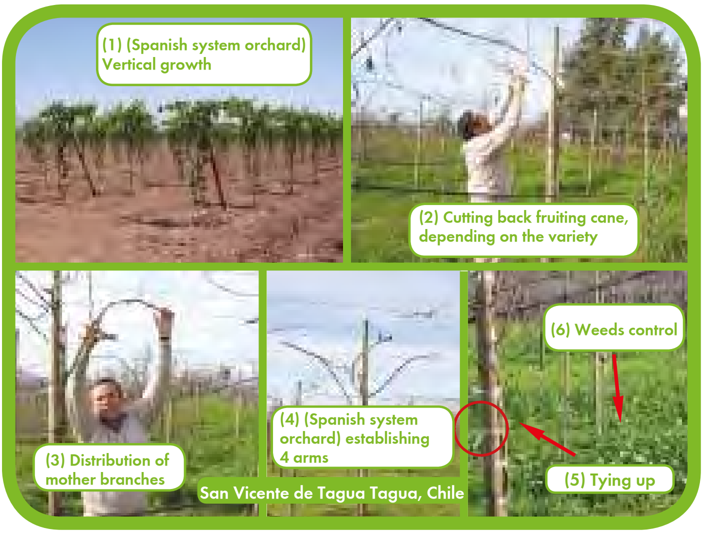


Figure 43. *Formation of a Spanish system vineyard, in San Vicente de Tagua Tagua, Chile. See text and photographs of steps 1 to 6 (Silva, 2004; Palma, 1998).*

2.14.4.2 Plant Pruning for Formation and Production

In high densities vineyards (i.e. more than 1250 plants/ha), this pruning is performed during the first and the third years. It is a winter pruning, since fruiting buds induction and differentiation had already occurred in the previous growing cycle. Besides, the buds fertility and, consequently the canes lengths, have been already defined (Cariola, 2004).

a) Short pruning varieties (4-5 buds): Perlette; Red Globe, Princess, Flame; Crimson and Autum Seedless **displaced Type "H "** cane pruning system (Figure 44, a, b, c, d and e; Figure 47).

b) Medium pruning varieties (6-8 buds): Superior S; Black S and Crimson Seedless **Type "T" simple or double** cane pruning system (Figure 45).

c) Long pruning varieties (8-15 buds): Thompson and Superior Seedless.

Figure 44. *Displaced "H" cane pruning system in var. Red Globe (a, b and c) during three years, and pruning in Superior Seedless variety (d and e), during two years (Cariola, 2004).*

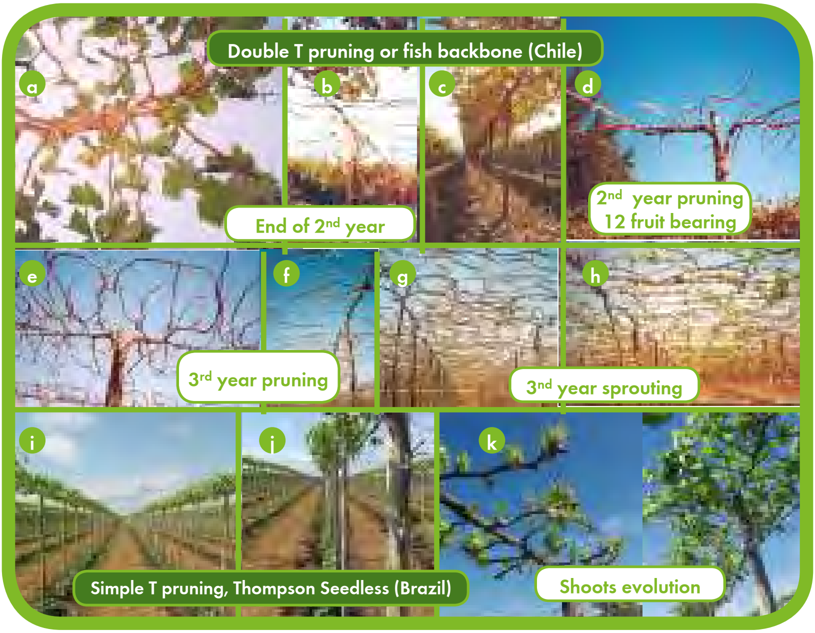


Figure 45. *"Double T" cane pruning system or fishbone (Chile) (a, b, c, d, e, f, g, and h), and "Simple T" cane pruning system at different phenological stages (used in Brazil, in high density vineyards (i, j, and k). (See the evolution of this type of pruning system) (Cariola, 2004).*

2.14.4.3 Green Stage Pruning

It is possible to improve the fertility of fruit bearing canes by controlling excessive foliage (canopy, in high density vineyards, with more than 1.250 plants/ha), thus avoiding bushy grapevines (higher canes luminosity) and improve fruit conditions (bunch aeration and color, and less berry rot)) (Figure 46).

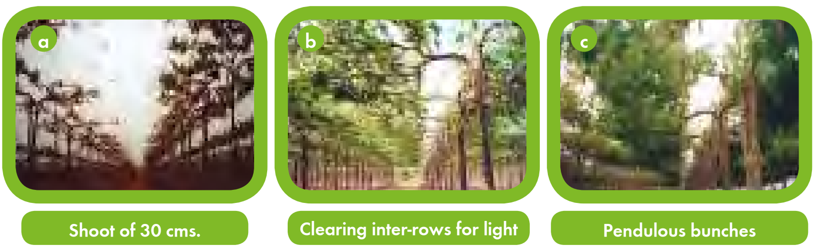


Figure 46. *Canopy management or green stage pruning during crop growth and development (a, b and c) (Cariola, 2004).*

Figure 47. *Between-row alleys clearing pruning, allows light entrance which stimulates color development and aeration (a and b), and beginning of veraison, with luminosity at equilibrium (c and d). Displaced "H" cane pruning system (short pruning), Chile (Cariola, 2004).*

2.14.5 Hormone Application

The hormones involved in the physiological processes related with berry production consist of 5 groups of growth regulators known as auxins, gibberelins, cytokines and growth inhibitors (abscisic acid and ethylene). A theoretical scheme of the functioning of the fruit precursors and their possible relation to sugars is depicted in Figure 48. It is believed that auxins encourage the gibberelines synthesis, which in turn, allows the synthesis of sugars and aminoacids from saccharose (which is the main transport carbohydrate in fruit plants) (Fichet, 2004). The nutrients and hormones availability and the competition between organs, make the fruit/leaf relationship so important.

Any stress situation due either to lack or excess of water, high or low soil temperature, salinity increase, or reduced root growth due to nematodes or diseases, or root pruning, will make the root system send an hormonal signal from roots to the aerial parts, giving rise to the model shown in the right side of Figure 48, resulting in fruit drop.

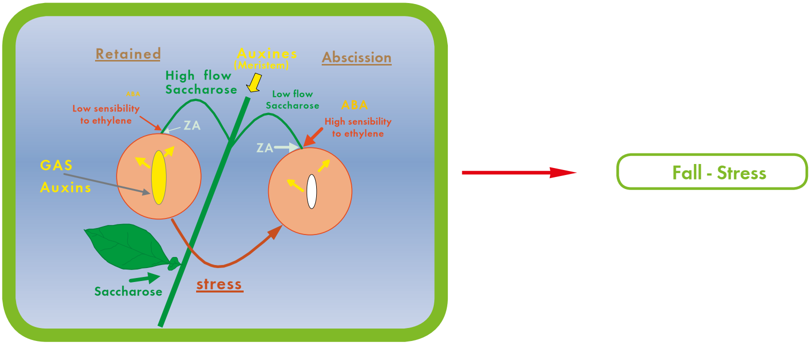


Figure 48. *A theoretical scheme of the interactions between precursors and inhibitors, in a citrus fruit. The fruit retention could result from a high indole acetic acid (IAA) and gibberelic acid (GA3) syntheses in the ovary and/or ovule or developing seed, along with a low abscisic acid (ABA) synthesis, which produce a high carbohydrate (saccharose) demand by the fruit. At the same time, the abscission zone (AZ) presents a low sensibility to ethylene. Under stress conditions (competition and water deficit) a drastic reduction in the synthesis of IAA and GA3 occurs, along with an increase in the ABA concentration. Saccharose supply diminishes and increases the ethylene sensitivity at the AZ which, in turn, results in the drop of the growing fruit (Fichet, 2004).*

Auxins are produced in the shoot tip. They regulate the nucleic acid syntheses, preserve the chlorophyll, regulate apical dominance and branching, stimulate root initiation, influence the nutrient and metabolites transport, promote cell elongation, determine the end of dormancy, stimulate callus formation, inhibit the lateral buds growth, increase the water permeability of the cell wall, and increase the cell solutes for the cellular integration. Finally, auxins promote the gibberelins syntheses, either in the ovule (parthenocarpic or fecundated), and/or in the ovary.

Gibberelins are synthesized in all the tissues, especially in the young leaves. Their role is to regulate the nucleic acids syntheses, preserve chlorophyll, inhibits the initiation of root primordial, speed up the seed germination and thus, the berry growth. Their transport is bipolar since they move in all directions in the plant. They also promote cell elongation, and, in Thompson Seedless, elongate the berry stem. Following thinning, they contribute to the grape growth. In seedless varieties, they induce flowering and berry size, and improve cell permeability to water and increase cell solutes. Finally, it seems that active gibberelins promote the degradation of saccharose into more simple sugars and amino acids, which are required by the growing fruits for their different physiological processes.

Cytokinins, synthesized in the roots and fruits, have a fundamental relation with other hormones such as auxines. They affect the shoots, promote cellular division and diminish senescence. In general, they show a low mobility, except from the roots, from where they move fast (xyleme), when exogenously applied. They regulate the nucleic acid syntheses, preserve the chlorophyll and proteins, contribute to finalize the overwintering of buds, and increase the amount of cell solutes.

Growth inhibitors. These hormones aim at different objectives, depending on the selected inhibitor. Abscisic acid (ABA) is synthesized in the leaves, fruits and root tip. There is a direct correlation between its level and the abscission. ABA interacts with other phytohormones such as gibberelines and cytokinines in the buds and seed dormancy control. Ethylene is synthesized in any senile tissue and young tip where auxines are produced. They induce maturation, promote the thickening of shoots and generate epinasty and abscission.

When applying hormones, it is quite common to mix them with other elements such as calcium (calcium + gibberelic acid). They are applied through several systems (directed piton, immersion and electrostatic sprayers) as shown in Figure 49 (Soza and Del Solar, 2004).

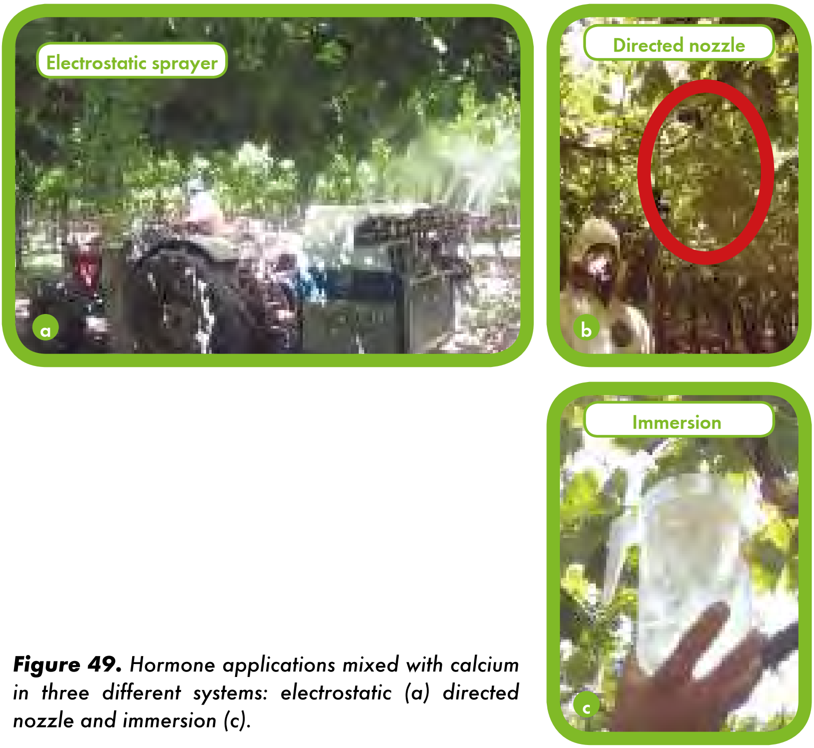


Figure 49. *Hormone applications mixed with calcium in three different systems: electrostatic (a) directed nozzle and immersion (c).*

Table 21 shows hormones effects on grapevine plants and berries.

Table 21. *Auxines, gibberelins and cytokinins effects on grapevine plants and berries (Soza and Del Solar, 2004).*

What effects can you obtain with hormone foliar applications on berries?

	Cytokins	Gibberelins	Auxins
Promotes flower cluster thinning	Probably no effect	In larger degree	Probably no effect
Induces parthenocarpy	Probably no effect	In larger degree	In larger degree
Promotes bunch compaction	In larger degree	In larger degree	No information available
Prevents the abs. of young berries and leaves	In minor degree	In minor degree	In larger degree
Promotes apical dominance	Probably no effect	Probably no effect	In larger degree
Increases berry size	In larger degree	In larger degree	In minor degree
Retards harvest maturity	In larger degree	In minor degree	No information available
Increases acidity	In larger degree	No information available	No information available
Retards fruit coloring	In larger degree	In minor degree	No information available
Increases berry weight	In larger degree	In larger degree	No information available
Increase escobajo	In larger degree	In larger degree	No information available
Promotes pedicel elongation	In larger degree	In larger degree	No information available
Promotes shattering	In larger degree	In larger degree	No information available
Promotes whitening	No information available	No information available	No information available
Promotes russet	Probably no effect	Probably no effect	No information available
Promotes cracking	In larger degree	Probably no effect	No information available

In larger degree · In minor degree · Probably no effect · No information available

Figure 50 illustrates the effects of hormonal applications to a single grape cluster which has been subjected to two treatments: the left part represents the check, whereas the right area received the auxins + gibberelic acid + calcium at the rate of 20 ppm showing different color and size berry (Soza y Del Solar, 2004).

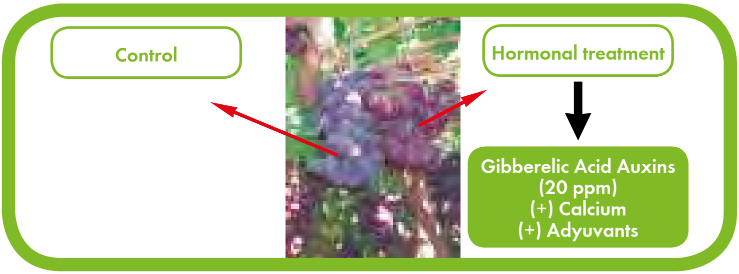


Figure 50. *Hormonal effect on a grape bunch which received different treatments by immersion, in Red Globe variety, Chile (Soza and Del Solar, 2004).*

2.14.6 Use of Girdling

Bark girdling is a circular 2 mm incision on the trunk, cordons or fruit bearing shoots, made with a double blade knife, aimed at interrupting the phloem flow (Figure 51). It should never affect the xylem (the harder tissue below the phloem) since the latter is composed of dead cells which means a slow healing that will be completed at the beginning of the following growing cycle,with the initiation of the cambium activity. Girdling is considered as a technique which helps improve certain plant characteristics, depending on the time in which this operation is performed. Thus, if it is made during fruit set, the berry size will increase but, in case is made during veraison, the berries will mature earlier. It must be pointed out that the temporary interruption of phloem will not only increase the sugar concentration in the above-ground plant parts, since the gibberellins and auxins levels will also raise. The increase of these promoters, along with higher carbohydrate (sugars) availability reduces the abscission, thus favoring the fruit demand. The application of gibberellic acid (GA3) along with the incision is especially suitable for low productive varieties.

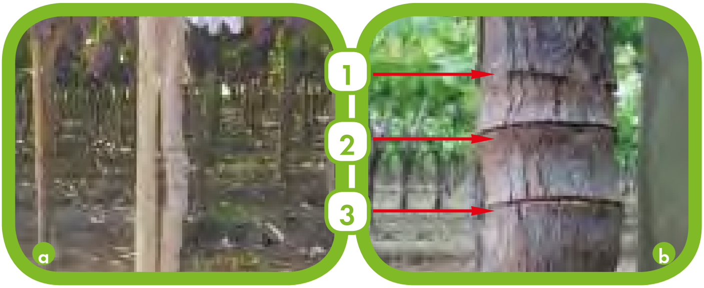


Figure 51. *Girdling throughout several seasons (a and b) (Palma, 2004; Soza, 2005).*

2.15 Physiological Disorders

2.15.1 False Potassium Deficiency and Spring Fever

The symptoms resemble a potassium deficiency but it goes accompanied by high levels of polyamine putrescine (Ruíz, 2000). It shows up at the beginning of the growing cycle in the first leaves of the shoots only, causing a limited foliar growth and unproductive buds. Cold Springs, wet soils and **K deficiency** are indicated as causing this disorder (Figure 52).

Figure 52. *Symptoms of the so called "Spring Fever" resemble False potassium deficiency (a and b) (Ruiz, 2001).*

2.15.2 "Hair Line" Berry Cracking

This fine crack affects the berries by the sugary exudates which are transmitted to the rest of the fruit bunch. Several causes are associated with this disorder: free moisture on the grapes skin; fruit exposed to shadow (due to poor foliage management aimed at grape bunches aeration); water condensation on bunches at post-harvest caused by interruptions on the cold storage chain); growth unbalances producing weak fruit by **excess nitrogen and calcium deficiency** (Figure 53).

It is important to point out that some researches shows this problem in Thompson Seedless variety during post harvest due to high concentrations of cytokins applied.

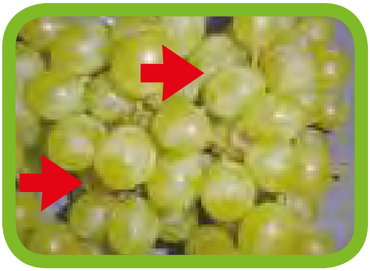


Figure 53. *Berries cracking, in Thompson Seedless variety (Palma, 2003).*

2.15.3 Berry Cracking

Symptoms consist of open cuts or healed scars in the skin. Causes are attributed to an inadequate water management, rainfall close to harvest time, or variety sensitivity to climatic conditions, and **calcium deficiency** (Figure 54).

Figure 54. *"Berry cracking" (a and b) (Palma, 2003).*

2.15.4 Bunch Stem Necrosis - BSN

The symptoms are: humidity, softening, internal browning, loss of color and sugar in berries accompanied by necrosis in the cluster peduncle and rachis. This problem can evolve into a majority of watery berries. Listed causes are: early Mg deficiency accompanied by ulterior K and Ca deficiency (pre-harvest); excess of N-NH4 + phytotoxic (>2000 ppm N-NH4+ in leaves); excess of vigor; shading; high fruit load during post veraison and –in general- a nutritional unbalance (Figure 55).

Figure 55. *Symptoms of watery, crystalline and soft berries accompanied by low sweetness (not higher than 11° Brix (a and b), and fruit stem necrosis (c). (Bay and Bornman; Palma, 2003).*

2.15.5 Loss of Berry Color

Berries with high sugar content, but cannot supply enough sugar to cover berries necessities, needed to increase their color pigments. Causes are attributed to excessive vigor, excessive production and K deficiency (Figure 56).

Figure 56. *Low berry coloration problem in a colored variety, and a poor pruning of green plants or canopy, caused by a low luminosity in the vineyard (a). This problem is due to an uncontrolled excess vigor and a lack of berries and canes maturation (b) (Cariola, 2004; Palma, 2003).*

2.15.6 Nutritional Unbalances

Nutritional unbalances occur due to an excess of nitrogenous fertilization (producing vigorous and succulent shoots) or to phosphorous, potash, calcium and boron deficiency, which reduce and weakens the root system and branches, making them more susceptible to host root diseases caused by fungus or viruses. These problems are triggered by poor water management of the vineyard and the presence of a high water nap (waterlogging) (Figure 57).

Figure 57. *High vigor determines excessive shading as a consequence of a nutritional unbalance (a and b). The presence of a water nap triggers the unbalance problem (c) (Cariola, 2004; Palma, 2004).*

2.16 Diseases, Insects and Weeds

2.16.1 Diseases

Nutritional unbalances may be caused by an excess of nitrogenous fertilization (which produce vigorous and succulent shoots) which make plants more susceptible to diseases. A poor management of the orchard's hydric conditions and the presence of a waterlogging table set off the development of these problems. Extreme weather, either very dry or very rainy climate, predispose the initiation of diseases such as oidium (Uncicula necator) (Figure 58), mildew (Plasmopara viticola), and grey mold (Botrytis cinerea) (Figures 59 and 60).
Oidium affects leaves, shoots, buds and fruits (commercial loss due to russet berries), and fruit rot caused by Botrytis constitute the major cause affecting post-harvest commercial losses to the vast majority of fresh grape exporters in the world.

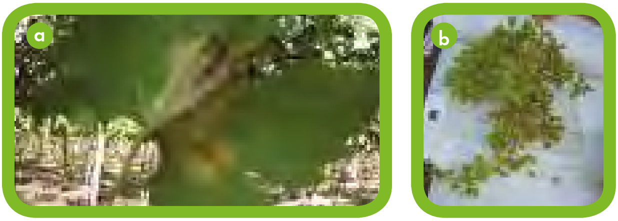


Figure 58. *Oidium infested leaf (asexual phase, Oidium tuckerii ; Sexual phase of Uncinula necator) affecting berry clusters (b) and buds in Chile (a)(Palma, 2004).*

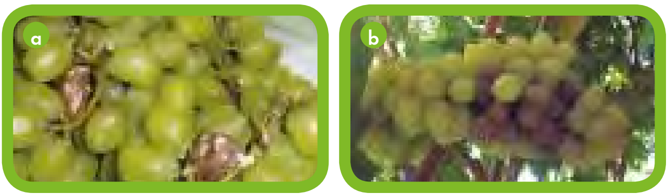


Figure 59. *Gray rot nest caused by Botrytis cinerea in grape clusters affecting a vineyard (a) and at post-harvest (b) (Palma,1992; Soza, 2005, field visit, Chile).*

Nutrition affects the disease tolerance by improving its control (Botrytis cinerea).

Figure 60. *A balanced nutrition controls "grey rot" disease (a and b) (Bull, 2003).*

2.16.2 Insects

An excess of nitrogenous fertilization produces a vigorous plant growth, which make them attractive to vectors (thrips and aphids) responsible of transmitting virus diseases. Plants with weak root systems are also affected by nematodes, phylloxera, margarodes, and fruit tree weevils. The following insects are described as important to grapevines:

- European grapevine thrips (Drepanothrips reuteri) – affects buds and causes berry russet.
- Grape berry moth (Thrips tabacci) - affects flowers and causes berry russet.
- California thrips (Frankliniella occidentalis) - affects flowers and deforms fruits.
- European peach scale (Parthenolecanium persicae) – affects branches and leaves.
- European fruit leccanium (Parthenocanium corni) – affects leaves and berry clusters.
- Grape mealy bugs (Pseudococcus afini) and long tail mealy bug (P. longispinus).
- Fruit-tree weevil (Naupactus xanthographus) – affects roots and leaves.
- False red spider of the vine (Brevipalpus chilensis) – affects buds and shoots.

Figure 61. *Insect larvae affecting the root system (Soza, 2004).*

2.16.3 Weeds

Herbicides must be applied for weed control to eliminate competition. Some weeds serve as host to vectors (thrips, aphids) transmitting virus diseases (Figure 62).

