Dry on vine San Juan´s experiences

Compendium of studies

Rodrigo Sebastián Espíndola

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La foto de tapa pertenece a una de las parcelas de estudio que dieron origen a este libro.

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Prologue

This compendium is the result of all the research and experiences carried out not only by the Grape Raisin Producer and Exporter Group of the Chamber of Foreign Trade of San Juan, Argentina, but also by INTA (National Institute of Agricultural Technology), UNSJ (San Juan National University) and COVIAR (Argentine Viticulture Corporation).

These activities started in 2007 with the 'First International Symposium on Table Grapes and Raisins' organized by INTA, in which the topic Dry On Vine (DOV) was formally introduced in Argentina by Dr. Matthew Fidelibus (UC Davis Researcher). In the last five years, the joint effort has allowed an improvement in the adoption of technology between grape producers for raisins and industrialists. Today there are over 30 raisin farmers that use DOV: Hector Alos, Gonzalo Huertas, Carlos Huertas, Giselle Alves, Enrique Meló, Guillermo Meló, Patricio Meglioli, Julio Pacheco, Martín Pantano, Marcelo Pomeranchic, Hugo Crescentino, Silvana Putelli, Guillermo Podestá, Ezequiel Cusnir, Jorge Escobar, Jose Murgic, Juan Carlos Reverendo, Alfredo Chiconi, Alfredo Ferre, Fernando Navas and Sergio Rossi, among others.

This compendium includes studies on this technology, the opinion of five innovative producers of the San Juan raisin sector, and the recommendations of Mathew Fidelibus, expert of the 'Kearny Research and Extension Center of the University of California, Davis.

DOV technology is considered to be new in San Juan, Argentina, not in others countries like Australia, and United States. It is thought to be a labor-saving technological alternative. It is important to state that the transformation of the traditional raisin production system into DOV requires studying and training since it is necessary to generate a cultural change in the conception of pruning systems within the leading systems. One of the most important difficulties to face will not be the use of technology, but the habit of those who handle pruning shears.

DOV technology represents a real strategy to generate cost savings, optimization of land use, and high quality raisins. These factors, taken as a competitive advantage, will allow greater aptitude and better access to the international market.

This compendium is divided into chapters in the following order: I) General information about the DOV system and raisin production systems; II) Local studies on the Superior Seedless variety; III) Local studies on the Flame Seedless variety; IV) Quality of DOV raisins; V) The experience of the local producers, and VI) Tips to build a DOV system, and final conclusions.

In some sections, the aim is to simplify the wording to facilitate understanding; however, technical vocabulary is generally used. Readers will be able to draw their own conclusions about the economic and technical convenience of using DOV systems.

It is not necessary to read Chapter I to understand the rest of the content of this compendium. This chapter is a bibliographic compilation that details economic and technical aspects for those who wish to deepen aspects of the application of DOV.

Chapter I

Introduction

I.1 Background

I.1.1 World, national and provincial situation of the production of raisins

In 2010, the world production of raisins was 1,062,000 t, with a decrease of 2.07% over the previous year (INV, 2011); 1,153,000 t for the 2012-13 season (Doreste, 2013), reaching values of 1,235,972 t in 2016 (ISDGPCC, 2016). The interannual variation, between 1% and 2%, indicates a stable behavior (Doreste, 2013). The United States and Turkey are the main raisin producers worldwide, and they have 60% of the market share. If Iran is included, the three countries account for 73% of the traded volume (USDA 2016). The rest of the market is distributed mainly between China, Chile, South Africa and Argentina (the same, 2016). These four countries generated a production of 285,000 t in 2016, which represents the remaining 27% (USDA, 2016). Argentina is located between the seventh and ninth places with productions ranging from 36,000 t a year (2010) to 40,000 t (2016) (3% of the world production) (INV- the National Institute of Viticulture-, 2011, Doreste, 2013, USDA, 2016).

In 2011 (INV), 621,015 t worth US $ 1,273,623,464 were exported, according to a report from 74 countries. The main exporters were Turkey, the United States, Iran and Chile with values of 210,000 t; 140,000 t; 78,000 t and 65,700 t respectively (Uquillas, 2010). By 2016, total exports reached 708,000 t (USDA, 2015).

The main importers worldwide are the European Union (EU), Russia, Canada and Japan with values of 315,000 t, 70,000 t; 35,000 t and 32,700 t, respectively (ibid, 2010). In 2016, the main importing countries were the European Union, Japan, Canada and China with values ranging from 25,000 t (China) to 330,000 t (European Union) (USDA, 2015). The EU only produces 10,000 t of the total it consumes (Doreste, 2013). The United States and China are among the main consumer countries. The former consumes 63% of its production, and the latter 94%. The United Kingdom is one of the countries with the highest consumption, and shows a sustained growth in imports (121,895 tons by 2010). Turkey (53%) and the United States (17%) are the main suppliers of this market (Calidad San Juan, 2008; INV, 2011; Doreste, 2013).

As mentioned before, Argentina is the seventh-ninth raisin producer worldwide with 36.000 t, average (Doreste, 2013; USDA, 2016) and 4.274 ha (INV, 2015). This represents 1.89% of the total vines established in Argentina (224,707 ha). However, if the production in the province of San Juan is analyzed, raisins have a relative importance in terms of hectares devoted to this activity, as well as its weight in the exports of viticulture origin, being the province that presents the greatest diversification with regard to the production of raisins, table grapes, must and wine (Huertas, 2017).

Table 1. Exports of must, raisins, and table grapes for San Juan in US dollars.