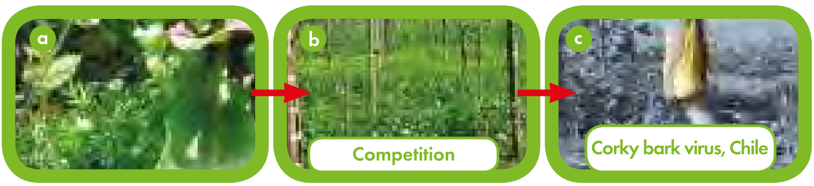


Figure 62. *The presence of weeds increase the incidence of virus-transmitting vectors (a, b and c), and at the same time, compete with the crop (Ljubetic, 2004; Silva, 2003).*

3 The Role of Nutrients

A suitable nutrients programme can only operate when there is a clear understanding of the main role played by them. Special attention must be given to potassium and calcium, which have proved to be important elements in all our demonstration fieldwork when aiming to improve yield and quality (also see Chapter 9). However, it is important to consider that in a balanced nutritional programme, all nutrients must be considered.

3.1 Potassium

Potassium essential roles in table grape are directly related to quality and quantity. Increasing the potassium level will improve plant performance.

3.1.1 Potassium for Quality and Quantity

Potassium is the most important nutrient affecting fruit size and quality.

Among its essential roles, potassium contributes to protein production and photosynthesis, and activates the transport and storage of plant assimilates (carbohydrates) transport from the leaves to the fruit, which is considered the plant "physiologic sink". An adequate potassium supply will sustain the leaves functions during the grapevine growth and will positively contribute to yield and high soluble solids contents (more sugar) in the berries at harvest time (Figures 63, 64 and 65).

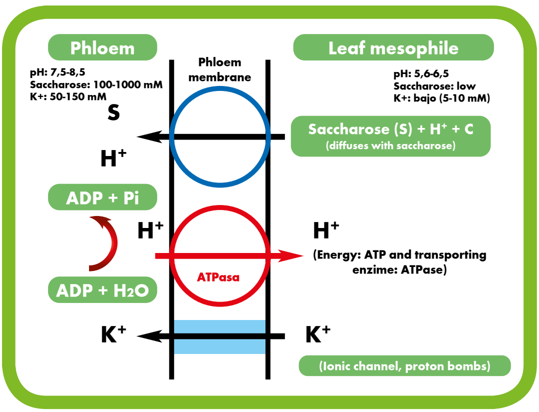


Figure 63. *The diagram shows the way by which the cell wall extends when K is present, since it regulates the phloem load (co-transport saccharose system) (Callejas, 2003).*

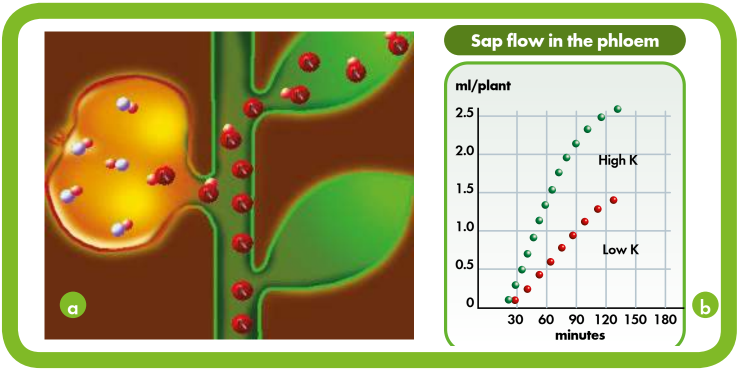


Figure 64. *K intensifies the transport (a) and storage of assimilates from the leaf to the fruit (b).*

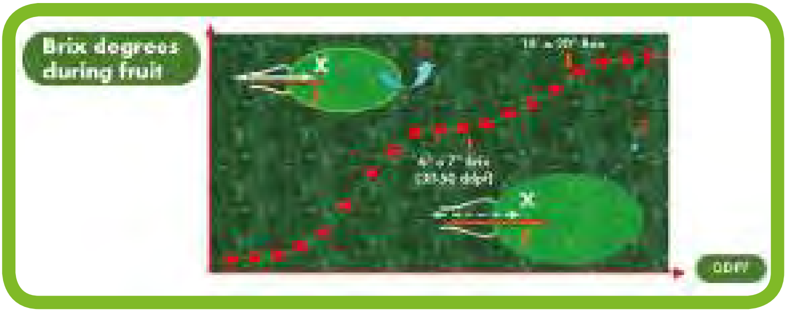


Figure 65. *K intensifies the fruit assimilates, transport and storage (Callejas, 2003).*

Potassium is a cation that is involved in the maintenance of plant internal osmotic potential (cell turgescence), that allows the entrance of water to the vacuoles and subsequent cell growth. For this reason, a wall capable of extending and accumulate solutes is needed. This means that K maintains a hydric internal balance, thus contributing to the opening and closing of stomata (guard cells) (Figures 66 and 67).

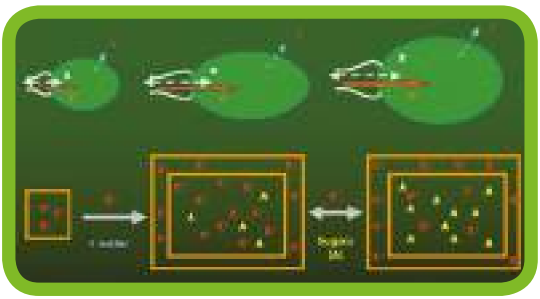


Figure 66. *Diagram explaining the way by which the cell wall extends in the presence of K (Callejas, 2003).*

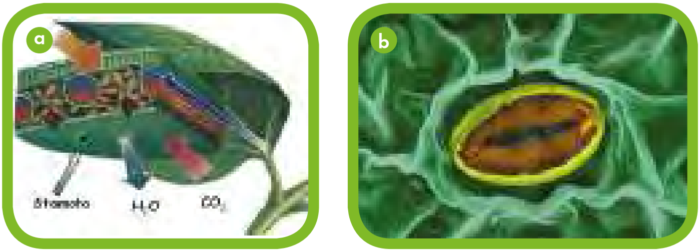


Figure 67. *Schematic representation of the gaseous interchange (a), which occurs in the leaf stomata (b) (Callejas, 2003).*

Potassium participates in the synthesis of proteins by favoring the conversion of the absorbed nitrate inside the proteins, thus contributing to a higher efficiency of the applied nitrogen.

Potassium increases yield when higher doses of this element are supplied (Table 22), resulting in a higher concentration of K in the leaves, since there exists a direct correlation between the level of this element in the petioles and yield (Palma, 2003).

3.1.2 Potassium Increases Yield

- Potassium effect on production and yield (Table 22).

Table 22. *Potassium fertilization increases yield (kg/plant) (Palma, 2003).*

K_2O rates	Grape production (kg/plant)	Relative effect of K on yield (%)
0	23.8	100
300	35.7	150
600	45.2	190

- Correlation between K content in the petiole and yield in berries (Table 23)

Table 23. *Relationship between potassium content in petioles, and yield (ton/ha) (Palma, 2003).*

K content in petioles (% D.M.)	Yield (ton/ha)	Relative effect of K on yield (%)
1.53	4.48	100
1.93	7.39	165
2.53	12.32	275

In summary, the role of potassium in grapevine is as follows:

- K promotes the production of proteins (faster conversion to protein).
- K promotes photosynthesis (more CO_2 assimilation, more sugar).
- K intensifies the transport and storage of assimilates (from the leaf to the "physiologic sink", which is the fruit).
- K prolongs and it intensifies the assimilation periods (higher fruit quality).
- K improves the efficiency of nitrogenous fertilizers.
- K regulates the opening and closure of stomata (guard cells).
- K is responsible for the synthesis pigments such as carotene.

3.2 Calcium for Strong Plants

Calcium has three main functions in the plant:

- Calcium is essential for cell walls and plant structure. Nearly 90% of the calcium can be found in the cell walls, where it contributes to cellular cohesion by maintaining tissue structures and promoting protein production (fast conversion to protein) (Figure 68).
- This function maintains the integrity of the cell membrane (calcium pectate is the cementing element of the middle lamella in the primary cell wall). This is important for the correct functioning of the availability mechanisms as well as to avoid or prevent its disintegration from the egress of elements from the cell.
- Calcium is also the base plant defense mechanism which detects and reacts in front of extreme external stress situations. Both roles, plant defense and tissue rigidity, are important in resisting pathogens attack which cause fruit rot in storage.

Figure 68. *Calcium contributes with 90% of the composition of the cell wall (a), and forms the calcium pectate, which is the cementing element of the middle lamella of the primary cell wall (b) (Source: Bull, B. 2001; Vega, 2003).*

A distinctiveness of calcium is that it is almost exclusively transported by the transpiration flow through the xylem (raw sap transport), and distributed to the roots and leaves, which are the main transpiring organs (Figure 69).

Calcium presents the following characteristic in the plant:

- Calcium moves very slowly through the water flow; it is practically immobile in the phloem flow.
- Calcium accumulates in old leaves.
- Calcium is antagonistic to potassium and magnesium (ionic competition).

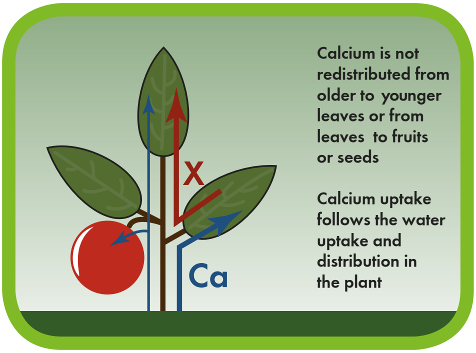


Figure 69. *Calcium upright movement occurs almost exclusive through the xylem tissue (raw sap), from the roots to the upper plant parts. Calcium is a very static element inside the plant, with no movement though phloem, thus its movement from the leaves to the physiological sink (fruits) and growing points is almost nil (Bull, 2001; Retamales and Yuri, 1995).*

The calcium dynamics and main factors which influence its absorption in the plant can be seen in the following diagram (Figure 70).

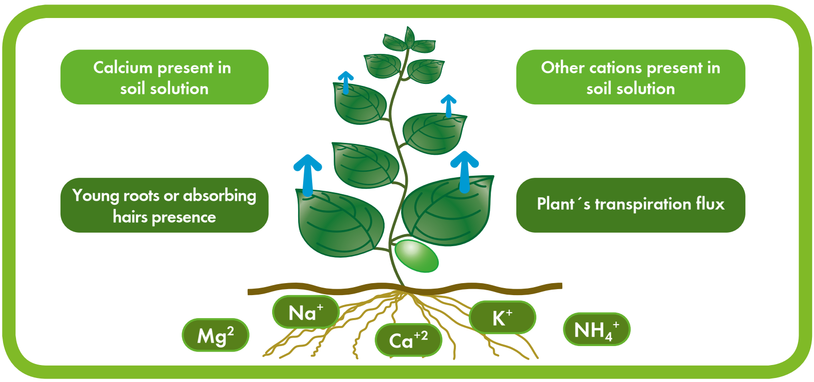


Figure 70. *Factors influencing calcium absorption in the plant (Bull, 2001).*

3.2.1 Calcium Inhibits Botrytis Cinerea Rot Due to Its Presence in the Cell Wall

- Diffusion of assimilates of low molecular weight (sugars, amino acids).
- Permeability of the plasmic membrane.
- Interaction between epidermal cells, and fungus (toxins, phenols).

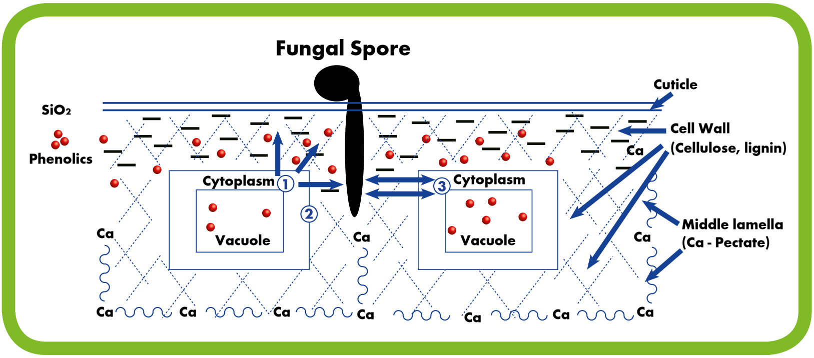


Figure 71. *Outline of Calcium action in diminishing grey mold rot caused by Botrytis cinerea (Bull, 2003).*

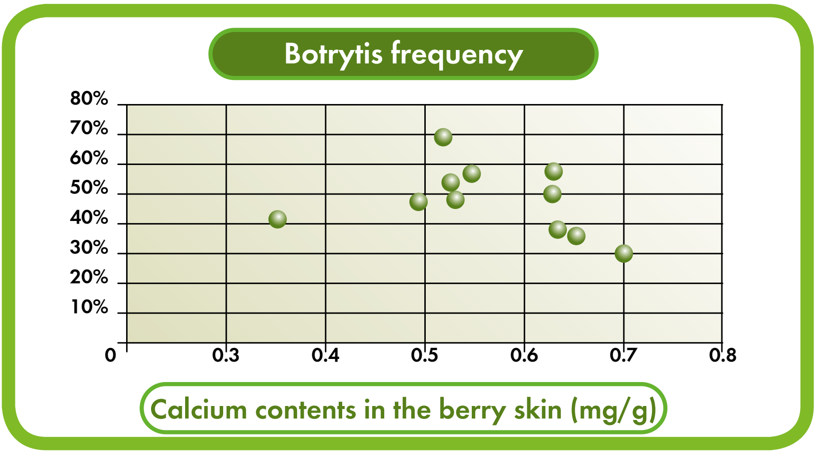


Figure 72. *High calcium content in berry epidermis is associated with a smaller incidence of Botrytis. (Blake, 2003).*

3.2.2 Calcium Stimulates Root Growth

Calcium enters the plant through the roots in 2 ways: the apoplast and symplast systems (Figure 73), and is in demand when new primary roots develop at a fast rate, with less suberization, which permits an efficient ion absorption, with less energy waste. It is understandable, then, the need to take advantage from a drip irrigation system, so that the nutritive solution goes directly to the rhyzosphere which, in turn, will secure the development.

Apoplast:

Trough cell wall and intercellular spaces

Symplast:

Through cytoplasm and intercellular spaces connected to plasmodesmata Involves walls and then, plasmodesmata Slower movement, with energy expenditure

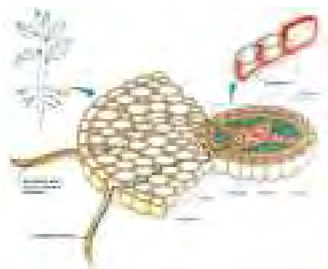


Figure 73. *Schematic representation of a root with the two ways, with different energy demand, by which calcium enters the plant (Taiz & Zeiger, 2002).*

It must be pointed out that this demonstrated that exist different surfaces or areas of absorption from root tip of according to the contributed element, so,we have this way that the nitrogen is of the bigger longitude followed by potassium and calcium to its absorption, phosphrous is the smaller distance (mm) from the root tip. (figures 145).

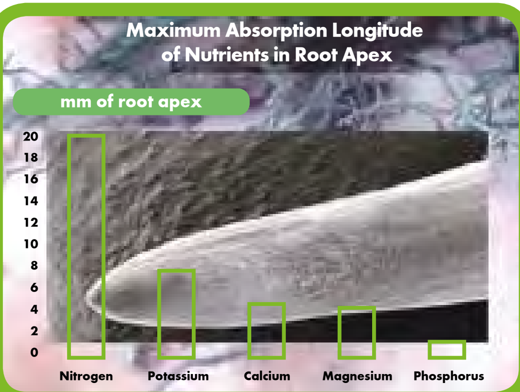


Figure 74. *Maximum absorption longitude for different elements (Adapted from Mendoza, H. 2003. Graduate in grapevine physiology. Cevid, Universidad de Chile).*

3.2.3 Calcium Improves Quality and Berry Condition

Foliar applications of calcium nitrate at 1%, during 10 days before harvest, produce the following post-harvest effects (refrigerated storage) (Figures 75).

- High firmness of berry skin.
- Lesser loss in berry weight.
- Lesser thresh loss.
- Lesser loss due to berry rots.

Figure 75. *Direct foliar applications of calcium to grape bunches, improve the skin firmness at post-harvest (Ibacache, 2004).*

Calcium foliar applications directed to the fruits, contributes to strengthenen the berry cell wall. This is due to the fact that while oxalic acid may become toxic, the cells liberate calcium from the pectates in the wall to neutralize this toxicity. Calcium oxalate is formed, which precipitates the vacuoles, debilitating the cell wall, thus producing weak berries (Figure 76).

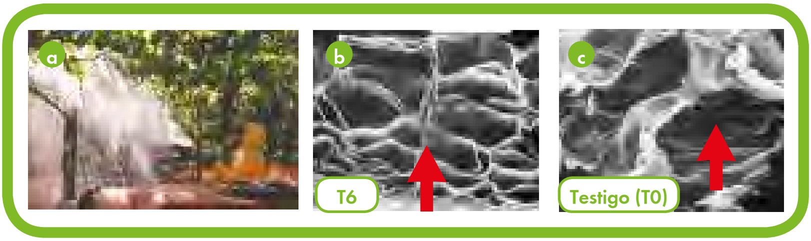


Figure 76. *Foliar applications in the orchard, directed to the grape bunches contributes to improve berry skin resistance (a). Observation with a sweeping electro-microscope (b) shows the effect of calcium application (T6) in Thompson Seedless variety; a good structure and organization of parenchymatic cells is observed. Check treatment for the same variety (T0) is shown in (c), whereby collapsed cells are observed by the same microscope at 450 microns magnification (Raffo, 2005. Field visit, SQMC; Soza and Del Solar, 2004).*

Besides calcium content in the tissues, it must be mentioned the importance of the presence of boron (B), which exerts a control over the cell wall. Boron induces the accumulation of pectins, which thickens the cell wall and improves the elongation and differentiation of the cell tissues (Figure 76, right). A boron deficiency triggers a secondary effect: a higher activity of the indole acetic acid oxidase (Callejas, 2003).

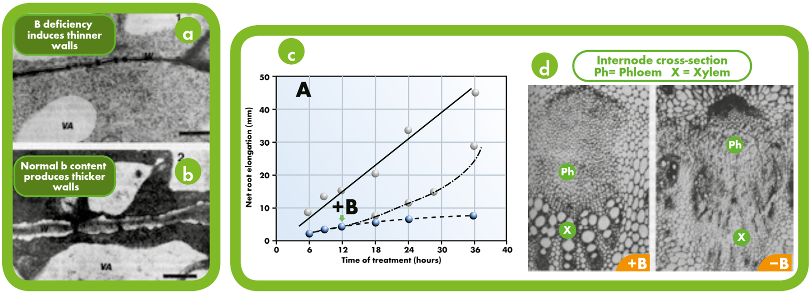


Figure 77. *Effect of B on the cellular wall and elongation (a and b) and tissue differentiation (c and d) (Pissarek, 1980 and Fisher and Hecht-Buchhultz, 1985, cited by Callejas, 2003).*

3.3 Main Quality and Conditioning Problems Due to K and Ca Defficiencies in Table Grape

Table 24 describes the main quality and conditioning problems in table grapes related to deficiencies caused by a K and Ca (and other elements) nutritional unbalance.

Table 24. *Problems related with of K and Ca deficiencies.*

	Main problems during growth	Related with Lack of K	Related with Lack of Ca
Plant performace	Low yield	X	
	Limited growth/vigor	X	
	Small bunches/berry weight	X	
	Lack of size and caliber (length + diameter)	X	
External and internal quality (taste)	Lack of color (in colored varieties)	X	
	Low Brix (Soluble solids)	X	X
	Low vitamin C		X
	Lack of acidity	X	
Quality in storage	Berry rot		X
	Berry threshing		X
	Short post-harvest life	X	X
	Soft fruit/limited peel hardness	X	X
Tolerance resistance	Status in water	X	X
	Diseases (Botrytis, Oidium)	X	X
	Cold and frost resistance	X	
	Salinity	X	X

Source: *Holwerda, 2004. international Seminar on table grape organized by SQM India.*

3.4 Summary of the Roles Played by Nutrients

In the next summary you can see the main roles of all nutrients.

- Nitrogen (N) – Chlorophyll and protein synthesis (growth and yield).
- Phosphorus (P) – Cell division, energy transfer, roots.
- Potassium (K) – Sugar, carbohydrates and assimilates transport, water regime regulation.
- Calcium (Ca) – Cell structure, storage, reduced diseases susceptibility.
- Magnesio (Mg) – Central part of the chlorophyll molecule constituent.
- Sulphur (S) – Synthesis of essential amino acids: cysteine, methionine.
- Iron (Fe) – Chlorophyll synthesis.
- Manganese (Mn) – Required for photosynthesis.
- Boron (B) – For cell wall formation (pectin and lignin), B is a structural component of the cell wall. For sugar metabolism and transport. For flowering, fruit set and seed development (pollen germination and pollen tube growth).
- Zinc (Zn) – Early growth and development (tryptophane synthesis, responsible of auxins formation).
- Copper (Cu) – Influences carbohydrates and nitrogen metabolism. Enzymatic activator for lignin and melanin production.
- Molybdenum (Mo) – a component of nitrate reductase enzymes (NO_3 > NO_2 > NH_3) and nitrogenase (N_2 > NH_3 transformation in N fixed by bacteria of the Rhyzobium group).

4 Guideline Data Facilitating Nutrition Management

Guideline data are essential for the agronomist in order to make objective recommendations in relation to the target market and buyer´s requeriments. This chapter deals with fresh fruit and plant tissue analyses to determine their nutrient extractions.

The nutrient absorption curves describes the nutrient availability in each phenological stage. A difference in demand can be found between the aerial parts (flowers, leaves, stems and fruits) and soil parts (roots). The curves of nutrients´ availability are basic for a fertilization recommendation; thus, in Chile, it was feasible to determine the real needs for Thompson Seedless (Sultanina) table grape variety through three production cycles.

Guidelines are given for all Nutritional recommendations managemenent in open field.

4.1 Nutritional Requirements

Table 25 shows the adult vineyard's fruit nutrient extraction (kg/ton).

Cuadro 25. *Demanda de nutrientes (kg/ton) de fruta fresca.*

Nutrients removed (Fruit)	kg/ton
Nitrogen (N)	1.3 - 1.8
Phosphorous (P)	0.3 - 0.4
Potassium (K)	2.3 - 3.1
Magnesium (Mg)	0.1 - 0.15
Calcium (Ca)	0.2 - 0.35

Source: *Caspari, H. (1996) HortResearch Publication - Grapevine Fertilizer Recommendations; cited by Bull (2003) and Neukirchen (2003).*

Elements extracted by different table grape tissues, in kg/ton of berries produced, is presented in Table 26.

Table 26. *Elements extracted by different table grape tissues during growing cycle (kg/ton).*

Tissues Kg/ton	N	P_2O_5 (P)	K_2O (K)	CaO (Ca)	MgO (Mg)
Fruits	1.9 (0.23)	0.52 (2.45)	2.96		
Shoots	1.7 (0.27)	0.61 (1.23)	1.48		
Leaves	1.7 (0.15)	0.35 (1.08)	1.30		
Total	5.3 (0.64)	1.48 (4.8)	5.7 (41.6)	56 (20.6)	34

Source: *Caspari, H. (1996) HortResearch Publication - Grapevine Fertiliser Recommendations; mentioned by Bull (2003) and Neukirchen (2003).*

4.2 Demand Curve

4.2.1 Macronutrients

Table grapes macronutrients demand by phenological stage in South Africa are similar to those observed by Ibacache (2001) in Chile. Courtesy of Dr. Steve Oosthuyse, 2004 (SQM-Mineag), and Bay & Boosman, 2003 (Kynoch, Yara South Africa) (Figure 78).

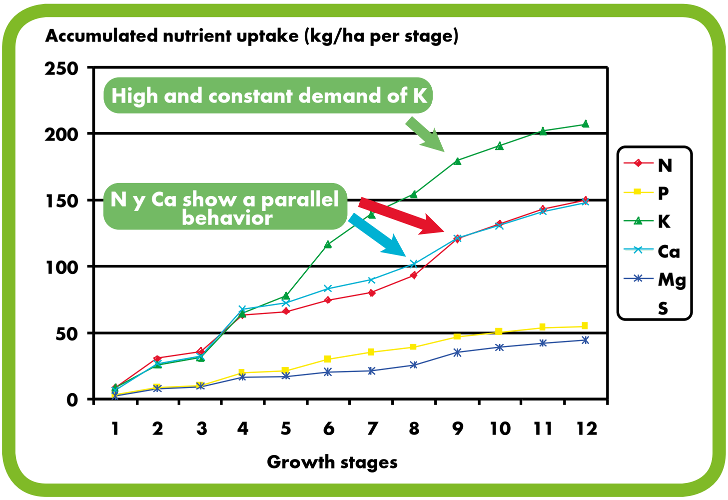


Figure 78. *Macronutrients´ curve in South Africa (Oosthuyse, 2004. SQM–Mineag).*

Notice that a constant K demand exists during berry's growth and development (curve identified with squares).

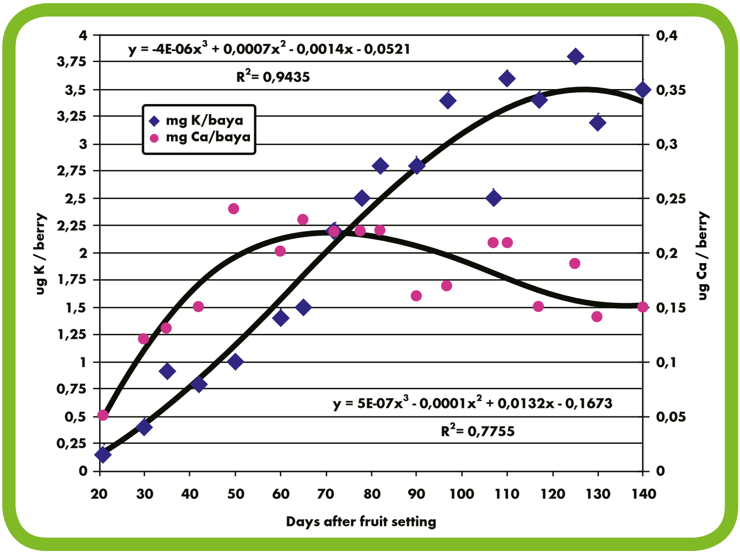


Figure 79. *K and Ca demand (mg of each element/berry), during berry growth and development (Callejas, 2003).*

Besides, there is an important effect of number of seeds in K absorption by the berries.

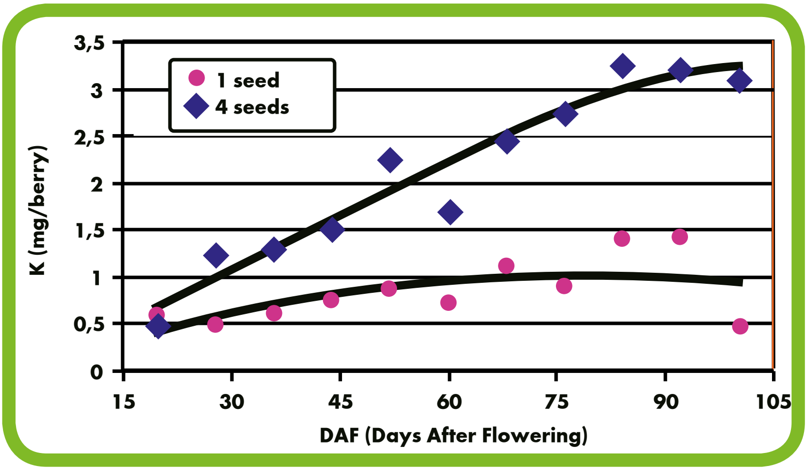


Figure 80. *K content in berries (Callejas, 2003).*

Note: *(DAF = Days after flowering).*

Field based research carried out in Chile (through a research agreement between SQMC and Experimental Research Station, INIA Intihuasi) on 10 year-old Thompson Seedless variety, **Ultrasol**^{TM} soluble fertilizers were compared with a local traditional fertilizer applied as soluble raw materials. The idea of using the traditional fertilizers in a soluble form, responded to a survey carried out among table grape technical departments of fruit export companies. Based on the experimental data, NPK units were homologized in the form of **Ultrasol**^{TM} products. After three years data, an absorption curve was made, based **Ultrasol**^{TM} on fertilized plants during the last two years. This nutrient absorption dynamics was the main contribution derived from this research work. Commercial fertilization recommendations are now made based on this Chilean absorption curve.

N is the most influencing growth and production element in table grape production. Chilean research (2001) showed that it is during veraison stage that this element reached its higher content, and showing an important distribution in the leaves, in comparison with other plant parts as shoots, bunches and fruiting branches (canes) (Table 27).

P influences production by directly affecting fruit quality. Chilean research (2001) demonstrated that phosphorous content increased to 0.43 g in bud break plants, to 7.38 g at veraison, 8.80 g at harvesting, and 5.10 g at leaves fall. At veraison, the phosphorous distribution was higher in the leaves, reaching 45% respect to other aerial organs (Table 27).

Regarding K, in the already mentioned Chilean research (2001), it was showed that at the season initiation, plants registered 2.89 g of potassium. This content increased to 69.02 g at veraison, 66.90 g at harvesting and 28.21 g toward the end of the season. The biggest K content reached during veraison stage, when the leaves attained the highest content (39.4%). At harvest, fruit accumulated 39.8% of the total K measured in the plants (Table 27).

The study also showed that a insignificant amount of Ca was absorbed during the 27 days following bud break. Later on, accumulation was intensified, by increasing to 5.98 g when shoots were 60-70 cm in length, to a maximum of 69.92 g at 8 weeks after harvest. In contrast to nitrogen, potassium and phosphorous, calcium content in bunches at harvesting was very low in relation to other vegetative organs. This element is stored mainly in the leaves, reaching 67.06%, as compared to bunch that had only 6.82% (Table 27).

Mg was low until 27 days after bud break. From there on, the accumulation had significantly increased from 1.24 g to 14.64 g, 5 weeks after harvesting. Like calcium, bunches accumulated only a small quantity of magnesium. At harvesting, bunches accumulated 10.32% of the total Mg, while the leaves absorbed the largest proportion (70.24%) (Table 27).

Table 27 shows the macro elements´ distribution in different tissues (%) in Thompson Seedless variety, from the study conducted by Ibacache in Chile (2001).

Table 27. *Macro elements´ distribution in different tissues (%).*

High accumulation of Ca and Mg in leaves

Macro elements distribution in different tissues (%)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
Phenology	**Veraison**	**Veraison**	**Veraison**	**Harvest**	**Harvest**
Leaves	59.6	45.0	39.4	**67.1**	**70.2**
Shoots	24.3	36.1	37.4	19.5	15.5
Bunches	10.3	12.8	16.5	**6.8**	**10.3**
Canes	5.8	6.2	6.7	6.6	3.9

Low accumulation of Ca and Mg in bunches

*(**Source:** Ibacache, 2001).*

In Chile, the real extraction of macro elements (kg/ha) in the production of table grape Thompson Seedless (Sultanina) variety in the Vicuña locality (Ibacache, 2001), showed the following demand by tissues, included bunches, shoots, canes and leaves (trunks and roots excluded) (Table 28).

Table 28. *Extraction of macronutrients in Chile (*).*

Kg/ha	N	P_2O_5	K_2O	CaO	MgO
Tissues (**)	99,6 (**)	23,9 (**)	99,8 (**)	85,7 (**)	24,0 (**)

Source: *adapted from Ibacache, 2001.*

***Note:** (*) Table grape crop in full production (1950 exportable boxes/ha).*

(*) Estimated in bunches, shoots, canes and leaves (trunks and roots excluded).*

4.2.2 Micronutrientes

Boron (B) is an important micronutrient used by the table grape plant in small quantities; thus toxicity could be easily produced. Since B is related to flowering, it is directly related to the percent of fruit set, which is an essential factor to guarantee production. Irrigation water with less than 0.5 ppm provides enough B to the crop; higher levels could be toxic.

Zinc (Zn) is a low soil mobility element; thus, roots must explore the soil in search for an appropriate absorption. Therefore, any factor that affects the roots´ growth, such as lack or excess of water, mechanical damages, plagues and root diseases, could accelerate the appearance of zinc deficiency. Zinc deficiency is a problem which usually is not easy to correct in grapevine. Treatments to be used depend on the particular soil conditions, species and period of the year. However, it is generally preferable to spray zinc directly to the plant aerial part. The mostly used procedure is to spray zinc foliar compounds dissolved in water (Razeto, 1986).

Since several soil conditions predispose Zn deficiency and, at the same time, affect Mn absorption; it is common that deficiencies of both elements appear simultaneously. In this case, it is advisable to solve both problems jointly. For this reason, a foliar spray could be tried in the spring with lower doses of a mixture of both elements, and using foliar compound fertilizers (Razeto, 1986).

Chloride (Cl) affects directly grape production by diminishing the leaves´ photosynthetic capacity, and fruit size.

The next figure shows the micronutrients demand in relation to phenological stages on table grape in Chile (Ibacache, 2001)

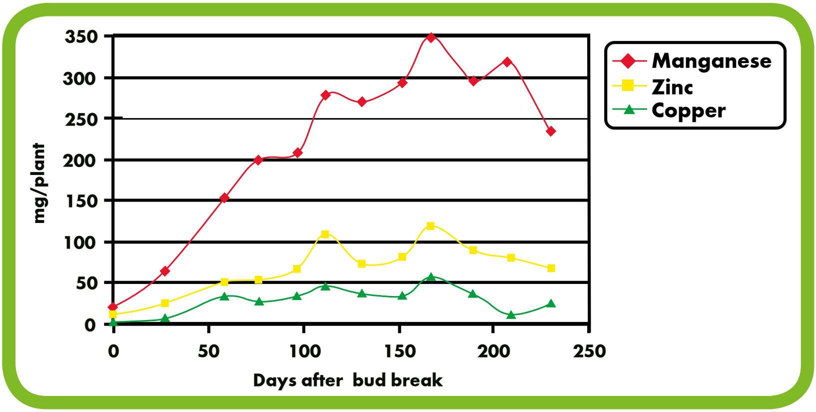


Figure 81. *Mn, Zn and Cu micronutrient curves in Thompson Seedless variety, in Chile.*

In the winter, the root activity is scarce as well as the nutritional requirements; then, it is not advisable to apply fertilizers, since the assimilation will be very low, as well as the risk of high lixiviation losses resulting from rains. The low nutrients´ requirement is covered by the plant reserves and by the fertilization remnants existing in the soil exchange complex. Therefore, post harvest fertilization has a very important role for restoring these nutritional elements.

4.3 Duration of Phenological Stages

The number of days required to complete phenological stages differs according to countries, as described in Chapter 2. The time period between each fertilization application in phases IV and I of the following season, depends on the length of the post harvest stage. In India, phase V correspond to the period from flowering (April) to pruning (October) (Table 29).

Table 29. *Number of days corresponding to phenological stages in different countries.*

Growth stages		Spain	Chile	S. Africa	India
		days			
I	Bud break to flowering	45	52	45	40
II	Flowering to veraison	75	55	37	40
III	Veraison to harvest	60	56	44	50
IV	Harvest to end leaf fall	65	70	195	60
V	Dormancy to bud break	120	120-150	44	
	April to October pruning				170

Source: *Holwerda, H. 2004.*

Nutrients´ extraction and demand to produce 25 ton/ha of table grape for the export market in South Africa The following number of days per stage would be required, as shown in Table 30.

Table 30. *Macronutrients demand for Thompson Seedless table grape in South Africa for a yield of 25 ton/ha.*

Phenological Stage	Days Nº	N	P	K	Ca	Mg
		(kg / ha / day)				
Bud break initiation - Flowering initiation	40	0.25	0.05	0.30	0.10	0.05
Full flowering	20	0.45	0.20	0.45	0.45	0.10
Fruit set - Veraison	60	0.60	0.15	0.75	0.40	0.10
Veraison - Initial Harvest	25	0.25	0.01	0.25	0.10	0.05
Harvest	20	< 0.10	< 0.01	< 0.15	< 0.01	< 0.05
Early Post Harvest	45	0.75	0.08	0.25	0.20	0.07
Senescence initiation - Leaf fall	30	<0.10	<0.01	<0.01	<0.01	<0.01
Total Season	**240**	**95.0**	**19.0**	**86.5**	**48.5**	**15.4**

Source: *Adapted from Conradie (2002), cited by Mendoza (2003); cited by Palma (2003).*

4.4 Nutrient Distribution According to Phenological Stages

The next table indicates the nutrient distribution (percent) according to phenological stages of table grape.

Table 31. *Percent distribution of elements according to phenological stages.*

Nutrient	Phase I %	Phase II %	Phase III %	Phase IV %	Need to Aplied
Nitrogen	40	20	0-10	30-50	Rapid growth
Potassium	20	40	20	20	Fruit growth
Magnesium	30	40	Foliar	30	Continue
Calcium	40	30	Foliar	30	Continue(Pre flowering)
Boron	50	50			Fruit set

Source: *Bull, 2003; Neukirchen, 2003.*

4.5 Tissues to be Sampled for Foliar Analyses

Analyses should be made in two well defined times: Flowering and Veraison.

4.5.1 Flowering

Samples for foliar analyses during flowering should be taken from the leaf or petiole located opposite to the bunch.

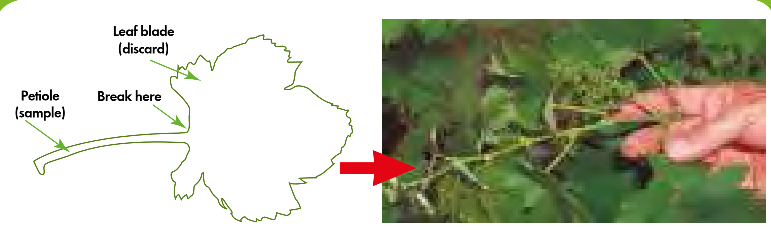


Figure 82. *Leaf opposite to the bunch at flowering (Razeto, 2004; Fertilizers for Wine Grapes B.H. Goldspink; J. Campbell-Clause; N. Lantzke; C. Gordon; N. Cross Editor: B.H. Goldspink, 1998. Agriculture Western Australia; YARA, Plantmaster of table grape, 2004).*

Standardized charts are available for sampling at each phenological stage. Table 32 shows the analyses interpretation from foliar samples obtained at **flowering**.

Table 32. *Interpretation of leaf petiole analysis, at flowering.*

Nutrient (element)		Interpretation			
		Deficient	Low	Normal	High/Excessive
N Total	%	<0.7	0.7-0.89	0.9-1.2	> 1.2
N - Nitríco	ppm	< 600		600-1500	>1500-2500
P	%	0.15-0.19	0.20-0.29	0.30-0.49	>0.4
K (with adequate N)	%	<0.79	0.80-1.29	1.3-3.0	>3.0
Ca	%	<1.0		1.0-2.5	
Mg	%			>0.4	
Na	%				>0.5
Cl	%				>1.0-1.5
Cu	ppm	< 3.0	3.0-6.0	>6	
Fe	ppm			>30	
Zn	ppm	<15	15-25	>25	
Mn	ppm			25-500	>500
B	ppm	<25	25-30	30-70	>70-100

Source: *Cited by Palma, 2003.*

1. Fertilizers for Wine Grapes (1998) Authors: B.H. Goldspink; J. Campbell-Clause; N. Lantzke; C. Gordon; N. Cross Editor: B.H. Goldspink Agriculture Western Australia

2. Leaf Analysis for Fruit Crop Nutrition (1997), Author: R.A. Cline, B. McNeillFact-Sheet, Order Not. 91-012, Ontario.

3. Fertilizing Fruit Crops (1996) Author: Hanson, E. Horticultural Extension Bulletin, MSUE Bulletin E-852.

4. Failla et al. (1993): Determination of leaf standards for apple trees and grapevines in northern Italy; Optimization of Plant Nutrition; Ed.: Fragoso, M.A.C. Pages: 37-41.

5. Razeto, B. (2004). Internal training SQMC, Santiago, Chile.

4.5.2 Veraison

Tissue: Leaf or recently mature blades, in the summer (Veraison).

Figure 83. *Mature leaf, during the summer (a y b) (Silva, 2004; Soza, 2004).*

The next table shows analysis Interpretation at **veraison**.

Table 33. *Analysis interpretation of the leaf petiole, at veraison in table grape.*

	Deficient	Low	Normal	High	Excessive
N (%)	<1.6	1.6 - 1.9	1.9 - 2.5	2.5 - 3.2	>3.2
P (%)	<0.13	0.13 - 0.16	0.16 - 0.35	>0.40	
K (%)	<0.7	0.7 - 0.9	1.0 - 1.8	>1.8	
Ca (%)		<1.8	1.8 - 3.5	>3.5	
Mg (%)	<0.22	0.22 - 0.25	0.25 - 0.5	>0.6	
Fe (ppm)	<40	40 - 60	60 - 250	>250	
Mn (ppm)	<20	20 - 30	30 - 250	>300	
Zn (ppm)	<18	18 - 28	28 - 150	>150	
Cu (ppm)	<3.5	4 - 5	5 - 20	>20	
B (ppm)	<15	16 - 25	30 - 80		>200
Na (%)					>0.3
Cl^- (%)					>0.6

Source: *Razeto, 2004.*

4.5.3 Berry Maturity

Nutritional levels in the leaf petiole at berry's maturation, have recently been determined (Table 34).

Table 34. *Standard nutritional levels in petiolar tissue, at berry maturation.*

Peciolar Analysis Sample taken during Berry maturity (% Dry matter)	Observation
N > 6%	N Normal Nutrition
P > 1.5%	P Normal Nutrition
K/Mg <1	K Deficiency
K/Mg >10	Mg Deficiency
K/Mg 2 -10	K and Mg Normal Nutrition
B < 15 ppm	B Deficiency

Source: *Delas, 1990 cited in IFA (2003) by Palma (2003).*

5 Visual Nutritional Deficiencies and Unbalances: Excesses or Toxicities

A visual description of nutrient deficiencies and excess unbalances is a useful tool to determine the cause of such unbalances. It is recommended to obtain a confirmation and better understanding of the symptoms´ nature via plant, soil or water analyses performed by a qualified laboratory. For example, a visual deficiency unbalance of a certain nutrient should be caused by an excess or unbalance regarding another nutrient (antagonism).

5.1 Deficiencies

5.1.1 Nitrogen Deficiency

- Pink to reddish shoots and petioles show. Leaves turn yellowish, smaller and thinner than normal.

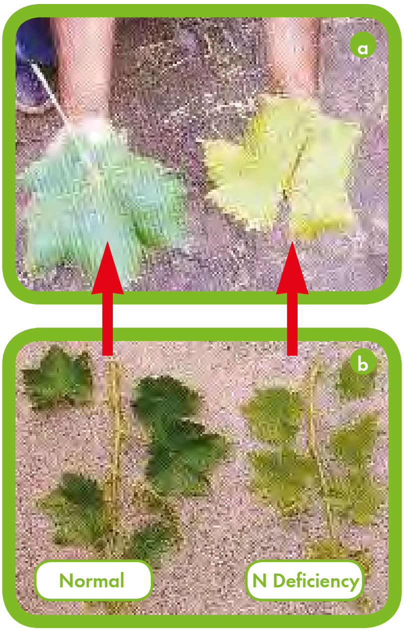


Figure 84. *Nitrogen deficiency is characterized by yellow and less developed leaves (right side of both pictures a and b). These are compared to normal, greener and larger than leaves (left, in both pictures a and b) (Razeto, 1993).*

5.1.2 Phosphorous Deficiency

- Reduced growth, dark green leaves, often with some light brown to purple brown injuries on the leaves borders, beginning in the margin. Leaves return hard and compressed.

- Some growing seasons characterized by cold springs, are associated to the appearance of a reddish pigmentation on the berries, atypical to the variety, affecting notoriously to white varieties such as Thompson seedless. The fruit matures prematurely.

- Phosphorus (applied foliar or fertigation trought Ultrasol™ fertilizer, monopotasic phosphate (MKP), will generate the development of well expanded leaves which help to protected them against sun burning (Sonata variety).

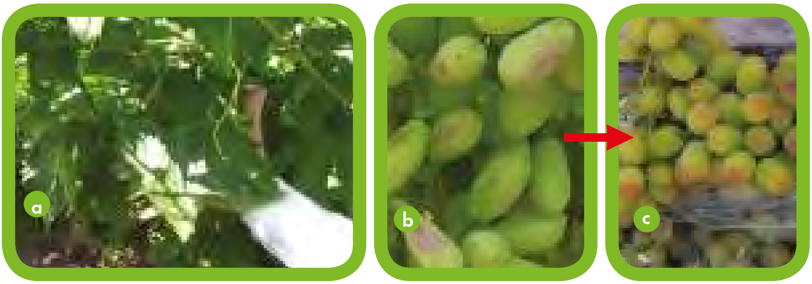


Figure 85. *Phosphorous deficiencies on leaves (a) and on bunches, promote red pigmentation which is abnormal in Thompson Seedless variety (b and c) (Holwerda, 2004; Palma, (2004).*

5.1.3 Potassium Deficiency

- Spring Symptoms: Distorted, ruffled blades with sporadically necrosis distributed marginal and interveinal necrosis.

- Summer Symptoms: Shining spots between main veins, yellow spots gradually turn yellowish brown and lilac brown.

- Late Summer and Autumn Symptoms: Black leaves symptom is observed at the end of summer on leaves exposed to direct sunlight.

Figures 86. *Symptoms of K deficiencies on Sultanina variety in Spring (a); plants developed in greenhouse with a potassium nutrient deficient solution (b); and leaves with symptoms (c) (Razeto, 1993; Ruiz, 2001).*

5.1.4 Calcium Deficiency

- Necrosis advances toward the leaf center, and dark brown pimples appear on the shoot bark.
- Fruit splitting (lack of both Ca and K).

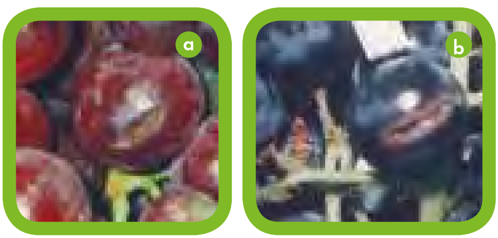


Figure 87. *Calcium deficiency showing cracks on the berries´ skin (a). Later on, these cracks turn bleached due to the effect of a slow release from the sulfur anhydrous generator to control botrytis, on packed grapes (latent infection) (b), (Palma, 2003).*

5.1.5 Magnesium Deficiency

- Symptoms of concentrated yellow areas in old leaves (or reddish on red varieties), at the end of the season.
- Green margins and interveinal chlorosis.
- Bunch stems necrosis (BSN), which corresponds to a rachis necrosis and later on, a lack of berries´ maturation, which at the end becomes crystalline.