	San Juan Exports - FOB values (USD)	
	2015	2016
Must (includes grape juice)	44,905,823.35	55,068,081.66
Dry grapes, raisins included	46,558,922.52	43,623,867.00
Wines	45,880,045.32	39,855,538.02
Fresh grapes	18,539,957.25	13,367,436.09

According to SENASA records and databases of the Argentine Customs system, 34,488 t were exported during 2016, of which 23,500 t were exported to Brazil (65%), followed by USA with 4,500 t (8%), Colombia 2,700 t (5%) and, fourthly, the Dominican Republic 1,222 t (2%), among others (SENASA, 2016). Argentina's raisin exports increased from US $ 61,740,290 to US $ 64,809,891, between 2011 and 2013, in terms of value, as a result of the improvements in international prices driven by record prices in Turkey and USA. In the same period, an opposite behavior was observed in terms of volume, registering a fall of 29,220 t to 29,047 t, for the same period (variation of -0.32% and -0.27%) (USDA, 2014). During 2016 USD 53.801.280 were exported; deterioration in export prices and a growth in volume were to be noted. Although there are no official statistics on the domestic consumption of raisins in Argentina, the private sector, the Chamber of Foreign Trade of San Juan, estimates that this consumption is around 4,000 t, which represents 11.60% of the total volume of production, with exports accounting for 88.4% (Huertas, 2017). It is important to note that San Juan is the province that produces more than 90% of Argentina's exports.

The area cultivated with varieties of raisins in Argentina was 3,681 ha in the year 2000, and it grew to 3,987 ha in 2013, which implies an increase of 8.31% (INV, 2007; INV, 2013). Based on the total Argentine production, it is estimated that today there are some 5,500 ha devoted to the production of raisins, a part of which comes from the productive sector of table grapes with varieties such as Flame Seedless, Superior Seedless and Black Seedless.

I.1.2 The production in San Juan

The main producer of raisins in Argentina is the province of San Juan with 3,248 ha (INV, 2015), which represent 73.24% of the total area. In order of importance San Juan is followed by the provinces of La Rioja with 535 ha, and Mendoza with 483 ha (INV, 2015). However, the INV (2015) registers the Flame Seedless variety (3,800 ha) as table grape. At present, 90% of this variety is destined to the production of raisins; this is why it is

possible to state that the surface cultivated with grapes to produce raisins is superior to 7,000 ha.
56% of the surface cultivated with vine for raisins in San Juan is located in the districts of Caucete with 562 ha, 9 de Julio with 543 ha, and 25 de Mayo with 537 ha. The districts of San Martín (129 ha) and Chilecito (433 ha) are the ones with the largest cultivated area in Mendoza and La Rioja respectively (INV, 2013).
The most important variety in Argentina for the production of raisins is Flame Seedless. In 2014, 19,226 t of this variety were harvested (42.1%), followed by Arizul (INTA CG 351) with 6,223.9 t (21.89%), white Sultana 3,261.2 t (12.42%) and Superior Seedless 1,114.8 t (10.04%), among others. In percentage terms, they show a variation of 443.10% with respect to 2003, -38.69%, -63.72% and -79.81% respectively (INV, 2014). Other varieties that are used are *Cereza*, Black Seedless, *Torrontes*, Muscat of Alexandria, among others.

I.1.3 Varieties for the production of raisins

The varieties of grapes destined to the production of raisins worldwide are Sultana, Fiesta, Selma Pete, Black Corinth, Muscat of Alexandria, Monukka, Ruby Seedless and Dovine (Christensen, 2000). Pugliese and Cáceres (2007) mention Sultana, Superior Seedless, Flame Seedless, Perlet, Loose Perlet, Beauty Seedless, Centennial Seedless, Dawn Seedless, Ruby Seedless and Tinogasteña INTA. Sultana (Thompson Seedless) is the variety with the largest cultivated area in California. It is apyrenic, with conical and big clusters, and medium oval light green to light yellow berries, with fleshy pulp and neutral flavor. Its raisins are bluish brown and medium weight (0.4 to 0.6 g) (Christensen, 2000). It is a variety of early maturity in San Juan. Its berries are considered to be small, with a diameter of 13-14 mm; its pulp has a firm texture. Its problems have to do with bud fertility and uneven the bud breaking (Pugliese and Cáceres, 2007).
Another important variety is Superior Seedless, which bud breaking before Sultana does, ripens in the same time of the year (early) and is harvested with 19° Brix. Its berries are large and elongated with a diameter of 18-20 mm. Its color is pale yellow, its skin is firm and has muscatel flavor. Seminal rudiments can be found. Its cluster is medium to large, and from loose to tight. It is very vigorous and productive; it has low basal bud fertility. It needs good exposure to light to favor the formation of productive buds, and it is very sensitive to powdery mildew) (Ibidem, 2007).
Fiesta is an apyrenic, very vigorous and productive variety, its clusters are large and conical with green to light yellow oval berries; it is fleshy with small seminal rudiments. Its raisins are dark brown with a tendency to be fleshier than Sultana (Christensen, 2000).

This variety produces 4 to 8 t/ha of raisins. In California, when the Dry On Vine (DOV) system is used, it is harvested with 20° Brix, around August 15th. With modern systems, such as open gable or overhead, it can yield 8 to 10 t/ha of raisins. It is pruned with 4 to 8 long canes, with an average cluster size of 400 g. It is sensitive to phomopsis and powdery mildew (Fidelibus et al, 2016).

The DOVine Californian variety was developed in 1995 by the United States Department of Agriculture (USDA), specifically for DOV systems. It is very vigorous, its guides are cut with 21° Brix, with yields of 8 to 10 t/ha of raisins. It is conducted with tetralateral cords, and 4 to 8 guides are left per plant; on average, its clusters weigh 400 g and it is sensitive to powdery mildew, excoriation and wind damage (Ibidem, 2016). Another variety developed in the year 2001 by the USDA for DOV systems is the Selma Pete whose vigor ranges from moderate to strong, and whose guides are cut around August 15th with 22° Brix. It has similar yields to DOVine (Ibidem, 2016). Other varieties intended for the production of raisins with non-traditional systems are the Summer Muscat and Diamond Muscat (Ibid, 2016). DOVine and Fiesta varieties are cultivars that produce higher yields; the previously mentioned varieties produce up to 10 t / ha of raisins. In general, Diamond Muscat produces lower yields, but the raisins are of a higher quality, and it can suffer damage due to heat waves. The Selma Pete variety contains the highest amount of soluble solids and has very good pasteurization capacity; Fiesta is the variety with the least amount of soluble solids.

Selma Pete variety was developed in 2001 by the USDA, specifically for DOV systems. Its vigor is moderate, and it ripens in the United States in mid-August. This variety takes four to five weeks to dry in the plant, with yields of 10 t/ha. It adapts to conduction systems such as *parral*, open gable and overhead. Its pruning is carried out with four to eight canes on cordons. Its clusters weigh from 180 to 200 g. It is sensitive to powdery mildew, and may have ripening problems in the presence of leafroll virus.