Figure 88. *Magnesium deficiencies affecting leaves (a and c), rachis and bunches according description in picture (b) and text. (Palma, 2004; Razeto, 1993).*

5.1.6 Magnesium + Calcium Deficiency

- Acidity damage associated with Mg and Ca deficiencies.
- Margins of older leaves become yellowish to light brown, and dry.
- Early stage of "bunch stem necrosis" (BSN) for deficiency of early Mg and later Ca, with shallow and concave desiccation of cortex on main axis of rachis.

5.1.7 Iron Deficiency

- Leafless shoots with small, folded, bleached leaves and reddish base, and relatively large tendrils.
- Lime induced chlorosis, with yellowing of the leaf blade tissue between green veins.

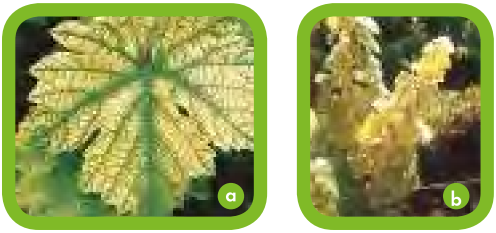


Figure 89. *Iron deficiencies (a), and grape shoots with iron chlorosis (b) (Ensenat, 2001; Razeto, 1993).*

- Rootstock are highly dependent on iron, and show an early deficiency in the field.

Figure 90. *Rootstock are very susceptible to iron deficiencies (a and b), (Courtesy of Yara specialties through Neukirchen, 2003).*

5.1.8 Zinc Deficiency

- Small leaf with sharp teeth, lightly protruding veins, asymmetric blade.
- Loose cluster of seeded berries, varying in size.

Figure 91. *Zinc deficiencies with asymmetric and inter-vein chlorotic leaves (a) and open petiolar bosom due to undeveloped basal lobules (b) (Ensenat, 2001; Razeto, 1993).*

- Bunch shattering is indirectly produced, since fruit seting is affected. Also, there is a direct influence by hormonal effect and other processes failures (synthesis of enzymes and proteins).

Figure 92. *Zinc deficiencies resulting in bunch shattering (Ensenat, 2001).*

5.1.9 Manganese Deficiency

- Mosaic - like disposed yellow area bounded by fine veins in interveinal areas.

Figure 93. *Manganese deficiency in leaves (a and b),(Ensenat, 2001).*

5.1.10 Boron Deficiency

- Interveinal chlorosis and leaf necrosis.
- Necrotic shoot tip, interveinal chlorosis, internode swelling.
- Coralloid deformed roots (coral type) and necrotic apexes.
- Bunches with one seeded berry and many small seedless berries (hen and chiken) of equal round (in stead of elongated) size.
- New shoots bearing short, zigzaging internodes.
- Apex dries off prematurely.
- Emission of lateral shoots.

Figure 94. *Boron deficiencies affecting shoots (a and b), and producing bunch shattering (c and d) (Cadahia, 2003; Callejas, 2003; Razeto, 1993).*

5.2 Toxicities

5.2.1 Boron Toxicity

- Intervenal chlorosis, accompanied by necrosis along the whole border of the leaf.
- Leaves still growing are curved up or down, because they stop growing on the borders, but not in the interior.
- Symptoms are similar to those that cause chloride toxicity.

Figure 95. *Boron toxicity (a, b and c) (Razeto, 1993; Palma, 2004).*

5.2.2 Chloride Toxicity

- Symptoms show scalding on the leaf border.
- Beginning of apical necrosis coincides with each irrigation.
- This symptom can also be mistakenly taken as a potassium deficiency and nutrient toxicity caused by B and N.
- Chloride toxicity often appears associated with high sodium (Na) levels. These high levels could come with the irrigation water (more than 4 meq/l chlorine level).

Figure 96. *Vinegrape leaves affected by chloride and boron toxicity, simultaneously (Razeto, 1993).*

5.2.3 Nitrogen Toxicity – Excess

- An excess of N produce a very vigorous vineyard (ambushed), with fertility bud problems, susceptibility to fungous diseases such as Botrytis affecting shoots and bunches, and insect attack by thrips and greenflies.
- Lack of luminosity and aeration produce low fruit yield, quality and condition.

Figure 97. *Vinegrape leaves severely affected by excessive nitrogen fertilizer application to the soil (Razeto, 1993).*

5.3 Damage Caused by non Traditional Factors

5.3.1 Stress Factors: Frost, Heat or Excess of Sun Light

- Shoot apex damage affecting growth immediately. The leaf is affected when is exposed to stress situations such as frost, heat (water deficit) or excess of sun light.
- Prevention: use of protecting frost equipment, which also help to homogenize vineyard sprouting.

Figure 98. *Sun light excess in the Peruvian desert (a), and vineyard leaves affected by excessive heat and soil water deficit (b), (Razeto, 1993; Soza, 2005).*

5.3.2 Strong Winds, Mainly at the Grapevine Establishment Stage

- Deformed leaves with irregular borders caused by strong winds.
- Young plants are particularly vulnerable when they are not protected by windbreak curtains (recently planted orchards).

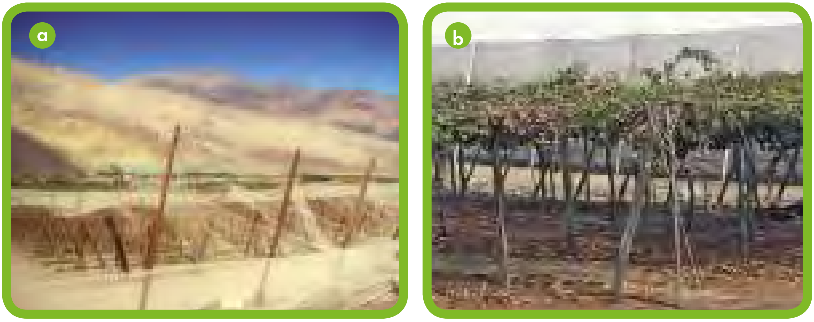


Figure 99. *Use of wind protecting nets during vineyard establishment, in Copiapo Valley, Chile (a), and in the Trujillo Desert, Peru (b), (Palma, 2004; Soza, 2005).*

5.3.3 Herbicide Use

- The use of hormonal - type herbicides, such as 2,4 D, produce leaf rolling and deformation, but usually without chlorosis, eventhough with fine punctuations in the shoots.

Figure 100. *Leaf damage caused by herbicides type 2,4 D application (Source: Bull, 2003).*

5.3.4 Fungus and Virus Diseases

- The vinegrape leaf chlorotic rolling produces similar symptoms to those from boron deficiency or toxicity (Figure 101 a).

- Among the virosis, the mosaic Grape Fan Leaf Nepovirus (GFLV), or nepovirus of the fan vineyard leaf, showing similar symptoms as those caused by magnesium, manganese or iron deficiencies (Figure 101b).

- Light brown to purple brown injuries on the leaves (c).

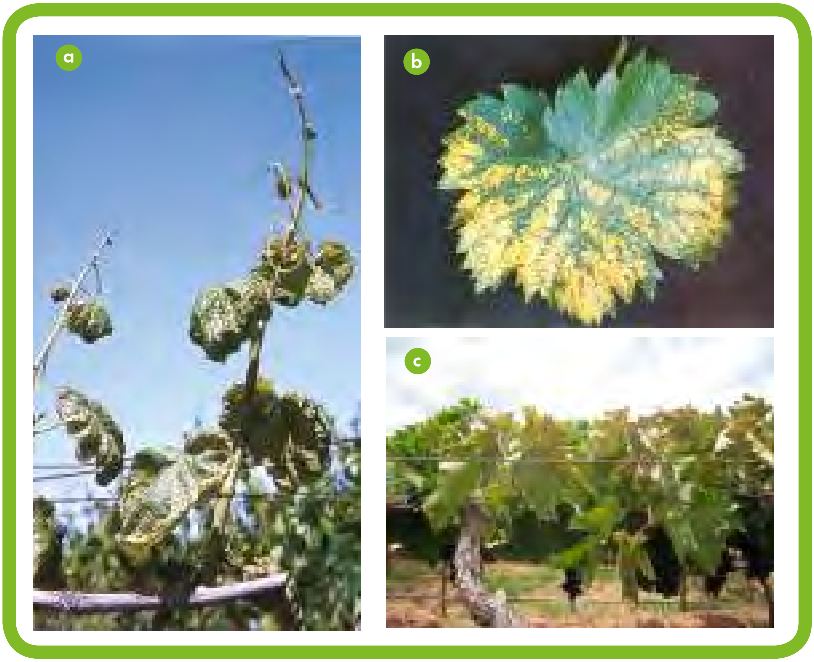


Figure 101. *Chlorotic leaf rolling in grapevine Sultanina variety (a), mosaic symptoms (b), light brown to purple brown injuries on the leaves (Razeto, 1993; Palma, 2007).*

6 Specialty Plant Nutrition (SPN) Product Characterist Regarding Imbalance Rectification

Balanced nutrition helps to prevent nutritional problems and to increase yield and quality in the table grape crop.

This Chapter describes which fertilizer products are available and why certain fertilizers products are better than others for correcting nutritional unbalances, by meeting the needs of the plant during its growth and development.

6.1 Selection of SPN Products

There are several possibilities in selecting fertilizers (SPN) for drip irrigation. Plant nutrition programmes recommended in Chapter 7 consider the following three alternatives:

a) Use of the Ultrasol™ line products in fertigation:

- Potassium Sulfate (**Ultrasol™ SOP 52**) (a).
- Potassium Nitrate (**Ultrasol™ K**) (b).
- Potassium Nitrate and specialty soluble mixtures for fertigation on NPK request (based in KNO_3), known as requested **Ultrasol™** or **Ultrasol™ Special** (c).
- Calcium Nitrate (**Ultrasol™ Calcium**) (d).
- Phosphate Urea (**Ultrasol™ Magnum P44**).

Figure 102. *Line of Ultrasol™ products (a, b, c and d).*

b) **Soil applications of granular NPKSCaMg product help increasing fruit yield and quality.**

- Bulk Blend granular mixtures (c) (**SQM Qrop™ mix** + Yara´s Tropicote): mainly used, when, due to stress situations, it is not possible to apply soluble fertilizers by technical irrigation system (presence of waterlogging) (b).

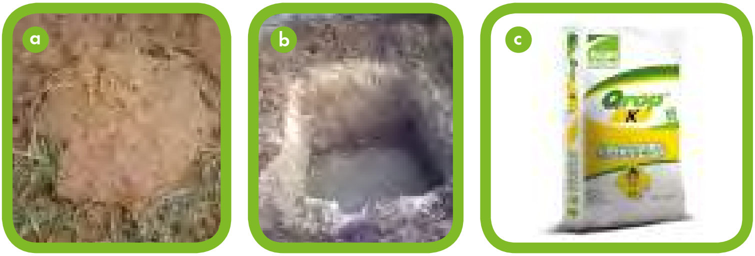


Figure 103. *Granular fertilizers for side dressing (a), especially when the orchard conditions does not allow the use technical irrigation systems for soluble NPK´s product applications (Ultrasol™); (b) under "water logging".*

c) **Crystallized foliar products applications or liquids way such as foliar Speedfol™ line** which, aside of nutrients, contain amino acids; thus, profitability based on yield and fruit quality increase would be guaranteed to the producer.

Figure 104. *Solid crystallized fertilizers or liquids way , corresponding to the **Ultrasol™** and **Speedfol™** lines, respectively. See descriptions in a, b, c and d photographs (SQMC, 2004. **Speedfol™** Project, internal information).*

The selection will depend on:

- Economy (costs/profits).
- Availability of products in the market.
- Knowledge about advantages and disadvantages of the product and its uses (consult with advisors, farmers and distributors).

6.2 Specialty Plant Nutrition per Nutrient

6.2.1 Nitrogen

Nitrogen is the basic component of chlorophyll structure and proteins, which are enzymes that catalyze and control all metabolic processes inside the plants. Nitrogen is essential to promote high yield and, at the same time, maintains plant healthy during the vegetative period.

However, a nitrogen excess or deficiency can drastically reduce yield and quality. To obtain high yields, with good quality, firstly a rapid plant development with a considerable foliar area is necessary to capture and use solar energy. Later on, N is necessary for the fruit growth. Excess of N is not desirable, since it allows expanding the vegetative period, interfering with the photosyntates accumulation in the harvested product, which is the fruit.

Nitrogen as nitrate is the preferred source of N

There are 3 main nitrogen sources:

- Urea, ammonium and nitrates.

6.2.1.1 Urea

Urea cannot be used directly by the plants. However, once applied to the soil, it will be quickly hydrolized to ammonium. Before or during this hydrolysis, N losses can occur as urea leaching or as ammonium volatilization.

6.2.1.2 Ammonium

Ammonium is easily fixed in the soil particles. This process, consequently, immobilizes N in the soil, thus restricting it's availability to the plant. Most of ammonium is transformed to Nitrate, and becomes available. Prior to this nitrification process, a significant amount of ammonium can be lost under high pH soil condition.

The conversion from urea and ammonium into nitrate can last from one to several weeks, depending on the pH, humidity, temperature and the presence of certain nitrifying bacteria (nitrosomes and nitrobacter). This can imply a fall in the N availability, resulting from a lack of precision in the N handling (Buckman and Brady, 1977).

An excess of ammonium and high temperature conditions in the rhizosphere, can deteriorate the root system as a result from of an oxygen drop due to the nitrification process.

The use of ammonium can induce a plant nutrition unbalance. Ammonium competes with the absorption of other main cations (antagonism), such as potassium, magnesium and calcium which avoids the appearances of nutritional disorders such as cracking, and diseases like fusariosis and botrytis. Ammonium absorption reduces the accumulation of carbohydrates.

6.2.1.3 Nitrate

In contrast, nitrate (NO_3-) applied to the soil can be directly absorbed by the plant. This doesn't require to be previously transformed, since it is soluble in the soil solution, taking easily contact with the roots. Partial applications of nitric fertilizers allow a precise handling of the N availability and contribution for the fruit tree. Nitrate does not volatilize, which means that it does not suffer N loss in the form of the ammonium emission. Being an anion, Nitrate promotes the availability of other cations (K+, Ca+2, Mg+2 and NH4+), given their synergism among them. The nitrate conversion into amino acids takes place in the leaf. Since solar energy is used for this conversion, the process is highly energy efficient. The NH4+ conversion takes place mainly in the roots. The plants burn the sugar during this conversion. This means that few sugars are available for the fruit growth and development. It is necessary to point out that nitrification can be inhibited by poor aeration, low pH, low T°, low presence of nitrifying bacteria's, and low soil organic matter percent (Figure 105).

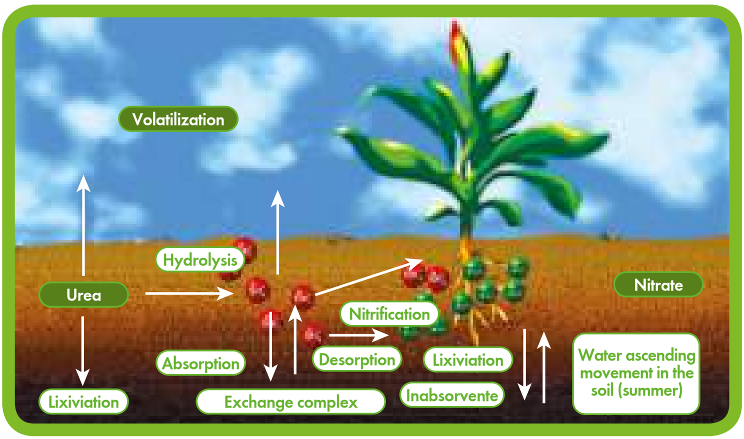


Figure 105. *Outline of the production of different available N sources to the plant.*

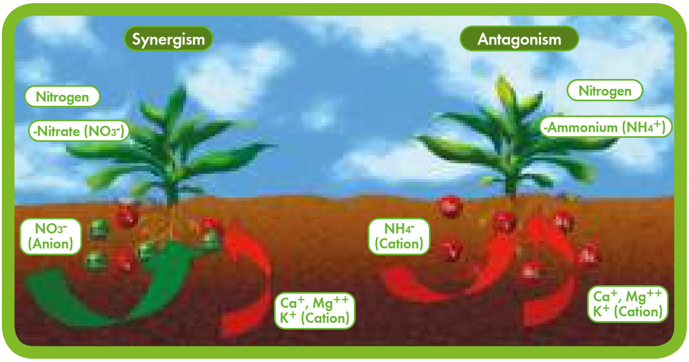


Figure 106. *Antagonism and synergism generated in the ions´ absorption by the plant in the rooting zone.*

Fertilizers that contain nitrate as N source will have an effect in the soil pH.

- Increase the soil pH (Potassium Sodium Nitrate in Brazil) (Figure 107).

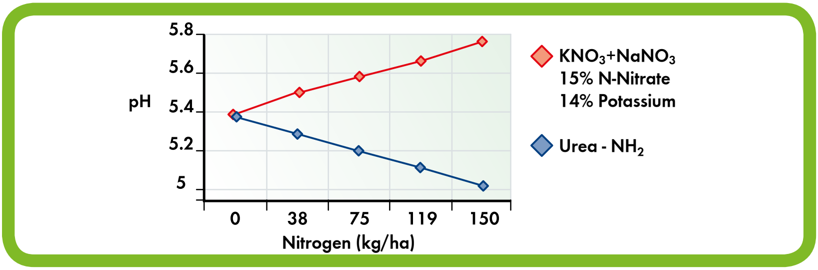


Figure 107. *Soil pH increment when using nitric N source (Goto, W. 2003).*

Figure 108. *Soil pH effect around the rhyzosphere when using certain nitrogen fertilizers. The plant presents a rosy color (left side) showing a neutral pH near to 7.0 (calcium nitrate use). In the right side the plant has a yellow color with an acid pH near 4.0 (ammonium sulfate use) (Vega, 2003).*

The Nitrogen source is important when volatilization occurs. Yara´s technical department provides a test for this process. A change from yellow to blue color (Petri dish) shows a positive reaction, originated by Urea (volatilization process) (Figure 109).

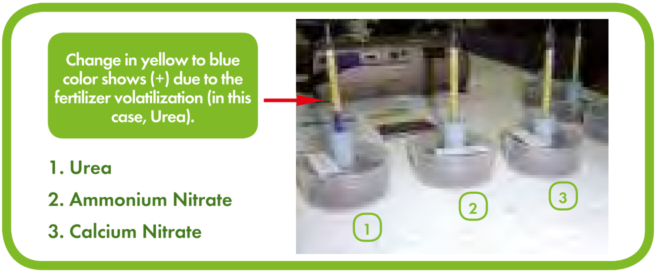


Figure 109. *Ammonification Test (Yara, 2004. Internal training, Yara/SQM).*

The nitric sources improve plant quality and condition:

- Ammonium absorption reduces the carbohydrate accumulation.
- Nitrate diminishes chloride absorption.
- Nitrate increases cation absorption (K+, Ca++ and Mg++) which avoid nutritional disorder appearance such as bunch stem necrosis (watery berries), berry cracking, and diseases suchas oidium and Botrytis.

6.2.1.4 NO_3^- Versus $SO_4^=$ and Cl^- on Table Grape

Ca absorption is positively influenced by No_3- concentration in the rhyzosphere. With $SO_4^=$ and, especially Cl^- increments, there is a loss in fruit size , while salinity increases independent from its pH. A Ca deficiency in the cellular wall originates an increment in rotting caused by Botrytis cinerea (grey mold) and lack of post harvest fruit condition. This is due to the increase of physiologic disorders, such as internal brownish coloration and senescence, as a result of anticipated maturation.

6.2.2 Potassium

Potassium Nitrate (KNO_3): Ideal potassium fertilizer for all phenological stages. Also provides part of the plant nitrate demand. It presents a high solubility of 320 g/l at 20 °C.
Potassium Sulfate (K_2SO_4): Its use should be limited to the supply of total sulfur requirements. Ideal fertilizer for the final growth stage, when N is not required (excess vigor). This product has a limited solubility in the field, near 6% (when mixed with other fertilizers).
Potassium Bicarbonate ($KHCO_3$): Mainly used as a pH corrector to increase the pH.
Potassium Chloride (KCl): Increases salinity in the rhyzosphere. Competes in the root absorption sites with other ions (NO_3^-, $H_2PO_4^=$, $SO_4^=$), resulting in nutritional unbalances.

6.2.3 Calcium

Calcium Nitrate: Is the largest used calcium source. **Solid Calcium Nitrate** $(5(Ca(NO_3)_2)NH_4NO_3)$ contains enough ammonium for pH control in hydroponic production. **Liquid Calcium Nitrate** $(Ca(NO_3)_2)$ is free of ammonium, and can be used when ammonium is not recommended.

Calcium Chloride ($CaCl_2$): Similar effect as explained previously for KCl.

6.3 Summary of Most Used SPN Soluble Products for High Tech Irrigation

The next table summarizes the most used SPN soluble products for high tech irrigation and possible restrictions for fertigation.

6.3.1 NPK Crystallized Solid Fertilizers

In the world's fertilizer commercialization, there is specialty fertilizers for fertigation, such as "Ultrasol™ products" - technical degree - produced in SQM industrial plants.

Table 35. *Macronutrients contributed by crystallized solid fertilizers of the SQM "Ultrasol™" of the standard soluble line.*

Ultrasol™ Product	N %	P_2O_5 %	K_2O %	S %	MgO %	CaO %	Chemical Properties		
							pH 1 g/l at 20 °C	E.C. (mmhos/cms)	Solubility (15° C)
Initial	15	30	15	1	1		4,84	1,28	420
Development	18	6	18	8	2		5,02	1,47	619
Growth	25	10	10	1	1		5,03	1,45	546
Production	13	6	40				5,15	1,33	345
Multipurpose	18	18	18	1	1		4,91	1,27	467
Fruit or KS		9	47	5			6,16	1,37	319
Veraison	5	48	16			5,10	1,43	137	
Post-harvest	13	13	36				4,87	1,25	363
Quality	15		18			15	5,33	1,13	262
SOP 52			52	18			4,5	1,54	70*
Magnum P44	18	44					1,8	1,51	960

NOTA: *At 20 °C.

Source: *SQMC, Libro azul, 2002.*

6.3.2. Raw Materials

6.3.2.1 Macronutrients

The next table shows the main characteristics of soluble raw materials - agricultural grade –commonly used in fertigation.