Black Corinth (Zante currant) is a seedless variety of small, cylindrical clusters. Its berries are very small, round and reddish black. When it dries, its raisins turn from dark brown to black (Ibid, 2000). Flame Seedless is a very vigorous variety, it bud breaks four days after Sultana does, and ripens a week before; that is to say, it has a shorter cycle. The clusters are medium-sized, light; the stalk is firm; the berries are round and medium-sized (16-18 mm), with crisp pulp and sweet taste, the color ranges from bright red to intense pink, and the skin is very thin. It usually has traces of soft, thin and imperceptible seeds (Cáceres *et al*, 1996. This variety is resistant to shelling. It is very vigorous, with high yields and good basal bud fertility.

Perlette is a variety that bud break and ripens (21° Brix) seven days before Sultana does. It has small (14-16 mm) spherical berries with a thin skin, and it is pale yellow. It is an apyrenic variety that can present seminal rudiments according to the year. It is very vigorous and productive; it has loose and branched clusters; it fructifies in the basal buds (*ibidem*, 2007).

Another variety that can be used for raisins is Loose Perlette, very similar to the previous one; it is very fertile and its cluster is somewhat looser than Perlette (Caceres et al, 1996). Beauty Seedless is among the non-traditional varieties that can be used for the production of raisins; it ripens earlier than Sultana does. It has waxy bluish black berries, shorter than Sultana, with a spicy flavor, tender and firm pulp, and it is seedless. Its clusters are large, very tight and produce shatter. It is prone to sunburn (Pugliese and Cáceres, 2007). Centennial Seedless, an early seedless variety with elongated yellowish green berries (16-18 mm), with crispy and firm flesh, is also included in this category. Its flavor is sweet and its skin is coarse. Its clusters are medium to large, long and loose, with a high shelling degree due to a weak bond of the berry to the pedicel (*ibidem*, 2007).

Among the least known varieties is Dawn Seedless, which bud break two weeks after Sultana does, and ripens a week before Sultana does. It is harvested with 21° brix. Its berries are spherical, small (14 -16 mm), and uniform; they are green and become golden yellow when they are fully ripe. Its pulp is firm and neutral in flavor. Its skin is thick and has soft seminal remains. The cluster is medium, uniform and slightly compact. Another variety, Ruby Seedless, is late, and has spherical medium sized red berries; it is harvested when it reaches 18° Brix. Its skin is thin and presents seminal remains. The cluster is very large, long and resistant to shelling. It is very vigorous and productive, with good fertility of basal buds, and two to three clusters per shoot. It is very sensitive to powdery mildew and bunch rot with a tendency to produce berry breakage. Finally, the Tinogasteña cultivar, which is late, is spherical, large, and pink. Its flavor is neutral and has a thick skin with seeds. Its cluster is large and full, uneven, very vigorous and with very high yields (Cáceres, 1996).

In 2007 during the summer season, Pugliese and Cáceres, evaluated drying parameters (dry weight, drying ratio, drying time and quality) in different varieties in San Juan. Among those varieties they studied, Dawn Seedless, Perlette and Ruby Seedless had the highest drying performance, with values of 26.5%, 26.1% and 25.6% respectively. Superior Seedless presented the lowest performance: 21.2%. The earliest and the ones with the finest skin, Perlette and Loose Perlette, took less time to dry: 19 days, while Tinogasteña took 35 days. In 2007, Loose Perlette showed the best drying performance: 25.4%, followed by Sultana and Flame Seedless. The one with the worst performance was Perla

Nera variety: 18.8%. That year the drying periods varied from 7 to 27 days. In 2008, the best drying yields were found in varieties such as Arizul (24.56%) and Fiesta (22.97%). The drying periods were similar to those of the previous year. Finally, in 2009, Sultana, Black Seedless and Flame Seedless presented the highest yields with 27.66%, 27.47% and 25.33%, respectively (Pugliese and Espíndola, 2011).

Table 1: Main varieties admitted in drying yards in Argentina in 2011.

Variety	Total (qq)
Flame Seedless	187,571
Arizul (INTA 351)	97,100
Sultana Blanca	71,102
Superior Seedless	49,550
Torrontés Sanjuanino	15,737
Cereza	5,414
Emperador	5,199
Tinogasteña	4,288
Criolla Chica	3,859
Moscatel de Alejandría	2,224
Other	9,051
Total	451,095

Source: INV

Table 2. Ratings of raisin varieties according to the Chamber of Foreign Trade. 2006-2010 INTA's raisin making process proficiency report

2007		2008	
Variety	Rating	Variety	Rating
Perlette	8	Dawn Seedless	7.8
Sultana	7.75	Superior Seedless	6.4
Dawn Seedless	6.75	Flame Seedless	8.8
Loose Perlette	6.75	Perlette	7.6
Flame Seedless	6.5	Beauty Seedless	4.8
Superior Seedless	6.25	Loose Perlette	7.6
Tinogasteña	6	Sultana	7.8
Centenial Seedless	5.5	Perlón	5.8
+Ruby Seedless	4.5	Nevado INTA.	4.6

Source: INTA

The same study determined that Dawn Seedless and Perlette cultivars have an early harvest, with an excellent yield in raisins. The Tinogasteña cultivar is also remarkable, being the latest one and with a high production. The use of early and late varieties allows the optimization of the use of drying sheds (*Ibidem*, 2011).

I.1.4 Physiology and grapes drying process

The grape berry consists of an outer layer (the skin), the pulp, the seeds and the prolongation of the channels of the peduncle, called stele, through which the sap that feeds the berries flows (Hidalgo and Hidalgo, 1999).

The skin is the part of the fruit that surrounds the pulp or fleshy part and constitutes 4.5% to 11% of the berry (Vila *et al*, 2010). When the environmental and nutritional conditions are favorable, large berries with a lower skin-pulp ratio are produced (Catania and Avagnina, 2007). The skin contains the polyphenols and aroma components (Catania and Avagnina, 2007), including terpenes, derivatives of isoprene, pyrazines, alcohols, sulfur compounds and thiols (Vila *et al*, 2010). The outermost layer of the berry is a waxy cuticle that consists of a cellular material made up of wax platelets. The cuticle represents a firm barrier to the movement of water into the atmosphere by evaporation, due to the movement of the air, among other factors (Whiting, 1992). It is lipid polyester usually insoluble, elastic and resistant to thermal degradation (Lúquez, 2001).