Table 36. *Characteristic of main products used in fertigation.*

	Nutrients (%)														Chemicals Property				
	Nitrogen (N)	Phosphor (P_2O_5)	Potassium (K_2O)	Sulphur (S)	Magnesium (Mg)	Calcium (Ca)	Sodium (Na)	Iron (Fe)	Molybdenum (Mo)	Chloride (Cl)	Boron (B)	Zinc (Zn)	Copper (Cu)	Manganese (Mn)	pH (Solution 1 g/l)	Conductivity at 1 g/l	Solubility in g/l (20 °C)	Acidity (A) or Basicity (B)	Salinity ($NaNO_3$=100%)
Nitrogenous Fertilizers																			
Ammonium Sulphate	33,0			0,1											5,5	1,6	1877	59 A	105,0
Nitric Acid (54-59%)	12-13																	26 A	
Amonium Sulphate	21,0			22,0											5,5	2,1	754	110 A	69,0
Phosphatic Fertilizers																			
Mono Ammonium Phosphate (MAP)	12,0	61,0		0,3											4,9	0,8	400	65 A	34,2
Mono Potassium Phosphate (MKP)		52,0	34,0	0,2											4,5	0,75	230	Neutral	8,4
Di Ammonium Phosphate (DAP)	18,0	46,0													4,1	0,9	686		24,0
Phosphoric Acid (85%)		61,0		2,0											3,1	1,8			
Urea Phosphate	18,0	44,0													2,7	1,5	620		
Potassic Fertilizers																			
Potassium Nitrate Standard Crystallized	13,5		45,0												8-10	1,3	335	26 B	73,6
Potassium Nitrate Hydroponic Grade	13,6		46,3												8-10	1,3	335	26 B	73,6
Potassium Sulphate Crystallized			50,0	18,0											7,1	1,4	148	Neutral	46,1
Potassium Chloride Standard			60,0							47,0					5,6	1,7	360		
Fertilizers with Ca and Mg																			
Calcium Nitrate	15,5					26,5									6,5	1,2	1294	20 B	52,5
Magnesium Calcium Nitrate CALMAG	13,5				6,0	17,0									5,4	1,08	1418		
Magnesium Nitrate	11,5				16,0	1,0									6,0	0,5	701		60,0
Magnesium Sulphate Anhydrous				26,0	32,0										5,7	1,28	437		
Magnesium Sulphate Heptahydrate				13,0	16,0										4,0	0,73	700		

Source: *Adapted from Cadahia, 1998; Domínguez, 1996 and SQMC, Agenda del Salitre, 2001.*

6.3.2.2 Micronutrients

Normally used microelements in fertilization programmes are described in Tables 37 and 38.

Table 37. *Micronutrients provided by inorganic salt fertilizers or through chelates.*

Ultrasol™ Product	S %	Fe %	Cl %	B %	Zn %	Cu %	Mn %	Mo %	Solubility 1 g/l 20 °C
Boris Acid				17					
Borax				11					
Copper Sulfate Monohydrated						35			
Copper Sulfate Pentahydrated						25			200
Cu EDTA						13			
Cu HEDTA						9			
Poliflavonoids						6			
Amonnium Molibdate								54	
Sodio Molibdate								39	
Iron Sulfate		36							260
Fe EDTA		13							
Fe HEDTA		8							
Fe EDDHA		6							
Fe EDDHMA		6							
Fe DTPA		6 - 10							
Fe Organics		8							
Zinc Sulfate Monohydrated					35				
Zinc Sulphate Heptahydrate					23				750
Zn EDTA					6 -14				
Zn NTA					13				
Zn HEDTA					9				
Zn Organics					8				
Manganese Sulfate Monohydrated							32		900
Mn EDTA							9-15		
Mn Organics							7		

Source: *Adapted from Cadahia, 2002; Domínguez, 1996 and SQMC, Agenda del Salitre, 2001.*

Table 38. *List of Ultrasol™ Micro Rexene® products used in soil, and fertigation applications.*

Chemical Formula	Chelating Agent	% p/p Typical Metal Content	Physical Form	EC in mS/cm at 1 g/l	Most Common Applications	Remarks
Iron Chelates (Fe)						
Ultrasol™ Micro Rexene® FeM48	EDDHMA	6.5	micro-granular	0.6	S/H	Premium Products
Ultrasol™ Micro Rexene® FeM35	EDDHMA	6.5	micro-granular	0.6	S/H	Standard and High Grades
Ultrasol™ Micro Rexene® FeQ48	EDDHA	6.0	micro-granular	0.6	S/H	Basic Grade
Ultrasol™ Micro Rexene® FeQ40	EDDHA	6.0	micro-granular	0.6	S/H	Standard and High Grades
Ultrasol™ Micro Rexene® FeQ15	EDDHA	7.0	micro-granular	0.6	S	Basic Grade
Ultrasol™ Micro Rexene® FeD6	DTPA	6.1	liquid	0.2	H/F/S	Highly Concentrated Liquid
Ultrasol™ Micro Rexene® FeD12	DTPA	11.6	crystals	0.4	H/F/S	Dry, pure version
Ultrasol™ Micro Rexene® FeD3	DTPA	3.1	liquid	0.3	S/H	Basic Grade
Ultrasol™ Micro Rexene® FeD7	DTPA	6.9	micro-granular	0.7	S/H	Basic Grade
Ultrasol™ Micro Rexene® FeH4,5	HEDTA	4.5	liquid	0.3	S	Broadacre Crops
Ultrasol™ Micro Rexene® FeH13	HEDTA	12.8	micro-granular	0.3	S	Dry, pure version
Ultrasol™ Micro Rexene® FeH9	HEDTA	9.0	micro-granular	0.6	S	Basic Grade
Ultrasol™ Micro Rexene® FeH8	EDTA	7.7	liquid	0.3	F/S	10% w/v liquid; for tankmixes
Ultrasol™ Micro Rexene® FeE13	EDTA	13.3	crystals	0.2	S/F	Versatile Iron Product
Ultrasol™ Micro Rexene® FeE6	EDTA	6.1	liquid	0.3	F/S	Potassium Based
Manganese chelates (Mn)						
Ultrasol™ Micro Rexene® Mn6	EDTA	6.2	liquid	0.2	F/H	Highly Concentrated Liquid
Ultrasol™ Micro Rexene® Mn13	EDTA	12.8	micro-granular	0.4	F/H	Dry, pure version
Zinc Chelates (Zn)						
Ultrasol™ Micro Rexene® Zn9	EDTA	9.0	liquid	0.3	F/H/S	Highly Concentrated Liquid
Ultrasol™ Micro Rexene® Zn15	EDTA	14.8	micro-granular	0.4	F/H/S	Dry, pure version
Copper Chelates (Cu)						
Ultrasol™ Micro Rexene® Cu9	EDTA	9.0	liquid	0.3	F/H/S	Highly Concentrated Liquid
Ultrasol™ Micro Rexene® Cu8	EDTA	8.0	liquid	0.3	F/H/S	Lipvid Form
Ultrasol™ Micro Rexene® Cu15	EDTA	14.8	micro-granular	0.4	F/H/S	Dry, pure version
Calcium Chelates (Ca)						
Ultrasol™ Rexene® Ca3	EDTA	3.1	liquid	0.1	F	Lipvid Form
Ultrasol™ Rexene® Ca10	EDTA	9.7	micro-granular	0.4	F	Dry, pure version
Magnesium chelates (Mg)						
Ultrasol™ Rexene® Mg3	EDTA	2.6	liquid	0.2	F	Lipvid Form
Ultrasol™ Rexene® Mg6	EDTA	6.2	micro-granular	0.4	F	Dry, pure version

Rexene® is a registered trade mark of Akzo Nobel Chemicals BV or one of its affiliated companies in one or more territories.

Source: *Akzo Nobel, 2005. Internal training, SQM/YARA/AKZO NOBEL, Sao Paulo, Brazil. Note: /Meanings: F= foliar; H= Hydroponic (Crops without soil) and S= Soil.*

7 Plant Nutrition Practices and Effective Programmes

In this Chapter, an effective plant nutritional programme for table grape is formulated, based on the information presented previously.

The crop specific programme will depends on a series of variables. Based on this chapter, distributor or agronimist will be able to determine which nutritional programme is the most appropriate for his area. Beside, the local **SQM** representatives can provide additional information.

An example on how to calculate the fertilizers´ recommendation for table grape is presented, considering the prospective yield and the efficiency of the irrigation system used.

The following steps should be considered by table grape producers when formulating soil fertilizer recommendations:

a) Soil and water analyses.
b) Balance the nutrients according with the soil analysis and, add strategic reserves to the soil base.
c) When organic matter or manure is applied, consider that substantial nutrient quantities could be released during the growing season. These quantities should be subtracted from the final fertilizer application.
d) Fertilizer programmes should be based on the nutrient absorption per phenological stage, in relation to the prospective yield, nutrient soil reserve, and the nutrient absorption efficiency of the irrigation system.
e) After calculating the total nutrient requirement for the prospective yield, fertilizers can be selected for each phenological stage.
f) It is advisable to analyze the soil after each cropping season during the post harvest period, and to correct the soil fertilizer doses applied in previous season.

7.1 Injection of SPN Products (Ultrasol™) for Fertigation

Figures 110 and 118 (10 cases) show the effect of fertilizer injection under field conditions in different countries, utilizing minimum elements that guarantee their application.

7.1.1 Case 1

Use of SPN products (**Ultrasol**TM) line (Chile).

- Tank A: application of phosphoric acid in tank A together with N, P, K, S and Mg.
- Tank B: only injection of Ca, to avoid products precipitation.
- Flow meter to measure the fertilizer volume applied directly into the injecting pump, which is common for all tanks (b).
- Flow control faucet.
- Injection pump.
- Filters at the tank exit.
- Interconnection of tank at the exit of each of them(*).

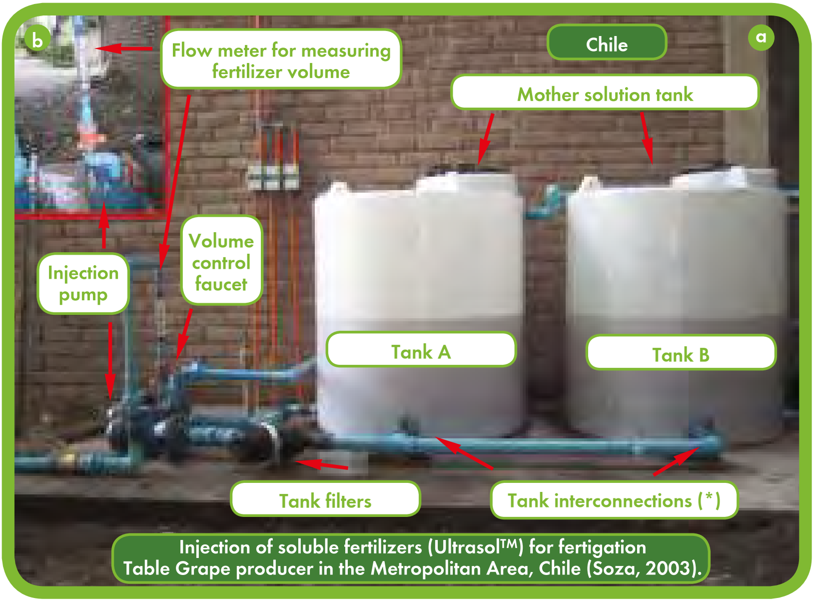


Figure 110. *Injection of soluble fertilizers (UltrasolTM) in fertigation. See details on pictures a and b. Metropolitan Area, Santiago of Chile (Courtesy of J.A. Soza, Technical Adviser, 2003).*

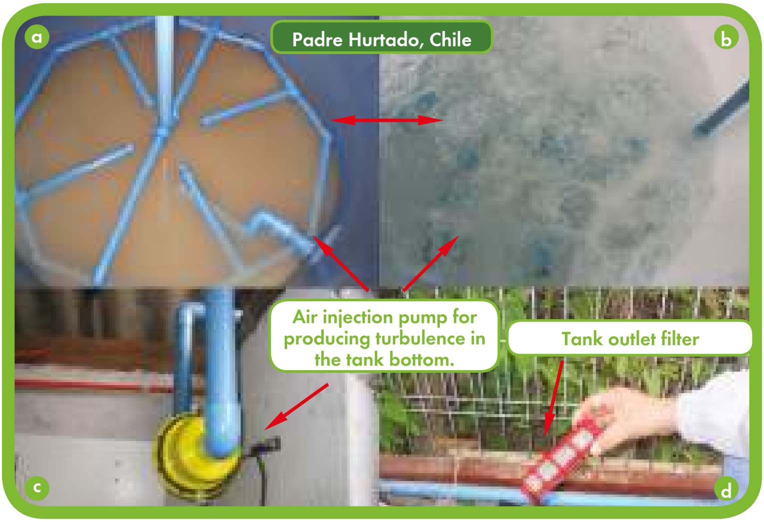
Note: (*) To avoid imcompatibity between tanks A and B to have the precaution of prepare the same levels of solution or incorporate valve of one way flow. At the exit of B tank, that include Calcium.

7.1.2 Case 2

Use of SPN products (Ultrasol^{TM}) line (Chile).

Furthermore, the following implementations in the irrigation control unit for a good injection of soluble fertilizers through fertigation (Chile) are to be considered:

- Additional small filters at the outlet of each tank (d).
- Air injection pump to produce turbulence in the tank bottom, allowing an optimum homogenization of the applied products (a, b and c).



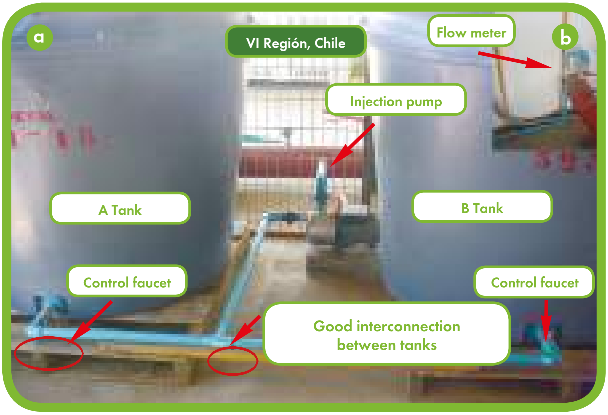
Injection of soluble fertilizers (Ultrasol^{TM}) for fertigation
Orchad "El Descanso", Metropolitan Area , Santiago of Chile (Soza, 2004; Oyarzun-Azud Chile, 2004).

Figure 111. *Injection of soluble fertilizers (Ultrasol^{TM}) for fertigation. See details in a, b, c and d. Orchad "El Descanso", Metropolitan Area , Santiago of Chile (Courtesy of J.A. Soza, Technical Adviser, 2004).*

7.1.3 Case 3

Use of **SPN** products, **Ultrasol**^{TM} line (Chile).

- Application of phosphoric acid in the tank, together with N, P, K, S and Mg.
- Tank B: Ca injection only, to avoid the product precipitation.
- Direct flow meter to the irrigation line to measure the fertilizer volume (b).
- Volume control faucet for the fertilizer injection.
- Injection pumps with their respective control faucets.
- Tanks interconnection at the outlet of each of them.



Soluble fertilizer injection for fertigation
Grower: Agrosuper, Region VI, Chile (Palma, 2004)

Figure 112. *Soluble fertilizer injection for fertigation. See details in pictures a and b. Orchad "Chancón". Grower: Agrosuper, Region VI, Chile (Courtesy of Agrosuper Production Management; (Palma, 2004, Chile).*

7.1.4 Case 4

Use of **SPN** products, **Ultrasol**TM line (Chile).

- Tank A: application of phosphoric acid, along with N, P, K, S and Mg.
- Tank B: Ca injection only, to avoid products precipitation.
- Tank C for microelements.
- Flow meter to measure the applied fertilizer volume (b).
- There is no interconnection between tanks, since the injection regulations are independent.

Figure 113. *Injection of soluble fertilizers (Ultrasol™) for fertigation. See details in photos a, b and c. Orchad "Cantera". Grower: Oscar Prohens, III Region, Copiapo Valley, Chile (Courtesy of growers, Picture took by Palma, 2004).*

Injection of soluble fertilizers (UltrasolTM) for fertigation
Grower: Orcar Prohens - III Region (Palma, 2004)

7.1.5 Case 5

Use of **SPN** products, **Ultrasol**™ line (Argentina and Chile).

- Tank A: application of phosphoric acid, together with N, P, K, S and Mg.
- Tank B: Ca injection only, to avoid precipitation of products.
- Injection of fertilizers through the venturi.
- Control faucet to regulate the fertilizer volume.
- Tanks interconnection.
- Tanks can be made of plastics or solid concrete.
- Mechanical agitator.

Figure 114. *Injection of raw material fertilizers for fertigation in less sophisticated systems. Argentina and Chile (a, b and c) (Palma, 2004).*

7.1.6 Case 6

Use of **SPN** products, **Ultrasol**™ line (Chile).

- Each section has valves – control faucet – flow meter – venturi, which correspond to each injection unit of each individual tank (b and d).
- Automatic control panel, according to previously defined irrigation policy (c).
- Injection of fertilizers measured by m^3 of fertilizer tank per liter of irrigation water injected (a).
- Controllers of pH and electric conductivity by specific probes.

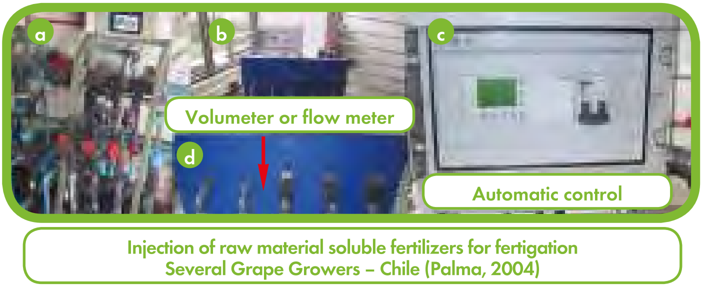


Figure 115. *Injection of raw material fertilizers for fertigation, in sophisticated systems in Argentina and Chile. See details in photo a, b, c and d (Palma, 2004; Oyarzun-Azud Chile, 2004).*

7.1.7 Case 7

Use of soluble crystallized solid fertilizers, which are raw materials, in automatic injection systems, according to an irrigation programme (Spain).

- Injection of fertilizers through piston pump.
- Three mother solution tanks: A, B and C.
- Injection of fertilizers measured by m^3 system of fertilizer tank per liter of irrigation water injected (b).
- Controllers of pH and electric conductivity, by specific probes (b).
- Separate application of nitric acid in an external deposit to the irrigation control unit (c) .

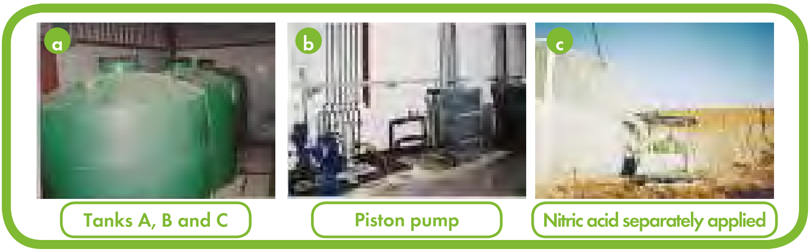


Figure 116. *Injection of fertilizer raw materials for fertigation in sophisticated systems, in Spain. See details in a, b and c pictures (Palma, 2003).*

7.1.8 Case 8

Use of soluble liquid fertilizers formulated at request (Spain), or use of liquid raw materials (USA).

- Loading of distribution truck at the central plant, with liquid fertilizers (courtesy of Gatt fertilizers, cited by Cadahía, 2003 (Spain) (a).
- Liquid fertilizer CaO 10 - 0 - 7 - 13.5 (Spain) (c and d).
- Injection of liquid fertilizers through a venture, from a 5,000 l capacity tank (Fresno, USA). (Palma, 1998) (b and e).

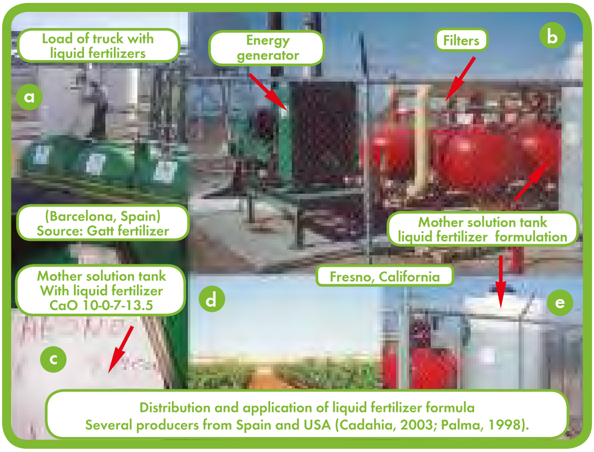


Figure 117. *Distribution and application of liquid fertilizers formulated in Spain (a, b, and c) and USA (b and e) (Courtesy of Gatt fertilizers, mentioned by Cadahía, 2003) (Spain); Palma, 1998 (USA)).*

7.1.9 Case 9

Use of **SPN** products (South Africa).

- Injection pump connected directly to the flow meter for each fertilizer tank (c).
- High capacity tank (10.000 l) (b and c).
- Injection piston pump.
- Controllers of pH and electric conductivity, through specific sensors.
- Automation through individual injection implement per tank (d).

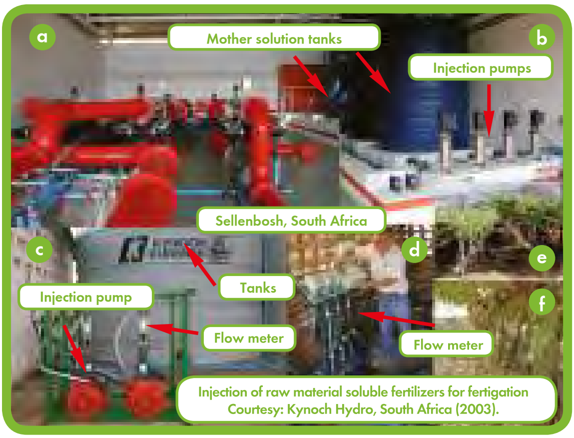


Figure 118. *Fertilizer injection of soluble raw materials through fertigation in Stellenbosch, South Africa (Courtesy of Kynoch Hydro, 2003).*

7.2 Soil Programmes Recommendations

To select the most appropriate fertilizers, the following factors should be considered:

- Fertilization based on prospective yield, with an appropriate nutrient balance.
- Care of Ca/K, Ca/Mg, K/Mg and K/Ca+Mg relationship.
- Technified irrigation, which allows higher yield and quality.
- Balance of Nitrogen, nitric and amonia forms, with wide prevalence of nitric over amoniacal forms, during the budding to fruit setting stage.
- Application of potassium free chlorine sources, for localized irrigation.
- Complete fertilization with macro and micronutrients, according to soil, water and plant analyses.
- Use of diagnostic and monitoring tools, such as: soil and foliar analyses, extracts with suction probes, saturated soil extract, chlorophyll meters, dendrometers, and moisture meters (FDR or TDR).
- Split nutrient application, according to the crop extraction.

The following products would be needed to meet the required demand for the production of 30 ton/ha of fresh table grape (see Section 4.1):

N = 159 kg/ha; P_2O_5 = 45 kg/ha; K_2O = 171 kg/ha;
CaO = 56 kg/ha and MgO = 34 kg/ha

But, before calculating the definitive nutrient requirement, the utilized irrigation system should be defined, and the application of the appropriate correction, depending on the efficiency of each element. Therefore, a table grape fresh production under a drip irrigation system would demand the following nutrients (Table 39 and 40):

N = 198 kg/ha; P_2O_5 = 128 kg/ha; K_2O = 213 kg/ha;
CaO = 56 kg/ha and MgO = 34 kg/ha

Table 39. *Nutrient absorption efficiency, according to the type of irrigation system used.*

Nutrient absorption efficiency according to irrigation type	Unit	N	P_2O_5	K_2O
Furrow (traditional)	%	40 - 60	10 - 20	60 - 75
Sprinkler	%	60 - 70	15 - 25	70 - 80
Dripping	%	75 - 85	25 - 35	80 - 90

Detail of calculations, and an example is shown in Table 40.