The main nutrients of grapes are not only water and sugar (glucose and fructose in equal parts), but also mineral salts, predominantly potassium, nitrogenous substances, tartaric and malic acids that are in the pulp (Carranza, 2009). The cells of the pulp have a thin wall and large vacuoles that store the main components (Whiting, 1992). The pulp represents 80%-90% of the weight of the grape (Vila *et al*, 2010).

The seeds are inside the pulp and differ according to the varieties, and are not found in apyrenic varieties (Carranza, 2009). They represent 4%-13% of the weight of the grape and contain astringent tannins and catechins that make them bitter (Vila *et al*, 2010). The growth of the berry follows a double sigmoid curve. There are three stages: the first is characterized by rapid growth where cell division predominates; in the second phase there is a slowdown in growth, and the seed finishes its ripening; and, finally, a third stage in which the growth is accelerated by cellular elongation, and ends up with a ripening period where physiological and organoleptic changes take place (Mullins et al, 1992).

During the growth of the fruit, the accumulation of sugars and water, the synthesis of pigments and aromas, and the degradation of acids take place. When the grapes ripen, the skin gets its color, mainly red grapes (Vila *et al*, 2010). The pigmentation is due to the presence of anthocyanins that are red flavonoid pigments, malvidin being the most frequent (Carranza, 2009). The anthocyanins are synthesized from the conversion of the phenylalanine and acetate precursors in the cytoplasm, and then they accumulate in the vacuoles of the hypodermal cells (Catania and Avagnina, 2007).

Other pigments are the flavonols, which give the skin different tones of yellow, and are synthesized in the skin as a response to light stimuli. In addition to the phenolic compounds, aromas, pectic substances, tannins and enzymes are also found in the skin (Carranza, 2009).

The berry is green before veraison, that is to say, it has chlorophyll that allows it to produce some of the compounds that nourish it. Most of these compounds come from the leaves that reach the fruit from the ‘vascular bundle’ (Hidalgo and Hidalgo, 1999). It should be noted that sugars, water and mineral substances are transported to the berries by the connecting tissues (xylem and phloem). The sugar that reaches the fruit via phloem is sucrose (produced by the photosynthesis of the leaves) to be split into glucose and fructose, and then it accumulates in the vacuoles. These monosaccharaides also serve as precursors to synthesize within the berry the rest of the compounds such as pigments, phenols, acids and odorant substances, by means of the activation of certain genes (Vila *et al*, 2010).

Drying grapes is a process that allows the fresh fruit to have a longer useful life. The final moisture content of the product is 10%-15% and the concentration of sugar is 70%-80%, this condition being unfavorable for the survival of most organisms that deteriorate food (Whiting, 1992).

To obtain raisins, over-ripeness is achieved; at the beginning, a phenomenon occurs, such as the change of color: white grapes become golden, and red grapes become deep blue (Catania and Avagnina, 2007). In the drying process, 95% of the lost weight is water, 2% is carbon dioxide; constant amounts are produced during the drying, and the remaining 3% corresponds to other compounds (Martin and Stott, 1957). The berries lose firmness and begin to stick in the fingers of those who handle the grapes. The skin loses astringency and herbal aromas due to the change in the composition of the cell wall; these processes are carried out by pectolytic enzymes that hydrolyze the pectins, making them soluble in water. Some anthocyanins migrate to the pulp, which is easily appreciated, since rubbing the pulp with the fingertips dyes them red. When the ripen seed begins to turn brown, dry and hardened, it can be detected visually. The stalk turns brown and begins to lignify (Catania and Avagnina, 2007).

During the first stage of the drying process, grapes do not wrinkle; that is to say, they keep their shape due to an elastic contraction of the skin (Martin and Stott, 1957). Afterwards, an equalization of temperatures between the berry and the environment takes place, and then dehydration starts. The duration of this period depends on the size of the berry (Whiting, 1992).

In the second stage, the skin begins to wrinkle, which is linked to a loss of 20%-50% of the original weight. The loss of water during this period is due to the increase of the permeability of the cuticle, accompanied by a low relative humidity of the surrounding environment, producing a water gradient (Martin and Stott, 1957). During the last stages of the drying process, water loss is prevented thanks to the osmotic effects of sugars (Whiting, 1992).

The third and last stage occurs when approximately 95% of the water evaporates (Martin and Stott, 1957); in other words, when the moisture content of the berry and of the air achieves balance (Whiting, 1992).

I.1.5 Effect of the defoliation in the physiology of the plant

Little is known about the photoassimilates reaching the storage organs, with respect to: the moment in which a cut of shoots occurs, the number of remaining leaves, and the location of the leaves that were removed. The existence of reparative mechanisms in vine plants under stress conditions has been proved, for example, when defoliation occurs (Smart, 1992). This practice allows to shape the foliage and to increase production. Experimental data indicate that defoliation increases the photosynthetic capacity of the leaves, and stimulates the export of assimilates (Koblet *et al*., 1996) or, in other words, it improves the outflow of assimilates from the remaining leaves. However, the reassignment of photoassimilates is necessary for the permanent supply to the receiving organs. The removal of the foliar area causes an increase in the demand of photoassimilates due to the reduction of the assimilation area. The regulation of photosynthesis is related to the composition of carbohydrates and their concentration in the mesophyll. An activation of the photosynthesis takes place when there is a decrease in the total carbohydrate content of the plants, after a partial removal of the foliage (Smart R., Canopy Management, 1992). The leaves removal in the early stages of the berries development can reduce yields due to damage to flowers and clusters (Vasconcelos and Castagnoli, 2000). However, a blunting or elimination of secondary shoots produces an increase in the percentage of curdled flowers, since the growth of their vegetative apex competes with the flowers for photoassimilates (Vasconcelos and Castagnoli, 2000). Conversely, if the number of meristems is limited (for example, by severe pruning), each shoot will grow rapidly and the leaves will expand to their maximum possible size, but the development of the canopy will be poor due to the small number of shoots. In treatments where the apex is eliminated, the final number of berries per cluster, the cluster weight and the yield per shoot increase.

However, the removal of ripen leaves two weeks after flowering reduces the leaf bud fertility in the following season (Vasconcelos and Castagnoli, 2000).

The source-sink balance can be altered by defoliation practices. When defoliated, a powerful sink area is created for the carbohydrates and the flow of photoassimilates is redirected in all the stages of the development of the shoots. It also promotes transport to the defoliation area from the young leaves. The stimulation degree of this transport depends on the severity of the defoliation. It not only reduces the area that generates photoassimilates, but there are also lesions in the plant that trigger the metabolisms of alarm substances such as ethylene, jasmonic acid, ABA, hydrogen peroxide, among others (Keller, 2003).

The development of the leaf area increases with the number of shoots due to a greater number of leaves per vine. The vine assimilates a finite amount of carbohydrates during a certain period of growth. However, the amount depends on the environment, environmental conditions and the balance of carbohydrates between sources and sinks (Martin & Stott, 1957).

The organic compounds produced during photosynthesis and the assimilation of nutrients, carbohydrates and mineral ions must be transported from a place of production and storage (source) to the places where they are finally used (sinks) (Keller, 2003). A source is any organ of the plant that exports material. For example, ripe leaves produce more photoassimilates than they need for their own growth and metabolism, but all green tissues (including shoots and clusters) can contribute to the production of assimilates. Other sources can be the wooden structures (canes, trunks and roots) that function as storage organs (*Ibid*, 2003). A sink is a non-photosynthetic organ of the plant that produces insufficient amount of photoassimilates to complement its growth and metabolism. They can be growing vegetative organs (young leaves, radical hairs), storage organs (shoots of canes, trunks and roots), or reproductive organs (flowers, fruits and seeds in development). Sugar, starch, amino acids and proteins stored in these tissues can be redistributed in spring to tolerate bud break and the initial growth of shoots and roots before the new leaves start exporting sucrose (Ibid, 2003).

The accumulated reserves after harvest are fundamental for the bud break. The relations between producer and consumer organs are fundamental for the management, transport and distribution of photoassimilates in the plants. The transition from sink to source occurs when the leaf is one third of its size; however, it continues to store photoassimilates until it reaches half its final size (Keller, 2003).

Carbohydrates, mostly starch and mineral nutrients, are stored as reserves in the vine. They are used in the absence of newly formed photoassimilates (Winkler, 1962). The reserves of carbohydrates support the vegetative growth during the development of the canopy. The number of reserves varies; therefore, the amount of growth that they can support will also vary. These reserves are used to support the growth of the shoot up to the tenth leaf. The mobilization of reserves increases until the sixth expanded leaf and then it decreases. When the leaf ripens, about 40 days after unfolding, it is a source with a gradual decay of photosynthetically immovable carbon. But it becomes a major source of nutrients, such as nitrogen and phosphorus, towards the end of its life (Keller, 2003).

The starch is in the living parts of the plants, starting in the middle section of the branches and continues towards the apex and its base. Its accumulation is slow at the beginning, while there is growth of the branches and clusters, and then it accelerates when the temperature begins to decrease until the proximity of the vegetative zero. It is transported through the phloem and it becomes the reserve of the living tissues of the central cylinder, branches, trunk, neck and roots of the plant. Its concentration in leaves reaches a maximum shortly before sunset and a minimum at sunrise (Hidalgo, 1999).

Reserves of mineral nutrients, especially nitrogen, are important to the total growth of the vine. Arginine is the main form of nitrogen storage (Kliewer and Ough, 1970). It is assumed that a large percentage of this element is required for the new vegetative growth, and it flows from the nitrogenous reserves in the permanent structures of the plants, predominantly in the roots. More recent studies quantified the mineral elements required for the maintenance of the vine in pots and their remobilization from the reserve organs. So it can be said that the root system provides 40% of the nitrogen that is necessary for the new stems in young plants. Conversely, in field plants between 14% and 26% of the nitrogen required by the new growing stems was remobilized from other permanent organs and not from the roots (Williams *et al*, 1987). The roots begin to provide reserves to sustain the growth rate per shoot when carbohydrates are not enough; therefore, the shoots begin to compete with each other for carbohydrates, water and nutrients. At this point the real amount of growth per shoot is reduced (Winkler, 1962).

Two-year old plants of the Thompson Seedless variety that grew in a field were evaluated, and it was determined that their content of dry matter was three times higher than in potted plants (Williams *et al*, 1987). Between 10% and 30% of Carbon 14 assimilated by young plants is transported to the trunk depending on the time of year. This indicates that the amount of carbon that the plant absorbs and that is distributed to the trunk and canes, varies throughout the vegetative cycle depending on the age, the type of establishment of the vineyard, and the genotype (Hidalgo, 2002). In another study with plants of the Thompson Seedless variety it was determined that 15 g of plant-1 nitrogen were remobilized from the roots to the stems, between the bud break and flowering. This represented 70% of the nitrogen requirements in the stems. The roots are capable of supplying the rest of the plant with the nitrogen absorbed from the soil, even at the beginning of the vegetative cycle (*Ibid*, 2002). The nitrogen accumulated in the fruits comes mainly from the nitrogen stored in the roots and trunks. This was determined by using fertilizers marked with nitrogen 15. It can be said that the amount of nitrogen remobilized from roots, trunks, and other permanent structures, depends on several factors, including the age of the plant, the time of year, and the growth conditions (Williams *et al*., 1987). In a study carried out in 1994, pruning samples were taken in order to determine the amount and redistribution of the isotopic tracer in different parts of the plant. High amounts of autumn nitrogen were stored in perennial parts (30% of the total), while this figure was 17% in the case of spring nitrogen. Therefore, a part (83%) of the assimilated nitrogen in spring was used to guarantee the growth of the new shoots and ensure the first steps of the growth, until the leaves of the base expanded. The sources and sinks are coordinated in such a way that the demand for assimilates by the sink and the supply of the source are always proportional (Smart, 1992).