Table 40. *Steps recommended to meet the requirements for a 30 ton/ha of fresh table grape production program.*

	N	P_2O_5	K_2O	CaO	MgO	S
	kg/ha					
1. Total to be Applied	198	128	213	56	34	18
2. Phenological Phases (see table 31, secction 4.4)	N	P_2O_5	K_2O	CaO	MgO	S
	%					
Post-harvest	30	25	20	30	30	30
Bud break, Flowering, Fruit initation	40	20	40	40	30	10
Fruit growing	20	45	20	30	40	50
Maturity and Harvesting	10	10	20	0	0	10
Total	100	100	100	100	100	100
3. Phenological Phases	N	P_2O_5	K_2O	CaO	MgO	S
	kg/ha					
Post-harvest	59	32	43	17	10	5
Bud break, Flowering, Fruit initation	79	26	85	22	10	2
Fruit growing	40	58	43	17	14	9
Maturity and Harvesting	20	13	43	0	0	2
Total	198	128	213	56	34	18

Nutrient demands (kg/ha) by each phenological stage have been determined for different countries (Tables 41 to 50) (Egypt, Peru, South Africa, India and Chile).

7.2.1 Nutrients Demand in Egypt

Table 41. *Recommended nutrients by phenological stage in **Egypt** (kg/fd).*

TABLE GRAPE										
Note: 1 feddan = 0.44 has		Nutrients (%) en kg/fd								
Period	**Product**	**N**	**P_2O_5**	**K_2O**	**CaO**	**MgO**	**S**	**density**	**kg/Fed**	**Lts/Fed**
Bud Break To Bloom	Diamond I +	8	8	4	1	0,1	0	1,25	75	60
	Topaz III +	8	0	0	9	4	0	1,41	89	63
	Tot. Nutrients/Period	*13*	*6*	*3*	*9*	*4*	*0*			
Bloom To Setting	Quartz II +	4,3	4,3	6,9	1	0,1		1,19	174	146
	Topaz III +	8	0	0	9	4	0	1,41	56	39
	Tot. Nutrients/Period	*12*	*7*	*12*	*7*	*2*	*0*			
Setting To Veraison	Quartz III	1,5	1,5	6,5		0	2	1,14	615	540
	Topaz III +	8	0	0	9	4	0	1,41	44	32
	Tot. Nutrients/Period	*13*	*9*	*40*	*4*	*2*	*12*			
Veraison To Harvest	Quartz III	1,5	1,5	6,5		0	2	1,14	385	337
	Topaz III +	8	0	0	9	4	0	1,41	11	8
	Tot. Nutrients/Period	*7*	*6*	*25*	*1*	*0*	*8*			
Post Harvest To Fall	Amber III	4,3	1,3	5,3	0	0	2	1,16	283	244
	Topaz III +	8	0	0	9	4	0	1,41	122	87
	Tot. Nutrients/Period	22	*4*	*15*	*11*	*5*	*6*			
Total (kg/fed)		66	32	95	31	13	26		1.854	1.556
Total (kg/ha)		150,8	72	213,75	72	32,3	59			

Source: *Programme suggested by Misr Specialty Fertilizer Company (MSF, a Joint Venture between Yara and SQM) in Sahara Desert (applying Hydroterra Liquid Product Line).*

7.2.2 Demanda de Nutrientes en Perú

Table 42. *Recommended nutrients and products by phenological stage in* ***Peru*** *(kg/ha).*

			Nutrients (kg/ha)					
Soil	**Phenological stage**	**kg/ha**	**N**	**P_2O_5**	**K_2O**	**S**	**MgO**	**CaO**
Ultramix 14 - 16 - 22 - 3 - 4	Post-harvest	200	28	32	44	6	8	0
Subtotal			28	32	44	6	8	0
U. Development/ Phosphoric A./Calcium N.	Bud break–Flowering–Fruit set		44	17	28	13	3	26
U. Multipurpose/Potassium N./ Calcium N.	Fruit set – Fruit growing		69	41	82	2	2	26
Standar U. Mixed/Calcium N.	Maturity - Harvest		71	27	61	0	0	26
Subtotal			184	85	171	15	5	78
Total			212	117	215	21	13	78

Soil application relation: 45% N-Nitric; 55% N-Ammoniac
Fertigation application relation: 64% N-Nitric; 36% N-Ammoniac

Source: *Palma, 1998. Technical assistance SQM Peru S.A.*

7.2.3 Nutrient Demand in South Africa

Table 43. *Recommended nutrients by phenological stage in* ***South Africa*** *(kg/ha).*

			Nutrients (kg/ha)					
Stage	**Phenology**	**Days**	**N**	**P_2O_5**	**K_2O**	**S**	**MgO**	**CaO**
1 (Sep 1)	Bud break - Flowering initation	45	25	8	16	3	7	23
2 (Oct 16)	Flowering initation - Veraison	37	20	16	2		6	19
3 (Nov 22)	Fruit set - Harvest	44	12	6	31	5	1	3
4 (Jan 5)	Harvest - Prunig195	59	20	39	6	4	15	
5 (Jul 19)	Post-pruning – Bud break	44	2	1	1	0	0	1
Subtotal		365	118	38	103	16	18	61

Source: *Courtesy of Dr. Oosthuyse, S. SQM Mineag, 2004.*

7.2.4 Nutrients Demand in India

Table 44. *Recommended nutrients by phenological stages in* ***India*** *(kg/ha).*

			N	**P_2O_5**	**K_2O**	**MgO**	**CaO**
	Estimated yield (ton/ha) 40	kg/ha	146	71	169	49	29
Phases	**Period of the phenological stage**		**N**	**P_2O_5**	**K_2O**	**MgO**	**CaO**
I+IV	After pruning (Abr) to flowering initiation (Dic).	kg/ha	102	42	68	26	18
II	Flower initiation to veraison (early Dic to early Feb).	kg/ha	29	21	68	15	12
III	Veraison to end harvest (early Feb to early Mar).	kg/ha	15	7	34	7	0
	Total	kg/ha	146	70	169	48	30

Source: *Holwerda, 2004.*

7.2.5 Nutrients Demand in Chile

7.2.5.1 Vineyard development stage, first and second year

Table 45. *Recommended nutrients and products for table grape in development stage, 1st and 2nd year, in* ***Chile*** *(kg/ha).*

Stage	Product	kg/ha	Nutrients (kg/ha)					
			N	P_2O_5	K_2O	S	MgO	CaO
Bud break (Oct)	Ultrasol™ Initial	25	4	8	4	0,3	0,3	
Growth (Nov)	Ultrasol™ Growth	50	9	3	9	4	1	
	Ultrasol™ Quality	150	23		27			23
Growth (Dic)	Ultrasol™ Initial	50	8	15	8	1	1	
Growth (Jan)	Ultrasol™ Growth	25	6	3	3	0.3	0.3	
	Calcium Nitrate	100	16					26
	Magnesium Sulphate Hept.	100			13	16		
Growth (Feb)	Ultrasol™ Growth	100	25	10	10	1	1	
Growth (Mar)	Ultrasol™ Post-Havest	100	13	13	36			
Subtotal		700	103	51	96	19	19	49

Source: *SQMC. Libro azul (2002).*

7.2.5.2 Vineyard in Full Production

7.2.5.2.1 Stage 1: Bud break to Flowering

Table 46. *Recommended nutrients and products for table grape production in Stage 1.* ***Chile*** *(kg/ha).*

Period	Recommended Products	kg/ha	Solution g/l	Ultrasol™ Selection Superior Grade Use Observations
Bud break to flowering	Ultrasol™ Initial Superior Grade	225	0,4 - 0,8	If soil has a low P-Olsen content (less than 10 ppm)
	Ultrasol™ Superior Grade Multipurpose	175	0,3 - 0,7	If soil has a medium P-Olsen content (10-20 ppm)
	Ultrasol™ Superior Grade Post-Harvest	250	0,3 - 0,7	If soil has a medium to low potassium content (less than 200 ppm of potassium)
	Ultrasol™ Superior Grade Development	200	0,3 - 0,7	If soil has an adequated phosphate and potassium content
	Ultrasol™ Superior Grade Growth	200	0,3 - 0,6	If soil has a high levels phosphate and potassium, or scarce OM content

Source: *SQMC. 2004. Technical bulletin on table grape.*

7.2.5.2.2 Stage 2: Flowering to 10 mm Berry

Table 47. *Recommended nutrients and products for table grape production in Stage 2. **Chile** (kg/ha).*

Period	Recommended Products	kg/ha	Solution g/l	Ultrasol™ Selection Superior Grade Use Observations
Flowering to Berry 10 mm	Ultrasol™ Quality	200		Recommended to obtain an adequate calcium and potassium supply via soil, especially in soils with less than 15 Cmol (+)/kg or 15 meq/100 g of Calcium.
	Ultrasol™ Superior Grade Production	225		Recommended for the active potassium absorption stage and, in less degree, for phosphorus and nitrogen.

Source: *SQMC. 2004. Table Grape Technical Bulletin.*

7.2.5.2.3 Stage 3: 10 mm Berry to Veraison

Table 48. *Nutrients and products recommended for table grape production in Stage 3. **Chile** (kg/ha).*

Period	Recommended Products	kg/ha	Solution g/l	Ultrasol™ Selection Superior Grade Use Observations
Berry 10 mm to Veraison	Ultrasol™ Superior Grade Production	200		Recommended for the active potassium absorption stage and, in less degree, for phosphorus and nitrogen.
	Ultrasol™ Superior Grade Fruit	200 - 300		Recommended for the active potassium absorption stage, in low potassium soil content and in soils with OM superior to 3%, with high phosphorus content.

Source: *SQMC. 2004. Table Grape Technical Bulletin.*

7.2.5.2.4 Stage 4: Veraison to Harvest

Table 49. *Nutrients and products recommended for table grape production in Stage 4. **Chile** (kg/ha).*

Period	Recommended Products	kg/ha	Solution g/l	Ultrasol™ Selection Superior Grade Use Observations
Veraison to Harvest	Ultrasol™ Superior Grade Fruit	100 - 200		Recommended for the active potassium absorption stage, in low potassium soil content and in soils with OM superior to 3%, with medium phosphorus.

Source: *SQMC. 2004. Table Grape Technical Bulletin.*

7.2.5.2.5 Stage 5: Post Harvest

Table 50. *Nutrients and products recommended for table grape production in Stage 5.* ***Chile*** *(kg/ha).*

Period	Recommended Products	kg/ha	Solution g/l	Ultrasol™ Selection Superior Grade Use Observations
Post - Harvest (immediately after harvest)	Ultrasol™ Superior Grade Post	200		If soil has a medium to low potassium (less than 200 ppm of potassium)
	Ultrasol™ Superior Grade Multipurpose	150 - 200		For soils with medium phosphorus and potassium contents.

Source: *SQMC. 2004. Table Grape Technical Bulletin.*

7.3 Foliar Feed Nutrition Programmes

Phenological stages require specific nutrients, which can be complementarily applied to the soil as foliar applications (Figure 119).

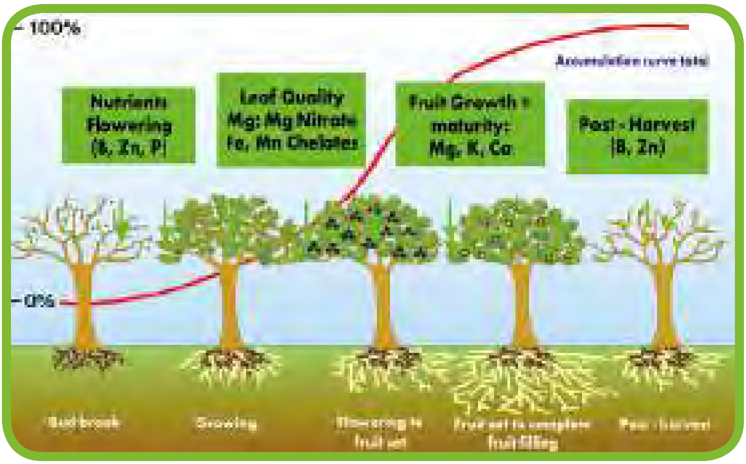


Figure 119. *Foliar programme application according to certain element requirements, under specific phenological stages of deciduous fruit trees (SQMC, Adapted from Libro Azul, 2002).*

The use of foliar **SQM** line products (**Speedfol™**) is recommended. These products contain particular nutrients, and specific products such as, amino acids (especially chelated) and phyto- hormones or growth regulators (Figure 120).

Figure 120. *Foliar application of Speedfol™ line to table grape (Spanish vineyard in Chile) (Pictures (a) to (i)) (Palma, 2004; Raffo, 2004).*

Foliar **Speedfol™** line application recommendations (dose and period) for table grape are described:

- **Speedfol™ Amino Starter SC:** Three applications (5 l/ha). 1^{st}: at 10- 15 cm shoot stage. 2^{nd}: at 20- 50 cm shoot stage. Both applications are to promote uniformity. Especially after hydrogenated Cyanamid application, to avoid "spring fever". 3^{rd}: at post - harvest.
- **Speedfol™ Mg SC:** Three applications (2 to 5 l/ha). 1^{st}: at 20- 50 cm shoot stage. 2^{nd}: two weeks after the first application. 3^{rd}: 10 days after application of the 3^{rd} giberelic acid application. This product should be applied in orchards with "bunch stem necrosis" records.
- **Speedfol™ Amino Flower & Fruit SC:** Four applications (5 l/ha). 1^{st}: at 20- 50 cm shoot stage (substitution of **Speedfol™ Amino Starter SC**) mainly in orchards with "spring fever" records. This product can be mixed even with **Speedfol™ Amino Calmag Plus SC**, to reinforce their effect. Later applications: from and between GA_3 applications for growth.
- **Speedfol™ Amino Calmag Plus SC:** Five applications (5 l/ha). 1^{st}: starts at 20- 50 cm shoot stage (to reinforce the **Speedfol™ Amino Flower & Fruit SC** effect to control "spring fever"). 2^{nd}: 14 days later. 3^{rd}: at 4-5 mm berry stage. 4^{th}: at 2^{nd} application of GA_3. 5^{ve}: at veraison.

- **Speedfol™ B SP:** Two applications (3 kg/ha).1st: one week after 20- 50 cm shoot. 2nd: during post harvest.
- **Speedfol™ Zn SC:** Three applications (0.6 – 1 l/ha). 1st: one week after 20- 50 cm shoot stage. 2nd: one week after the first application. 3rd: during post harvest.
- **Speedfol™ Zn + Mn SC:** Three applications (1.2–2 l/ha). At the same application time than **Speedfol™ Zn SC**, since this product would be preferred to be applied when important Mn deficiency appear.
- **Speedfol™ Amino Calmag SL:** Three applications (10 l/ha). 1st: two weeks after 20- 50 cm shoot stage. 2nd: during the first giberelic acid application (4-5 mm berry). 3rd: during the second GA_3 application (8 days after the first GA_3 application).
- **Speedfol™ Ca SC:** One application (3 l/ha) two weeks after 20- 50 cm shoot stage.
- **Speedfol™ K SL:** Three applications (5 l/ha). 1st: at 20- 50 cm shoot stage. 2nd: during the first gibberellic acid application (4- 5 mm berry). 3rd: during veraison.
- **Speedfol™ Marine SL:** Three applications (10 l/ha). 1st: two weeks after 20-50 cm bud stage. 2nd: during the first giberelic acid application (4- 5mm berry). 3rd: during the second GA_3 application (8 days after the first GA_3 application).
- **Speedfol™ Amino Vegetative:** One application (5 l/ha) during post harvest. This product can replace to **Speedfol™ Amino Starter SC**.

Figure 121. *Sales containers of foliar "Speedfol™ product line".*

8 Research Results Demostrating the Necessity of Nutritional Balance

This Chapter shows a selection of scientific research results which demonstrate the effect of nutrients and nutritional unbalances on crop yield and quality, and the importance of selecting appropriate nutritional products.

8.1 Nitrogen

Nitrogen affects the leaf growth and foliar area: This research study confirmed that high nitrogen regimes increase the foliar surface and the number of nodes per plant. (Thompson Seedless Variety, growing on pearl – vermiculite mixture, which received different levels of a Hoagland nutritive solution, **USA**, 1969).

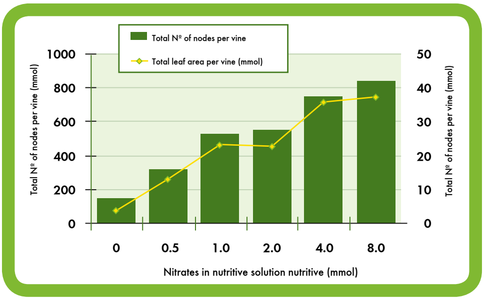


Figure 122. *Effect of N on the leaf growth and foliar area (Kliewer & cook 1971, cited by Yara in the Table Grape Plantmaster, 2004).*

N application increases bunch weight and yield: This study determined optimum N between 150 and 175 g/plant (in a 12 year-old Red Loomy Variety, on a clay-silty soil, with a pH level of 8.2, **Egypt**) (Figures 123 and 124).

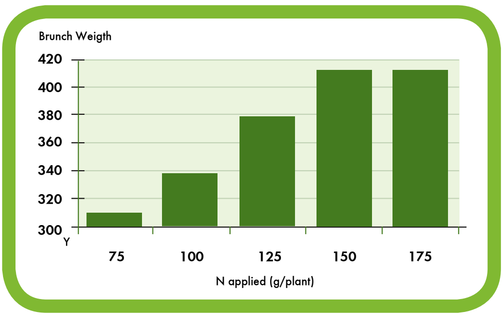


Figure123. *N effect on the bunch weight (Ahmeed et al, 1988, cited by cited by Neukirchen, Yara/SQM/Phosyn Workshop, Cape Town,* ***South Africa****, 2003).*

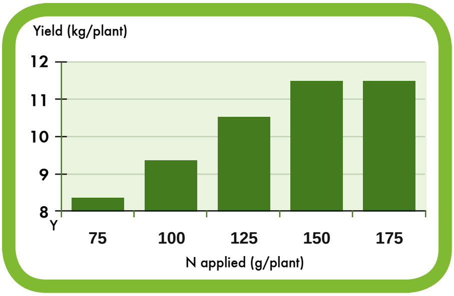


Figure 124. *N effect on table grape yield (Ahmeed et al.,1988, cited by Yara in the Table Grape, Plant Master 2004).*

N effect on the anthocyanins content in berries (Trail on 11 year-old plants): this research study demonstrates that the precursor for anthocyanin synthesis is present in the leaves. This synthesis is reduced under N deficiency. **(USA, 1997)**

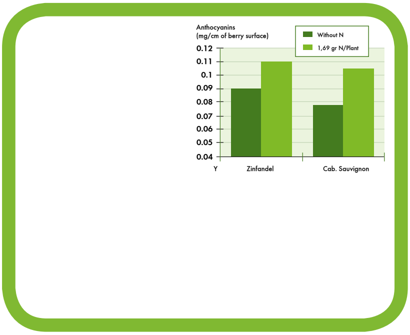


Figure 125. *N effect on the anthocyanine content in berries (Ewart, A. and Kliewer, W. 1977, USA, cited by Neukirchen, Yara/SQM/ Phosyn Workshop, Cape Town, South Africa, 2003).*

Foliar N applied during berry's development increases the total solids and SS/acid (soluble solids/acid) ratio and, consequently, quality (a one-year trial on 15 year-old plants, Beauty Seedless variety): urea was applied at fruit set during berry's elongation (India). The application of foliar urea (low in biuret), applied after fruit set, on a low N regime, can be used to improve grapes´ color. However, too much N can reduce coloration. This effect of N excess can be decreased by reducing the canopy, immediately after veraison (Ahlwat et al, 1985, cited by Yara in the Table Grape Plantmaster, 2004). **(India, 1985)**

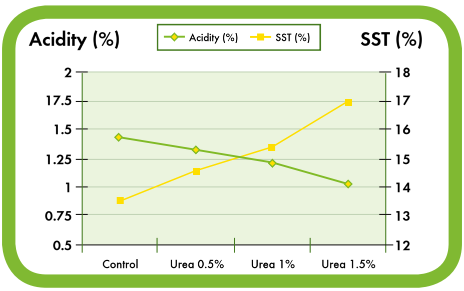


Figure 126. *N effect on berry quality (Ahlawat et al., 1985, India, cited by Yara in the Table Grape Plantmaster, 2004).*

- A vigorous growth, produced by an excess of nitrogen fertilization, increases leaves and bunches susceptibility to diseases such as Botrytis (grey mold) and oidium, as well as insect attack, by root phylloxera, and aphids or mites in the shoots (Yara, Table Grape Plantmaster, 2004). **(South Africa)**.

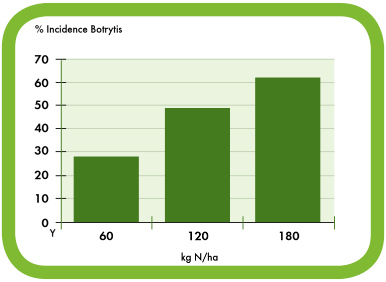


Figure 127. *N effect on Botrytis incidence (%) (Chambers et al. 1993, cited by Yara, Table Grape Plantmaster, 2004)*

8.2 Potassium

- K increases **bunch and berry weights:** a research study demonstrated that berries and bunches increase their weight between 24 and 44%, as a result of potassium applications, with a maximum response with dose above 400 kg/ha (8 years old Perlette Variety, on a silt-sandy soil, pH 8.5, with one application after pruning, 1993). **(India)**.

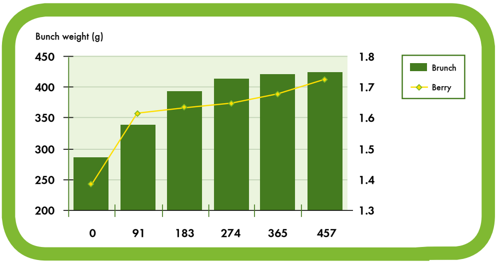
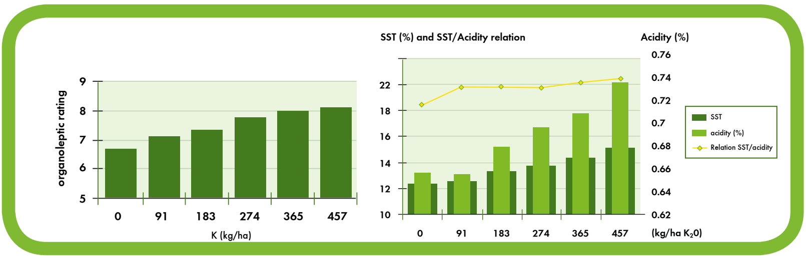


Figure 128. *K effect on bunch and berry weight (Dhillon et al., 1999, India, cited by Yara in Table Grape Plantmaster, 2004).*

- More potassium has a positive effect on the berry's organoleptic characteristics: an eight-year trial in silt-sandy soil, and pH 8.5, one K application after pruning, on variety old Perlette (1993) demonstrated that a higher flavor was obtained from increasing the K level. **(India)**.