I.1.6 Growth of the leaf area and photosynthetic activity

The growth rate of the shoots is influenced by genetic factors (cultivar, rootstocks temperature, soil moisture, nutrient availability, reserve levels, type of pruning, and age of the plant (Keller, 2003). The unfolding of the leaves in the knots occurs at the tip as the shoot lengthens, due to an increase in the average temperature over the days (Winkler, 1962). The complete expansion of the leaves occurs 30 or 40 days after they unfold, and it varies according to the variety, location and condition of the plant. The arrangement of the leaves in the stem is alternate and distichous so that a divergence angle of 180° forms between them, in such a way that they are opposite each other throughout bud break (Pratt, 1974).

The young leaves of the main growing shoots produce and release auxins, which stimulate the elongation of internodes and inhibit the growth of lateral shoots (Winkler, 1962). The apical dominance decreases when 18 to 20 leaves have developed during the bud break, due to the arrival of cytokinins produced at the tip of the roots and distributed by the flow of perspiration (Keller, 2003), from where side shoots can grow (Ibid, 2003). These shoots add an additional surface that provides a greater number of photoassimilates, since they become net exporters of carbohydrates because they have two fully expanded leaves.

During the veraison process[1], the branch has young leaves in the first three knots, leaves that grow between the fourth and eighth knots; and adult leaves in the ninth and twelfth knots (Ribéreau-Gayon and Peynaud, 1971). The adult leaves export photoassimilates towards young leaves and inflorescences during the flowering season. After the growth slowdown, the export of photoassimilates moves towards the old leaves, from the base of the branch and clusters (Hidalgo, 2002). The photosynthetic rate begins to decrease after the maximum expansion of the leaf occurs (Kriedemann et al, 1970).

A part of the sugar produced by photosynthesis is used in respiration (Winkler, 1962). What is not used immediately gives rise to other carbohydrates such as fructose, which is the sugar of the ripe grape; cellulose, which is one of the constituent materials of cells, or starch, which is stored by the plant (Hidalgo, 2002). Sugar is also one of the basic nutrients for the synthesis of proteins, along with other elements such as nitrogen, phosphorus and sulfur, and the synthesis of fats (Winkler, 1962).

High intensity light, temperatures between 25° C and 35° C, and adequate supply of water and nutrients are necessary during the pre-dormancy phase for the formation of inflorescences. The fecundity depends on the supply of assimilates to the buds, rather than on their exposure to light. These assimilates come mainly from the leaves that are on the same side of the shoot where the leaf bud is (Keller, 2003). In plants with excessive vigor, the buds are less fruitful due to the competition for photoassimilates and the buds' shading. In weak plants there is also low fertility (Hidalgo, 2002).

In order to obtain maximum quality and quantity harvests, depending on the desired objective, it is necessary to maintain the reproductive vegetative balance of the plant, which refers to the leaf surface in square meters that the plant must have for each kilogram of grape it produces (Vila, et al, 2010). In turn, the development capacity of the vine is determined by the total area of leaves, and by the percentage of sunlight saturation (Winkler, 1958). The sun emits electromagnetic radiation in a band of 300 to 1,500 nm. To perform photosynthesis, the plant uses wavelengths of 400 to 700 nm, called photosynthetically active radiation (Smart, 1992). The leaf absorbs between 85%- 90% of the photosynthetically active radiation; 6% of the rest is reflected and

4%- 9% is transmitted through the leaf (Keller, 2003).

All of the above impacts the productivity of the plant, which is determined by the leaf area and the number of leaves. Different experiences in *Vitis vinifera* varieties indicate that 7-15 cm^2 of the leaf area are required for a gram of fruit to ripen. The variation of these

[1] 2 It refers to a ripe shoot that is about to become an arm.

values will depend on factors such as cultivar, climate, plant formation, and cultural practices (Kaps and Cahoon, 1992).

With regard to the Thompson Seedless variety, Kliewer and collaborators (1970) determined that with a 10 cm^2- leaf area per gram of fruit a harvest maturity of 23° Brix is obtained. On the other hand, the concentrations of proline, arginine and total nitrogen in the juice of the berry reach a maximum when the ratio of leaf area is 10 -14 cm^2 per gram of fruit at harvest time (Kliewer, 1970). May and colleagues (1969) reported that 5-7 cm2 of leaf area per gram of fruit are required for the maturation process of Thompson Seedless grapes to reach completion in Australia. Kliewer and Antcliff (1970), in the same place in a different growing season, found that 10 cm^2 of leaf area per gram of fruit are necessary for it to ripen.

For the Moscatel of Alejandria variety, Winkler (1930) reported that 12-15 cm^2 of leaf area per gram of fruit are needed for ripening using ringed shoots. Therefore, a cluster of 40 berries will require 1,300-1,800 cm^2 of leaf area, which represent 12-16 leaves for the fruit to ripen correctly. Meanwhile, Buttrose (1966) determined that 1,500 cm^2 of leaf area per cluster is needed in Moscatel of Alejandria plants in pots for normal ripening, without affecting the development of the vegetative organs (Ibid, 1966).

To make an average size cluster ripen, 4,000 cm2 of leaf area are needed, so the shoot must have 16 leaves per cluster, since each one covers 250 cm^2 (Kliewer, 1970). With 16 leaves per shoot, the fruit obtains a quick coloration, a high percentage of starch and carbohydrates, heavier clusters and more sugar content (Weaver, 1963). Winkler suggests that with 24 to 26 leaves per cluster there is enough foliar area per unit of weight to obtain high quality fruit, either for table grapes, raisins or to make wine (Winkler, 1958). The restriction of the foliar area delays the ripening of the clusters, since it reduces the leaf-fruit ratio in the plant, being overloaded with fruits, which causes greater competition between them (Kingston and Van Epenhuijsen, 1989).

The growth of branches, trunks and roots is affected by the degree of defoliation and the moment it occurs. When defoliations of 50% or more start after curdling, the growth of the branches, trunk and roots is affected; whereas a reduction of 50% or more of the leaves in the veraison, affects the growth only of the trunk and roots. Finally, at harvest time, defoliations of 50% or more only affect root growth (Kliewer and Ough, 1970).