Figures 129 y 130. *K eeffect on berry´s organoleptic characteristics (Dhillon et al., 1999, India, cited by Neukirchen, Yara/SQM Workshop, Cape Town, South Africa, 2003).*

Foliar K favors **yield increase:** as was demonstrated from an trial on a 10 year - table grape vineyard, in silt-sandy soil, and pH 7.45, in which foliar K was applied after flowering (June 16th and Julio 1st). **(Turkey).**

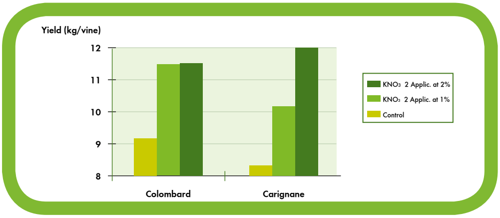


Figure 131. *K effect on yield (Altindisli, 1999, Turkey, cited by Neukirchen, Yara/SQM Workshop, Cape Town, South Africa, 2003).*

Foliar K application has a positive effect on table grape **quality: 7** applications (once a week), starting at fruit set, on a 10 - year Perlette variety, was equivalent to a total of 70 kg/ha application. Potassium sulphate at 1% (2 liters solution/plant) = 10 kg/ha, **(India).**

Table 51. *Effect of foliar K application on fruit quality (Singh et al. 1999, India, cited by Neukirchen, Yara/SQM Workshop, Cape Town, South Africa, 2003).*

	Control	Potassium 70 kg/ha
Berry weight (g)	2.03	2.1
Juice %	62.22	66.47
Reducing sugars %	13.37	14.42
TSS (%)	16.37	17.74
Acidity (%)	0.57	0.65
Berry stregth*	3.33	3.52
Concentration K (% de MS)	1.68	2.74

K and P **control diseases such as oidium, in table grape** [Powdery mildew, Oidium tuckerii (asexual phase) and Uncinula necator (sexual phase)]: 7 applications, starting when sprouts are 10 cm long, act as a plant defense mechanism, by directly affecting fungi growth. **(South Africa).**

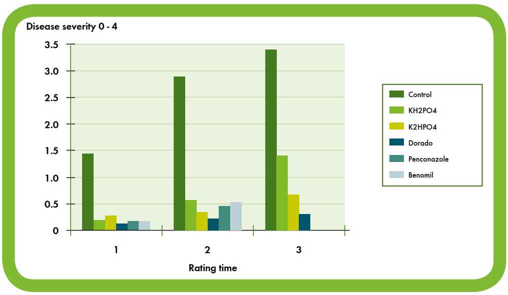


Figure 132. *K and P effect on disease control (Reuveni & Reuveni, 1995).*

Achieving a correct K: N ratio may help in **reducing fungi effects, such as the case of Botrytis**, since excess N stimulates a vigorous plant growth, turning plant tissue highly susceptible. High K levels prevent this rapid growth. Thus, a high K:N relation reduces the disease incidence (Table 52).

Table 52. *K:N proportion in the leaf, and Botrytis incidence.*

Botrytis Infection	N (%)	K (%)	N/K Ratio
Severe	2.1	0.8	2.63
Minimal	1.4	1.2	1.17

Source: *Bergmann (1996), cited by Yara in Table Grape Plantmaster, 2004.*

The K/(Ca+Mg) ratio is as important as the K:N ratio (Figure 133). K absorption preferably restricts Ca and Mg intake. An excess of any of them produces a deficit of any one of them or both of them, with the resulting quality and yield losses. **(France).**

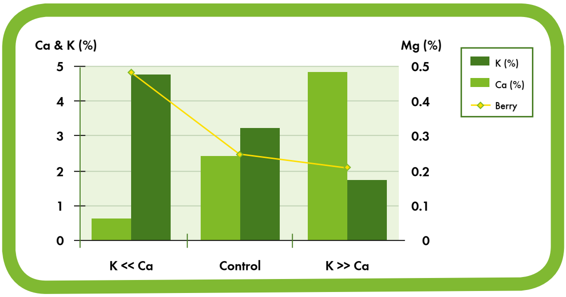


Figure 133. *Potassium and its interactions with Ca and Mg (Garcia et al. 1999, cited by Yara, in Table Grape Plantmaster, 2004).*

Excessive K application can induce Mg and Ca defficiencies: K (potassium sulphate in g/plant per week, was applied to Concord variety, from May 1st to September 1st, expanding in the soil as base thereafter, with drip irrigation (Figure 134). **(USA).**

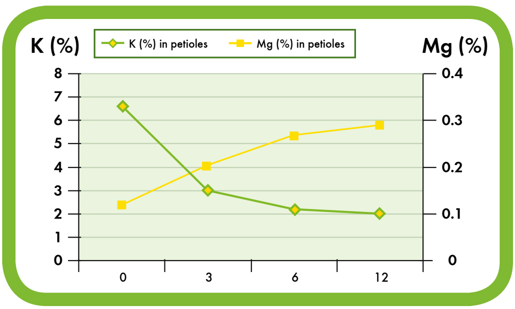


Figure 134. *K and Mg percentage in leaves´ petioles. (Morris et al. 1983; Am. J. Enol. Vitic. 34/1; 35-39, USA; cited by Neurtchirchen, Yara/ SQM Workshop, Cape Town, South Africa, 2003).*

The K content in berry is related to the levels of hormones applied (Orellana, 2003, degree thesis, Universidad de Chile, cited by Callejas, 2003; Soza, 2004).

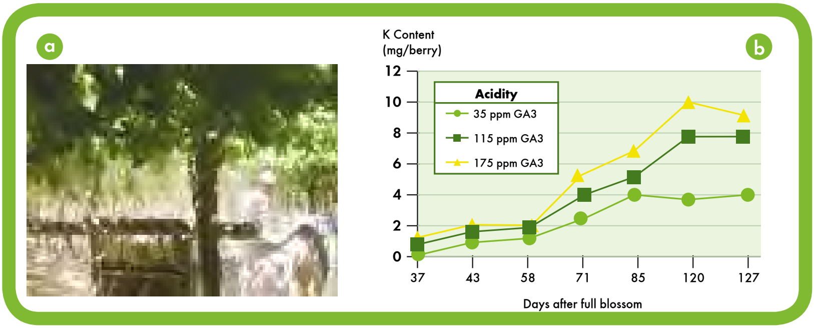


Figure 135. *Hormones and potassium foliar applications (a), and K content in berries (b). (Callejas, 2003; Soza, 2004).*

K deficiency originates nutritional disorders: The effect of K deficiency and high putrescine level, triggers a nutritional disorder known as ("False K deficiency") (Ruiz and Moyano, cited by Palma, 2003). Table 53 shows how disorder symptoms relate to high putrescine and low potassium levels in the leaf. (Chile).

Table 53. *Relationship between the high putrescine and low potassium levels in leaves with disorder symptoms (Ruíz and Moyano, 1990, cited by Ruiz, 2000).*

Location	Variety	Date	Potassium (%)		Putrescine (NMG)	
			Without Symptoms	With Symptoms	Without Symptoms	With Symptoms
La Granja	Thompson Seedless	December 1991	0.93a	0.85a	895.8b	9.964,9a
Ovalle	Pedro Jimenez	November 1991	0.77b	0.47b	1.585,3b	10.450a
Placilla	Thompson Seedless	November 1991	0.93a	0.83a	3.209,8b	21.148a
Polonia	Thompson Seedless	December 1991	0.96a	0.82a	1.219,2b	13.710 a

8.3 Calcium

Calcium is needed for a strong radicular development, especially at pre-flowering, and it is mainly present in leaves, which are the growth generators. Ca concentration increases in the plant throughout the growing cycle (from 1 to 4% Ca).

Nearly 40% of Ca absorption takes place between leaves´ emergency and fruit set. After fruit set, but before veraison, there occurs another 30% uptake, which accumulates mainly in the leaves and bunches. The remaining 30% is absorbed after veraison, mostly when the small bunches begin to lignify. In consequence, it is essential to apply calcium during the growing cycle in order to elevate Ca content in the tissues, thus minimizing post harvest transport and storage losses.

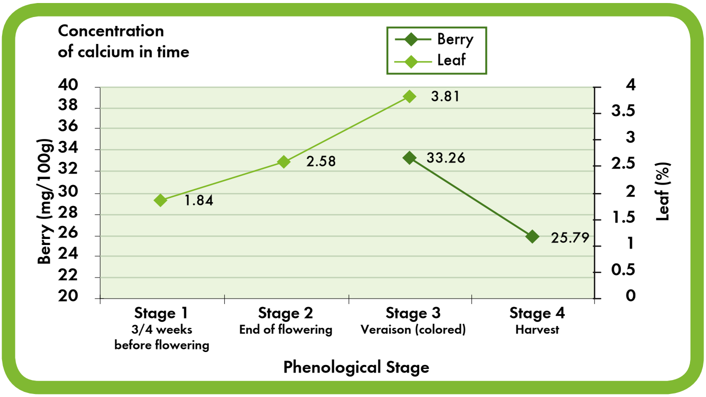


Figure 136. *Concentration of calcium in time (Phosyn–France (1998) cited by Yara, in Table Grape Plantmaster, 2004).*

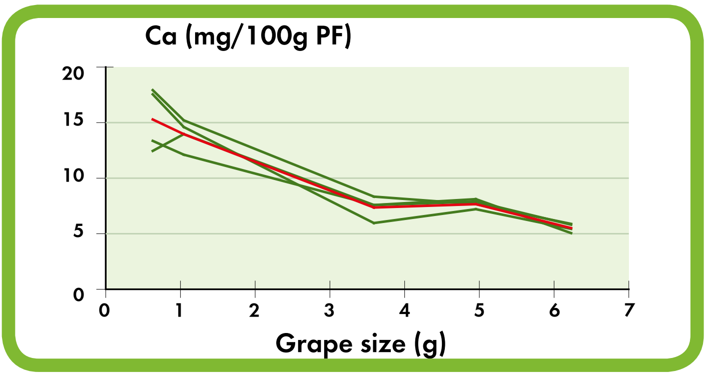


Figure 137. *Calcium content evolution and fruit size (Phosyn–France (1998) cited by Yara, in Table Grape Plantmaster, 2004).*

Calcium reduces post harvest weight and threshing losses: foliar calcium nitrate at 0.75% concentration, applied to Perlette variety, 10 days before harvest (storage at 1° C, and 80% relative humidity), showed how calcium content diminishes during maturation. This could be because the largest Ca proportion is localized in the grape skin. Therefore, it is important to maintain this calcium level by applying and/or spraying it to berries. (Figures 138 and 139). **(India).**

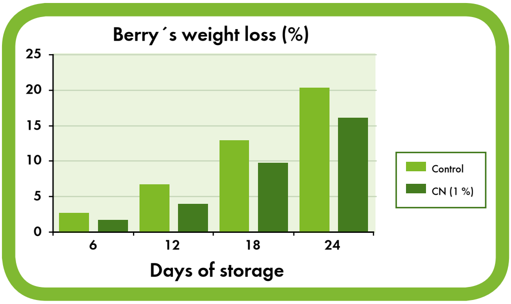


Figure 138. *Ca effect is expressed as a reduction of the berries weight loss (Singh & Kumar, 1989, cited by Yara, in Table Grape Plantmaster, 2004).*

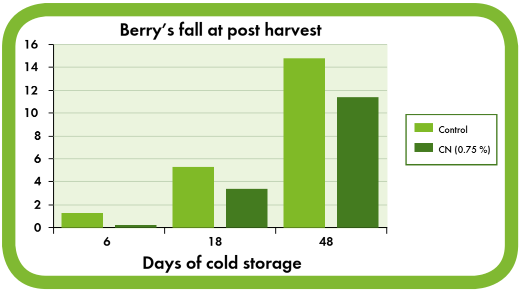


Figure 139. *Effect of calcium on the grape fall or post-harvest threshing (source: Kumar & Gupta,1987, cited by Yara, in Table Grape Plantmaster, 2004).*

Calcium reduces post-harvest dehydration in the Italia variety: scale 1 to 5, for different dehydration levels of berry and bunch stems, during post- harvest. (Brazil).

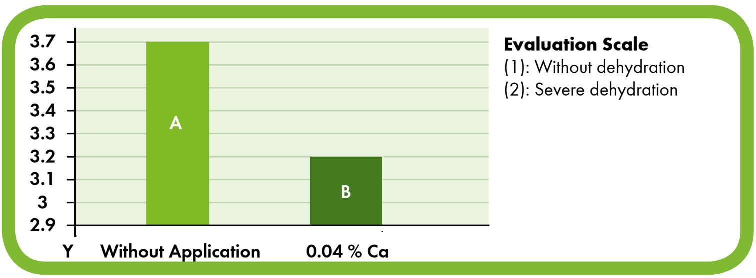


Figure 140. *Ca effect in reducing berry's dehydration. (Choudhury, Lima. Soares, Faria, 1999, Brazil, cited by Neukirchen, Yara/SQM/Phosyn Workshop, Cape Town, South Africa, 2003).*

Low Ca contents favor rot incidence: (Figures 140 and 141). **(India).**

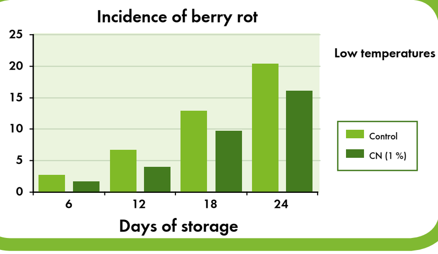


Figure 141. *Low calcium content increase berry rottenness (Singh & Kumar, 1989, cited by Yara in Table Grape Plantmaster, 2004).*

Calcium reduces rot in post harvest: Italy variety: pathologic deterioration according to different N sources. **(Brazil).**

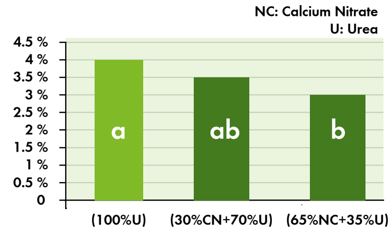


Figure 142. *High Ca content reduces berry rot (Choudhury, Lima, Soares, Faria 1999, Brazil, cited by Neukirchen, Yara/SQM/ Phosyn Workshop, Cape Town, South Africa, 2003).*

Calcium increases berry firmness: Thompson Seedless variety.

Early treatment: Stopit – 3 applications at a doses of 5 l/ha (4 mm berry; 8 days later; and veraison) with 1600 l/ha of water.

Late treatment: Stopit – 2 applications at a doses of 8 l/ha; 30 and 15 days before harvest with 1600 l/ha of water. **(Chile).**

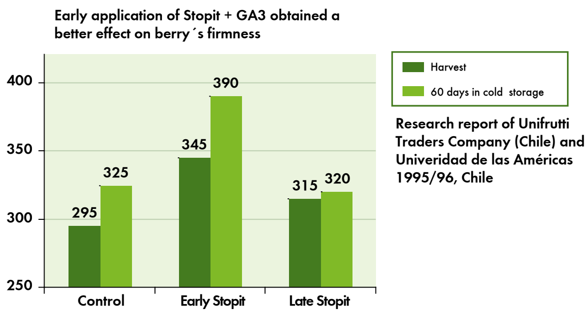


Figure 143. *Ca effect is expressed by increasing berry firmness (Research study carry out by Universidad de las América, Santiago, Chile, sponsored by Unifrutti Trarders Company, (1996/1997), Blake (2003), cited by Yara in Table Grape Plant Master, 2004.*

- **Calcium reduces internal browning on berries** (Thompson Seedless).
  Early treatment: Stopit – 2 applications at a doses of 8 l/ha (at pre-color stage) and 1 application of 8 l/ha, 15 days later.
  Late treatment: Stopit – 3 applications of 10 l/ha, every 15 days. (Chile).

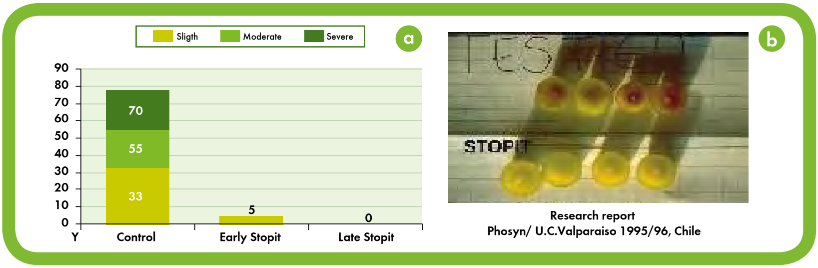
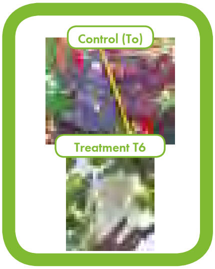


Figure 144. *Ca effect is expressed by reducing internal berry browning (a and b) Blake (2003), cited by Yara in Table Grape Plant Master, 2004.*

- **There is a synergism between calcium, phytoregulators, gibberellic acid and co-adjuvants**, since they produce better results by increasing calibers, weight, pressure and higher percentage of berry light color in Red Globe variety (by immersion). **(Chile).**



90 Days	T6 (GA_3 + Stopit + Auxym + Citowett)	T7 (GA_3 + Stopit + Kelpak + Citowett)	T0 (GA_3 + Stopit)
Berry average size	28.18 mm	27.96 mm	26.68 mm
Berry weight	14.49 gr	14.51 gr	12.70 gr
Light color	86.94%	58.33%	32.64%
Russet	Without difference	Without difference	Without difference
Botrytis	Without difference	Without difference	Without difference
Shattering	Without difference	Without difference	Without difference
Berry pressure	0.485	0.4625	0.4175
Whitish	Without difference	Without difference	Without difference
Craking	Without difference	Without difference	Without difference
Ss/ acidity ratio	Without difference	Without difference	Without difference

Figure 145 and Table 54. *Ca effect on size increment, weight, pressure (berry firmness stability) and color percentage (Soza and Del Solar, 2004).*

- Ca content in the berry is related with applied hormone levels (Orellana, 2003 in degree thesis from Universidad de Chile, cited by Callejas, 2003; Soza, 2004).

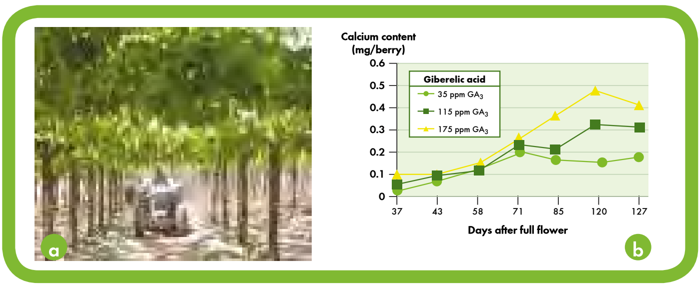


Figure 146. *Foliar applications of Calcium + giberelic acid in orchard (a) and Calcium content per berry (b) (Callejas, 2003; Soza, 2004).*

8.4 Magnesium

Magnesium deficiency is associated to the nutritional disorder named "bunch stem necrosis" (BSN), which affects the bunch rachis preventing the normal berry maturation. Finally, berries show a transfused and crystalline appearance without the appropriate soluble solids for their harvest.

- **Foliar Mg application reduces bunch stem necrosis (BSN)**: Riesling rootstock 5c (6 years), silt-sandy soil. Foliar magnesium sulfate was twice applied (16% MgO) during the season, in maturity at 5 and 2%. The yield increased due to the 14% drop in 1978. In consequence, 2 to 3 foliar applications before veraison reduce this nutritional disorder. (Figures 147 and 148) **(Germany).**

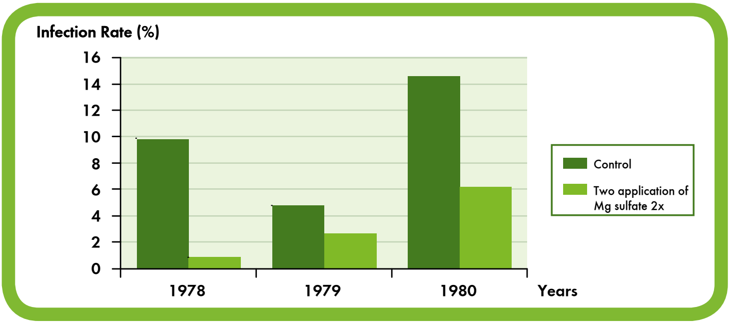


Figure 147. *Mg effect is expressed by reducing "bunch stem necrosis" from the rachis and berry (Beetz et al. 1983, cited by Neukirchen, Yara/SQM/Phosyn Workshop, Cape Town, South Africa, 2003).*

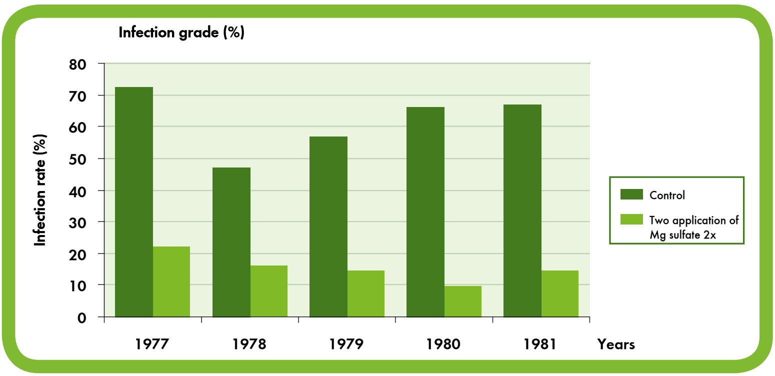


Figure 148. *Mg effect expressed by reducing bunch stem necrosis (rachis and of berry) (Haub, 1993, cited by Yara in Table Grape Plantmaster, 2004).*

9 Proven Cost Effectiveness of Balanced Nutritional Programmes

This Chapter summarizes economic results from **SQM** demonstration field trials. A traditional nutritional program with raw materials is compared with the use of specialty plant nutrition **"Ultrasol™"**. The demonstration trials were based on table grape Thompson Seedless variety in production stage as an adult orchard, and grapevine seedlings from a nursery.

9.1 Vineyard in Production Stage

The trial was carried out in Viluco (Metropolitan Region), near to Santiago, in a table grape field in production, using Thompson Seedless variety for fresh fruit export, during three growing seasons.

The summary of this field trial on fresh table grape is presented in Table 55. **SQM** balanced nutritional programme, using NPK specialty soluble **"Ultrasol™"** lines, is compared with the normal farmer´s programme using raw materials called control treatment, with only a single N application (urea called SQM-1) during three growing season, from 1999 to 2002. From the second year, a second control treatment was incorporated, which provided N and K elements (Urea and Potassium Chloride, called control + KCl).

Table 55. *Treatments applied during three production growing season in fresh table grape, Thompson Seedless.*

	Nutrients (kg/ha)						
Treatments	N	P_2O_5	K_2O	Mg	CaO	S	M.E.
Control (Urea)	60						
Urea+KCl1/	60		108				
SQM-12/	124	42	301	15	41	33	All
SQM-12/	104	42	252	15	41	27	All

1/Urea+KCl from the second year, (Control + KCl)
2/SQM treatments consider the Ultrasol™ Line according to the crop phenological stages.
Note: Experimental design used was a ramdomized block trial.

Source: *Ruíz, 2002. Research agreement between SQMC-INIA, Chile.*

Table 56. *Detail of applied treatments: SQM–1, SQM–2, Control with single N (Urea), and Control with N and K (Urea and Potassium Chloride), applied during 3 production growing season in table grape.*

Period	Product	Quantity (kg/ha) SQM1	SQM2
Bud break To fruit set	Ultrasol™ Growth	120	60
	Ultrasol™ Production	80	80
	Calmag	100	100
To fruit set Veraison	Ultrasol™ Fruit	330	200
	Calmag	140	140
Veraison	Ultrasol™ Veraison	100	100
Post harvest	Ultrasol™ Post harvest	150	200
Total		1.020	880
Control 100 kg/ha N	Urea	220	
Total		220	
Control 60 kg/ha N	Urea	170	
108 kg/ha K_2O	KCl	180	
Total		350	

Source: *Ruiz, 2002. Research Agreement SQMC-INIA, Chile.*

Total production differences and export percentages with their corresponding sizes distributions, are shown in Table 57. having differences in boxes per treatments.

Table 57. *Thompson Seedless production per treatment, base 8.2 kg net weight box.*

Treatment	Date	800 (Ex)		610 (VG)		600 (AG)		310 (VM)		300(AM)		Total
	Harvest	Boxes	%	Boxes	%	Boxes	%	Boxes	%	Boxes	%	(Boxes/Treat.)
Sector 3 Urea + KCl	9-Feb	10	0,5	698	33,9	119	5,8	983	47,7	249	12,1	2.059
Sector 4 SQM 1	20-Feb	19	0,8	942	37,3	263	10,4	1041	41,2	259	10,3	2.524
Sector 5 SQM 2	21-Feb	9	0,4	722	29,1	217	8,7	1342	54	195	7,8	2.485
Sector 1 y 2 Only Urea	24-Feb	0	0	144	8,57	134	7,98	894	53,2	508	30,24	1.680

Fuente: *Ruiz, 2002. Research Agreement SQMC-INIA, Chile.*

Table 58*. Final results. Income, according to fertilization programme.*

Sector Treatment	Total income per size (US$) 800 (Ex)	610 (VG)	600 (AG)	310 (VM)	300 (AM)	Total Export	Cost Fert.	Profit (US$)
Sector 3 Urea+KCl	101.2	5.179	717.57	4.870,8	720.86	11.590	64.8	11.525
Sector 4 SQM 1	192.28	6.990	1.585,9	5.158,2	749.81	14.676	501.3	14.174
Sector 5 SQM 2	91.08	5.357	1.308,5	6.649,6	564.53	13.971	438.4	13.533
Sector 1y2 Solo Urea	0	1.068	808.02	4.429,8	1.470,7	7.777	38.3	7.739

Source: *Ruiz, 2002. Research Agreement SQMC-INIA, Chile.*

Despite that treatments are completely balanced with specialty fertilizers (SQM-1 and SQM-2), their costs are higher than the control (Table 58). After deducting the extra costs of the fertilizers, the farmer obtains an **economic benefit** (net profitability) of US $2,650 in favor to SQM treatment, regarding the Control treatment (Urea) (Figure 149).

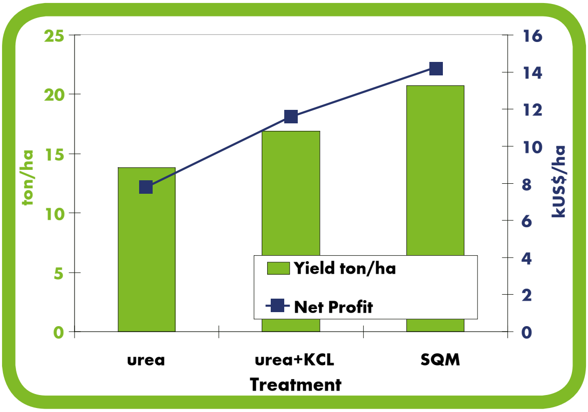


Figure 149. *High yield and profit in SQM treatment (Holwerda, H. 2004. Adapted from Ruíz 2002, Reseach Agreement Report SQMC-INIA, Chile).*

Results from three year's evaluation favored the SQM-1 and SQM-2 nutritional balanced treatments:

- Cost/Benefit.
- High yields (starting in 1999).
- Export percentage increment (from 1999 until February 2002).
- Gain in bunches' weight (g), and in berry's diameter (mm) (from 2000).
- Increase of foliar levels at flowering and veraison (November, 2001 and January 2002, respectively).
- Increase in starch %, P % and Arginine % in roots (August, 2001).
- Decrease of shattering % and dehydration (February, 2002).
- Dry weight gain measured as the winter pruning left overs, derived from a better plant nutrition, showing a better production per wood quality (May, 2001).

9.2 Vineyard Seedlings in Nursery

The research study was conducted in Marchihue (VI Region), Chile, on 40 plants selected at random, under a SQMC/University of Talca research agreement. Treatments were consisted of a SQM balanced nutrition which included application of Ultrasol™ Growth (25-10-10) and Urea, as compared to the traditional farmer's fertilization, consisting in only N supplied as Urea (Table 59).

Table 59. *Treatments applied to vineyard seedlings in nursery.*

	Month	Product	Dose kg/ha	# appl. every 3 days	N kg/ha	P_2O_5 kg/ha	K_2O kg/ha	MgO+ME
Normal applied by the farmer	Nov	Urea	11	10	51			no
	Dec/Jan	Urea	11	10	51			no
	Total			220	101			no
SQM	Nov	Urea	11	5	25			no
		U. Growth	20	5	25	10	10	yes
	Dec/Jan	Urea	11	5	25			no
		U. Growth	20	5	25	10	10	yes
	Total			310	101	20	20	yes

Source: *Moreno, 2000. Reseach Agreement SQMC-Universidad de Talca, Chile.*

The main results in the first year evaluation (1999) favored the SQM balanced nutrition treatment, were in:

- Increment of arms length (m), and canes thickness.
- Increment of trunk and arms dry weight (g).
- Increment of roots number and length per plant.
- Increment of roots dry weight per plant.

It is essential in table grape nurseries to promote the increase root number and length of seedling in a short time (Figures 150 a and b), so that when transplanted in the vineyard, will not suffer from stress.

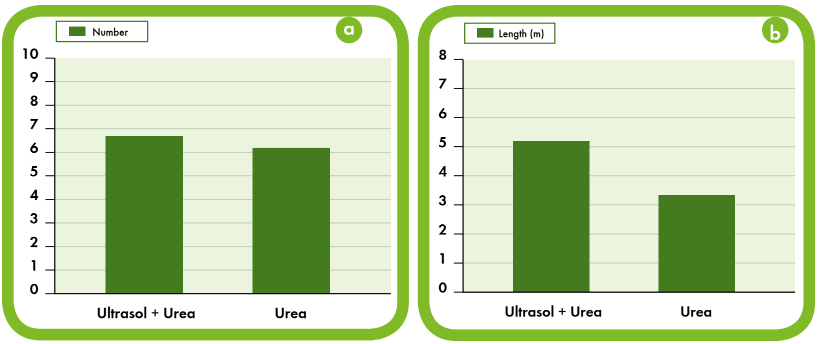


Figure 150. *SQM treatment with Ultrasol™ products which provide NPKSMg + ME. In the 1st year, there is an increment in number (a), and total root length per plant (b) (Moreno, 2000).*

The next figure 151 a and b show the application effect of SQM nutritional balanced product as compared to urea application only. This provides evidences that, in addition to the fertilization base, it is necessary to apply a complete fertilization during the growing season. The exclusive urea application is not enough to achieve an optimum plant development under restrictive soil conditions (Research Agreement SQMC-Universidad de Talca, 2000).

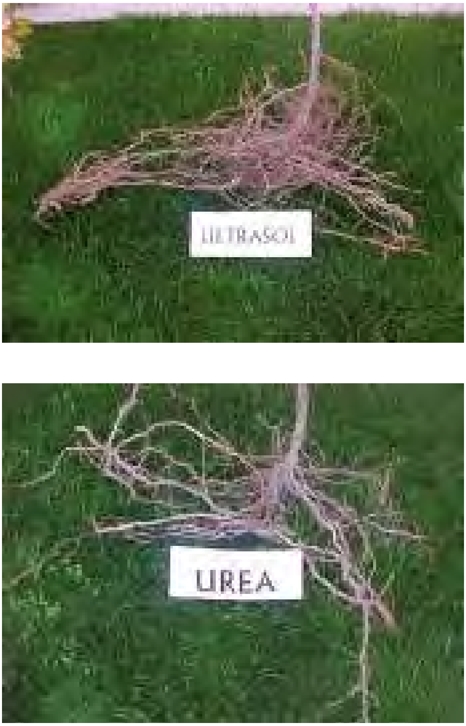


Figure 151. *SQM treatment with Ultrasol™ products which provide NPKSMg + ME. In the 1st year, there is an increment in the number and total root length per plant (Moreno, 2000).*

10 Literature

Allamand, M. 2004. Las fuerzas de hoy en el mercado mundial. Primer Seminario Internacional alternativas técnicas en uva de mesa organizado por Subsole S.A.. Santiago, Chile.

Amorós M. 1993. Riego por Goteo en Cítricos. Agroguías Mundi-Prensa. Segunda edición. 142 p.

Asoexport. 2003. Ciclo de seminarios frutícolas de actualización Técnico Comercial

Asoexport. 2005. Manual de inpección y embalaje de fruta fresca.

Bay, G; Bormman, K. 2003. Nutritional Situation of table grape in South Africa. Present by Kynoch Hydro Technical Team during workshop in table and wine grapes irganized by Yara/SQM/Phosyn, Cape Town, South África.

Blake, A. 2003. Improving table grape productive and quality with foliar applied nutrients. Presented in workshop on table and wine grapes, organized by Yara/SQM/Phosyn, Cape Town, South África.

Buckman, H y Brady, N. 1997. Naturaleza y Propiedades de los suelos. Ed. Montaner y Simón S.A. 590 p.

Bull, B. 2001. VII Seminario Internacional en tecnologías aplicadas a cultivos hortícolas organizado por SQM México/Yara. Puerto Vallarta, Jalisco, México.

Bull, 2003. Grape seminar opening during workshop on table and wine grapes organized by Yara/SQM/Phosyn, Cape Town, South África.

Bull, B. 2003. Material técnico de Yara – especialidad.

Bull, B. 2003. Nitrato de Calcio Hydro. VIII Seminario Internacional en Innovaciones tecnologicas en cultivos intensivos organizado por SQM México/Yara, Manzanillo, México.

Cadahía, C. 1998. Fertirrigación en plantas hortícolas y ornamentales. Ed. Mundi Prensa. Madrid. 475 p.

Cadahía, C. 2003. Fertirrigación. Segundo seminario Internacional de ferttirriego organizado por SQMC, Santiago de Chile.

Callejas R. 2003. Desarrollo Generativo de la vid. En curso diplomado fundamentos fisiológicos de la vid en la producción de Uva de Mesa. Cevid. Universidad de Chile. 12 p.

Callejas R. 2003.Desarrollo de la baya y su relación con los nutrientes. En curso diplomado sobre fundamentos fisiológicos de la vid en la producción de uva de mesa. Cevid. Universidad de Chile.

Callejas R. 2003. Funcionamiento de las hojas y su relación con la disponibilidad de asimilados. En curso diplomado sobre fundamentos fisiológicos de la vid en la producción de uva de mesa. Cevid. Universidad de Chile. 16 p.

Callejas R. 2003. Mecanismos de control del desarrollo de los árboles frutales. En curso diplomado sobre fundamentos fisiológicos de la vid en la producción de uva de mesa. Cevid. Universidad de Chile.18 p.

Cariola. L. 2004. Nuevos sistemas de conducción en uva de mesa. Primer Seminario Internacional alternativas técnicas en uva de mesa organizado por Subsole S.A.. Santiago, Chile.

Colombo, J. 2005. Análisis de la actualidad y perspectivas de la uva de mesa en los mercados de exportación. Segundo Seminario Internacional alternativas técnicas en uva de mesa organizado por Subsole S.A.. Santiago, Chile.

Conradie, W. 2000. Obtención de óptima producción y alta calidad de uva vinífera y de mesa mediante la nutrición a través de fertirriego. En Primer Seminario Internacional de Fertirriego organizado por SQMC, Santiago, Chile. 19 p.

Del Solar C, Soza, J.A. 2003. Efectos de fitorreguladores, Calcio, Magnesio, anillado, sobre la calidad y condición en Uva de Mesa cultivar. Thompson seedless y Red Globe. Sitio web www.uvademesa.cl 20 p

Domínguez A.1996.Fertirrigación. Ediciones Mundi-Prensa. Segunda edición. 233 p.

Du Préz, T. 2003. Fertirriego en uva de mesa y vinifera. Segundo seminario Internacional de fertirriego organizado por SQMC. Santiago, Chile.

Ensenat, L. 2001. Microelementos solubles. Una oportunidad para el fertirriego chileno. Capacitación interna SQMC organizada por Ciba España. Santiago, Chile.

Eymar, E.; Cadahía, C.; Sánchez, A.; López-Vela, D. 2000. Nutritional Diagnosis Based on Sap Analysis for Containerized Cupressus glabra and C. leylandii with Fertigation Systems. Communications in soil science and plant analysis. Vol. 31 (9 – 10). p1225 – 1248.

Ferreyra, R.; Sellés, G. 1997. Manejo del riego en condiciones de restricción hídrica. Serie la Platina, N ° 67. 36 p.

Ferreyra, R.; Sellés, G. 1999. Riego deficitario controlado. Serie la Platina, N ° 70. 66 p.

Fichet, T. 2004. Proceso fisiológico de la cuaja en cítricos. Boletín técnico Universidad de Chile. 14 p.

Finck, A. 1998. Fertilizantes y fertilización. Ed. Reverté, S.A. Barcelona. 439 p

García de Cortazar, V. 2003. Potencial primario, IAF y su efecto sobre el potencial productivo. En Diplomado fundamentos fisiológicos de la vid en la producción de Uva de Mesa. Universidad de Chile. 4 p.

Geny L et al. 2004. Hormonal status in grape berry during ripening: importance of calcium to polyamines and abcissic acid synthesis. Symposium Internacional ISHS on table grape. UC-Davis.

Gil G. 1999. Fruticultura - El potencial productivo. Ediciones Universidad Católica de Chile.Segunda edición. 341

Goldspink, J. Et al. 1998. Fertilizers for wine grapes. Agriculture Western

Goto, W. 2003. Internal information SQM presented in seminar international about nutritional speciality organized by Yara/SQM/Phosyn. Buenos Aires, Argentina.

Guardiola, J. 1990. Fisiología Vegetal. Ed. Síntesis. Madrid. 439 p.

Gurovich, L. 1987. Uso del ácido fósforico en la fertirrigación de parronales y huertos frutales regados por goteo. Revista Aconex 16. p 17-19.

Haberland, J. 2003. Física de suelos, algunos principios básicos. En curso Diplomado Fundamentos fisiológicos de la Vid en la producción de Uva de Mesa. Universidad de Chile.42 p.

Holwerda, H. 2003. Internal information SQM presented in seminar international about nutritional speciality organized by Yara/SQM/Phosyn. Buenos Aires, Argentina.

Holwerda, H. 2004. Presentation on table grapes in India. Internal information SQM-Europe.

Ibacache, A. 2001. Convenio investigación entre SQMC e INIA-Intihuasi, Serena, Chile.

Inpofos. 1990. Potasa: su necesidad y uso en Agricultura moderna. Instituto de la potasa y el fósforo de Canada. Boletín divulgación técnica. 44 p.

Instituto Internacional de la Potasa. 1994. Actualidad del Potasio. Guía de extensión (CH-4001). 137 p.

Instituto Internacional de la Potasa. 1995. Dinámica del Potasio en el suelo. Guía de extensión (CH-3048). 11p

Instituto Internacional de la Potasa. 1995. El Potasio en las plantas. Guía de extensión # 2 (CH-3048) 11 p.

Karp, G. 2003. cell and molecular Biology. Concepts and Experiments. Third edition. 786 p.

Ljubetic, D. 2004. Situación actual y perspectivas en el uso de portainjertos. Primer Seminario Internacional alternativas técnicas en uva de mesa organizado por Subsole S.A. Santiago, Chile.

Martinez J. 2000. Experiencias en la producción de estacas barbadas de vides y control de la fertirrigación en parronales de Uva de mesa en Chile. Fertirrigación y control en frutales y viñas. Primer Simposium Internacional organizado por Bioamérica S.A. 4 p.

Mendoza H. 2000. Fundamentos de fertirrigación: química de los fertilizantes y dinámica de los nutrientes en el bulbo de riego. Fertirrigación y control en frutales y viñas. Primer Simposium Internacional organizado por Bioamérica S.A. 24 p.

Mendoza, H. 2003. Fertirrigación en frutales. VIII Seminario Internacional en Innovaciones Tecnologicas en cultivos intensivos, organizado por SQM México/Yara, Manzanillo, México.

Moreno, Y. 2000. Informe convenio investigación entre SQMC y Universidad de Talca. Chile.

Napier, D; Oosthuyse, S. 2003. Mono potassium phosphate (MKP) as part of an integrated pest management program to control powdery mildew. SQM-Mineag, South Africa.

Neukirchen, D. 2003. Crop specific plant nutrition in table grape and grapevine. To meet the grower's needs. Research Centre Hanninghof, presented in workshop organized by Yara/SQM/Phosyn, Cape Town, South Africa.

Neukirchen, D. 2003. Nutrient management for Grapes. Research Centre Hanninghof, presented in workshop organized by Yara/SQM/Phosyn, Cape Town, South Africa.

Palma, J. 2003. Detección, seguimiento y control de soluciones nutritivas en tres variedades de uva de mesa de exportación. Segundo Seminario Internacional de Fertirriego organizado por SQMC, Santiago, Chile.

Palma J, 2005. Fertirriego en uva de mesa. Seminario internacional "manejo de riego y suelo en vides para vino y mesa" organizado por Estación Experimental la Platina, instituto de investigaciones Agropecuarias, Inia. Hotel Torremayor, Santiago de Chile

Palma, J. 2006. Estrategia de fertilización en vid de mesa, diseños y monitorización. Tercer Seminario Internacional de Fertirrigación organizado por Soquimich Comercial. Hotel Marriot, Santiago de Chile.

Pastenes, C. 2003. Fotosíntesis en Plantas superiores, desde la captación de la energía hasta la formación de productos finales. En curso diplomado fundamentos fisiológicos de la Vid en la producción de Uva de Mesa. Universidad de Chile.11 p.

Pastenes, C. 2003. Fotosíntesis en vides y su aplicación en aspectos de manejo. En curso diplomado fundamentos fisiológicos de la Vid en la producción de Uva de Mesa. Universidad de Chile. 12 p.

Pastenes, C. 2003. Fotosíntesis en vides de interés enológico. GIE

Internacional alternativas técnicas en uva de mesa organizado por Subsole S.A.. Santiago, Chile.

Razeto, B. 1985. Deficiencias de magnesio en frutales. Revista Aconex 11: 15.

Razeto, B. 1986. Deficiencias de zinc en frutales. Revista Aconex 13: 22-24

Razeto B. 1993. La Nutrición Mineral de los Frutales. Deficiencias y excesos. Publicación SQMC.Chile. Edición Diseño y Producción Eves S.A. 105 p.

Razeto B. 1999. Para entender la Fruticultura. Tercera edición. 372 p.

Razeto, B. 2004. Estandares nutricionales foliares en frutales en Chile. Capacitación interna SQMC. Proyecto Foliar Speedol. Santiago, Chile.

Reuveni, M; Reuveni, R. 1995. Efficacy of foliar application of phosphates in controlling powdery mildew on field - grown vinegrapes; effects on cluster yield and peroxidase in berries. J. Phytopathology, 143: 21-25.

Ruíz, R. 2000. Uva de mesa en Chile. Collección libros INIA N ° 5 ISSN 0717-4713. Ministerio de Agricultura. Santiago, Chile. pp 113-143.

Ruíz, R. 2002. Convenio de investigación entre SQMC e INIA-La Platina. Chile.

Sellés, G. 2003. Fundamentos para una optima programación de riego II Seminario Internacional de Fertirriego.SQMC. Santiago, Chile. 29 p.

Silva, M. 1986. Desequilibrios nutricionales en vides de mesa. Revista Aconex 13: 28-31.

Silva, H. Y Rodriguez, J. 1995. Fertilización de plantaciones frutales. Universidad Católica de Chile. 519 p.

Silva, M. 2004. Manejo sustentable del recurso suelo. Primer Seminario Internacional alternativas técnicas en uva de mesa organizado por Subsole S.A. Santiago, Chile.

Soza, J. 2004. Investigaciones en reguladores de crecimiento en uva de mesa. Primer Seminario internacional alternativas técnicas en uva de mesa organizado por Subsole S.A. Santiago, Chile.

Soza, J. 2004. Efectos de fitoreguladores de origen sintetico (CPPU) y calcio, sobre la calidad y condición en uva de mesa cvs. Thompson seedless. Capacitación interna SQMC. Proyecto foliar SpeedfolTM. Santiago, Chile.

SQMC. 2001. Agenda del Salitre. Sociedad Química y Minera de Chile S.A. Inscripción N ° 117.758 I.S.B.N. 956-8058-00-1. Undécima edición, 2001. 1515 p.

SQMC. 2002. Libro azul, fertirrigación. Tercera edición. 67 p.

SQMC-Chile: 2003. Material interno SQMC. Fundamentos básicos de nutrición vegetal aplicados a la producción de uva de mesa.. 18 p.

Tagliavini et al 2000 . Ripartizione degli elementi minerali nei frutti degli alberi decidui. Frutticoltura nº 1-2.000 p 83-87

Taiz & Zeiger. 2002. Plant Physiology. Third edition. 690 p.

Tamaro, D. 1974. Tratado de fruticultura. Septima edición. Ed. Gustavo Gili, S.A. 939 p.

Trebilcook, P. 2005. Una forma economica y fácil para monitorear riego, nutrientes y sales. Entrevista a Mr. Richard Stir Zaker. CSIRO, Australia. Revista Chile Riego. Mayo N ° 21.

Valdes, A. 1987. El potasio en el suelo. Revista Aconex 16: 13-16.

Valenzuela, J. 2001. Agenda del salite. p 921 – 938.

Vega A. 2003. Morfoanatomía de la Vid. En curso diplomado fundamentos fisiológicos de la vid en la producción de Uva de Mesa. Universidad de Chile. Santiago, Chile.

Vera, J. 2003. Riego inteligente. Segundo Seminario Internacional de Fertirriego organizado por SQMC. Santiago, Chile. 12 p

Yara, 2004. Plantmaster en uva de mesa. 34 p.

Yuri A; Retamales, J. 1995. Calcio en Fruticultura- Symposium Internacional de Nutrición, organizado por Universidad de Talca. 148 p.

SQM S.A.
Los Militares 4290
Las Condes - Santiago - Chile
Tel: (56 2) 2425 2000
E-mail: spn-chile@sqm.com

Soquimich Comercial S.A.
Los Militares 4290, piso 3
Las Condes - Santiago - Chile
Tel: (56 2) 2425 2000
E-mail: servicioalcliente@sqm.cl

SQM Ecuador
Avda. Constitución y Avda. Juan Tanca Marengo,
Edificio Executive Center, Piso 3, Of. 304-305 -
Guayaquil - Ecuador
Tel: (593 4) 215 86 39
E-mail: spn.ecuador@sqm.com

SQM Comercial de México S.A. De C.V.
Moctezuma 144, piso 4
Ciudad del Sol Zapopan, CP 45050, Jalisco,
Mexico
Tel: (52 33) 354 01100
E-mail: spn-mexico@sqm.com

SQM North America
3101 Towercreek
Parkway, suite 450
Atlanta, GA 30339 - USA
Tel: (1 770) 916 9400
Fax: (1 770) 916 9401

**SQM Europe,
Middle East & Africa**
Houtdok-Noordkaai 25a , 2030 Antwerpen -
Belgium
Tel: (32 3) 203 9700
E-mail: spn-emea@sqm.com

SQM China
Room 1001C, CBD International Mansion, No.16
Yong an dong li,
Jian Wai Ave, Beijing 100022 China
Tel: (86 10) 6461 8950
E-mail: spn-china@sqm.com