A factor related to the leaf area is the number of functional leaves that are found on the surface of the canopy and the leaves that are inside. Those found inside, being in the shade, affect the composition of the berry causing an increase in pH, potassium content, and a decrease in sugar content (Williams *et al*, 1978). The interception of 70% of direct sunlight occurs in the first 0.1 m of canopy, and it is this part that accounts for most of the fixed carbon (Smart, 1988). In the inner leaves of dense canopies, the amount of light they receive and the density of the flow of photosynthetic photons are reduced compared to those that are exposed to ambient light (Smart, 1991). The ratio of quantum flux of red light to far red goes from 1.1 to 1.2 in sunlight; to 0.1 or less that may be inside dense canopies (Smart *et al*, 1992).

The light inside the canopy is closely related to the number of shoots the plant has. Canopies with low shoot density (less than 10 shoots per meter) are very open, they have a high proportion of clearings, and most leaves and fruits are well exposed to sunlight. A high density of shoots (more than 30 per meter) results in canopies without spaces, and a large number of shady interior leaves and fruits (Smart, 1988).

Leaf area measurements are important to evaluate conduction systems, to calculate the rate of carbon dioxide assimilation, to determine the plant growth and its productivity, and to estimate population densities of pests and diseases. It is advisable to measure foliar areas with non-destructive foliage methods, which allows them to be available for further measurements. Measuring the shape of the leaf, and linear canopy measurements using portable equipment of foliar area and light interception, are among non-destructive methods (Kliewer and Ough, 1970).

A simple way to determine the leaf area directly in the field is by making linear measurements of the length and width of the leaf. This was verified by obtaining satisfactory results from measurements of leaf dimensions, with the actual leaf area determined with a leaf area meter. This technique consists of taking a certain number of leaves from the canopy, placing them in a bag and keeping them on ice until they are taken to the laboratory. The variables that are measured are the width of the leaf (W) and its the length (L); by multiplying the width by the length of the leaf (W x L), we obtain the square of the width of the leaf (W^2) and the square of the length of the leaf (L^2). With computer programs, a regression analysis is performed by using the dimensions obtained from the leaves. These programs resulted in two equations that can be used to determine the leaf area. The first equation is: Area = -1.14 + 0.527 (W^2) + 0.254 (L^2). For leaves larger than 300 cm^2 the most precise equation for variety Concord is: Area = -3.01 + 0.85 (W × L) (Elsner and Jubb, 1988).

Smith and Kliewer (1984) established the regression models that can be used to predict the leaf area in Thompson Seedless vines, and destructive measurements are not necessary. In this investigation, they performed regression analysis to determine if there is a correlation between linear length (L) and width (W) measurements of the leaves, the leaf area being determined with an integral meter of photometric area. Some prediction models that could be obtained for different situations are:

Flowering, 1981:

Y = (3,104 ± 1,371) + (0,554 ± 0,020) LW

r = 0,986 ± 0,003

The veraison 1981:

Y = (7,270± 1,826) + (0,567 ± 0,014) LW

r = 0,981 ± 0,008

Flowering, 1982:

Y = (1,821 ± 1,094) + (0,601 ± 0,020) LW

r = 0,990 ± 0,006

Oliveira and Montilla (1995) calculated the leaf area by means of an equation that describes the interception of the radiation by the canopy. They determined the correlation that exists between the leaf area of the canopy and the interception of its radiation. To do this, a leaf area integral meter was used, and the interception of the radiation was calculated with an equation similar to Beer's law. The equation obtained is: Sh (L) = Sh (0) exp (-KL), where Sh (0) is the flux density of photons measured horizontally above the canopy; Sh (L) is the flux density of photons below a leaf area index L; and K is a coefficient of extinction of the canopy. This coefficient represents the relationship between the projected shady area of the canopy on a horizontal surface and the superficial area of the canopy. The measures obtained were highly correlated; therefore, the relationship can be described by means of the following regression equations: Am = -8.635, 79 + 1.21 x (Ac) and Am = 0.11747 x $(Ac)^{1,2045}$ where Am is the area measured with the integral meter, and Ac is the calculated area.

Another alternative way to obtain the leaf area is to measure the length of the main shoot and its secondary shoots, and then both measurements have to be added. To do this, 30 shoots of 30 different plants are measured, and the average weight of clusters obtained from the measured shoots is determined; the right time to make this measurement is during veraison. The leaf area is calculated by means of regression models that must be generated if they do not exist for the variety under study. To generate these models, the length of the shoot and secondary shoots of 25 buds of different sizes, and the leaf areas of each shoot must be measured. The 25 pairs (length of the shoot and surface of leaves) are entered into computer programs and the regression model is calculated. With the values obtained by means of the regression model for each sprout, the leaf area per plant is calculated, and the kilograms of grapes of each plant are related (Vila *et al*, 2010), thus obtaining a more precise and comparable index.

I.1.7 Basics of Dry On Vine system (DOV)

The DOV system is an alternative method for the commercial production of raisins. The system was used for the first time in 1956 (Whiting, 1992). The difference with the systems for making raisins used in San Juan is that the clusters are dried in the plant (Espíndola and others, 2014). Harvesting takes place when the raisins have less than 18% moisture, and preferably 16% (Whiting, 1992). In this way, the process of harvesting the grapes, placing them on the ground in the sun, turning them around, and then picking them up, is reduced to cutting and picking up (Espíndola *et al.*, 2014).

It is a more economical system of raisins production, but it requires significant changes in the pruning system, in the conduction of the plant and in fruit handling (Whiting, 1992). When the DOV system is used, a cut is made in the branch, and the foliage and fruits remain lying on the wires, where the cluster will dehydrate (*Ibid*, 1992). The grapes take longer to dry with the DOV system, compared to the traditional system, since the temperatures at the height of the wires are lower than on the ground (Espíndola et al., 2014).

DOV is recommended for vigorous varieties that bear the negative effect of harvest pruning, and that have low basal bud fertility; that is to say, they have a low tendency to form clusters near the cross (Whiting, 1992). The problem is that the clusters near the cross generate rottenness or require manual picking up. (Espíndola *et al*, 2014). The branch must be cut in the right place to ensure that most clusters dry on the wires (Whiting, 1992). After harvest pruning, 40% of the active leaf area must be available to keep the vigor of the plant (Ibid, 1992). The clusters are usually cut by hand with a pruning yield of approximately 0.4 ha per person per day (Ibid, 1992).

The cultivars that best adapt to DOV are: Thompson Seedless, Fiesta, Dovine, Selma Pete, Black Corinth (Zante Currant), Summer Muscat, Diamond Muscat (Vasquez and Fidelibus, 2004). Flame Seedless´ s bud break is the third week of September, blooms the fourth week of October and ripens the fourth week of December. It is a vigorous variety that adapts to the DOV system.

I.1.8 Making raisins and drying systems

Dehydration allows food to prolong its conservation period, to reduce its weight and volume, and to save money on transport. However, drying processes consume large amounts of energy and the cost is high compared to that of other conservation methods (Holdsworth, 1988). The word '*dry'* is used to describe the loss of water under natural conditions, while '*dehydration*' is used to describe the loss of water under controlled conditions of air flow, temperature and humidity (Phaff, 1951).

The relative humidity, the speed of air flow, and the difference of moisture content between the environment and the berry exert influence on the drying process of the fruit. The rate of evaporation can be used to calculate the drying speed of the fruit (Wilson 1962). Many treatments have been developed to improve the drying speed of the grapes. These involve a modification of the berry cuticle or changes in the drying conditions to accelerate the loss of water (Whiting, 1992).

The traditional method used in Spain is the hot bath of wood ashes, lime $Ca(OH)_2$ and caustic soda $Na(OH)$. In Australia, the fruit is immersed in a caustic soda solution at 85°C for a few seconds. This treatment removes part of the wax, and divides the skin cells of the berry to increase the drying speed. However, this method is no longer used. It was replaced by immersion in cold oil, due to the fact that the fruit darkens because of the loss of sugar when it is in storage (Grncarevic and Radler 1971). Another method is the use of an alkaline oil emulsion. It is prepared by using immersion oils and potassium carbonate (K_2C0_3). The emulsion alters the waxy cuticle and improves drying (Grncarevic 1963).

The drying tunnel is an alternative that prevents the fruit from darkening and losing sugars; therefore, the quality obtained with this method is excellent. Drying is carried out for three days at 60°C. Despite being a costly drying process, it gives a higher added value to the fruit (Whiting, 1992).

In California, most hand-picked grapes are dried in individual trays or placed in a 6 to 10-level rack, made of steel and placed between rows of vines, exposed to the sun (*Ibid*, 1992). Subsequently the rack is sprayed with drying oil emulsion and potassium carbonate (Grncarevic and Lewis 1976). The temperature on the surface of the tray can exceed the ambient temperature by 5°C, and the raisins take from 10 to 20 days to dry, depending on the weather (Ibid, 1976).

When the weather conditions are not favorable for drying the fruit in the field or when rapid drying is required, dehydrating systems with burners that heat the air at temperatures of 50°C to 60°C are used; 6 to 10 hours are enough to complete the drying time (Berrett and Weste, 1978). In our area, no artificial dehydration system is used to dehydrate or dry the fruit; the grapes are dried in the sun on a plastic raisin mesh placed on rocks. This allows the temperature to increase due to the direct sun rays on the rocks; the mesh favors the drainage of rainwater without any environmental impact. According to the time of the year, after 5 to 7 days, the mesh is turned over and after 9-10 days the raisins are lifted from the mesh. Later the raisins are conditioned and processed (Pangavhave *et al,* 1999, Pugliese and Espindola, 2011).

Local studies show that in the province of San Juan, characterized by its great luminosity and intense solar radiation, small grapes can complete their drying process in about ten days, and larger ones require between twelve and fifteen days in the months of January - February (Doreste, 2011). Pugliese and Espíndola (2011) determined for the years 2006 - 2009, drying times of 15 to 23 days for the variety Superior Seedless and Sultana; and from 15 to 19 days for the Flame Seedless variety. This variation in time was determined by climatic factors.

When losing water during the desiccation process, the fruits lose weight; that is the reason why four kilograms of fresh grapes are needed to obtain a kilogram of raisins (Doreste, 2011). There is a risk of deterioration due to dust and infections caused by insects. Direct exposure to solar radiation will also deteriorate the color. Also, strange elements difficult to remove, such as small rocks, leaves, dust, among others, can also be picked up together with the raisins (Pangavhave and Sawhenoy, 2000).

The need for greater availability of wages to complete the tasks of picking up grapes and drying them gave rise to several efforts to make these tasks mechanical. However, the possibilities of mechanization have been limited by the conduction systems of the existing plantations and by the very philosophy of the production of raisins by exposing them to sun radiation (Constantino, 2000).

In San Juan, a reduction in labor costs is necessary, since they range from 67.8% to 85.6% of the total operating expenses. The way to reduce costs lies in the management of labor, since in agriculture the possible reductions in the use of fertilizers or pesticides are not significant (Allamad, 2006).

Since the limited availability of temporary workers limits the production of raisins, different systems have been tested since the 1950's, and DOV has proved to be the most promising one (Fidelibus, 2007). The transformation of grapevines into systems that allow the drying of grapes in the plant with the possibility of mechanization represents an alternative solution to this type of problem (Whiting, 1982).

DOV is an alternative method for the commercial production of raisins (Fidelibus, 2007). The system was used experimentally for the first time in California in 1956 (May et al, 1969). It was used as a method to save affected grapes in rainy seasons; but now the producers use the method as a standard management system. Although it was evaluated as a more economical form of production, it requires significant changes in the architecture of the conduction system and fruit handling system (Whiting, 1982). DOV was adopted in the production of raisins in Australia and California. In this system the fruit is dried by cutting canes. The shoots, leaves and fruits are left on the wires of the structure where they dehydrate. An emulsion of drying oil is applied to the grapes shortly after cutting them, and when the fruit is dry, it is manually or mechanically harvested with 16% moisture (*Ibid*, 1982). The most suitable conduction system is the vertical oriented system or trellis, since it allows the pruning of canes and makes harvesting easier because the average height decreases. Horizontal conduction systems such as '*parrales*' can also be used, although they are not as suitable as trellis are. Aged plants suffer greater weakening due to frequent cuts. That is why plants must be strong and vigorous to withstand the effects of harvest and pruning (*Ibid*, 1982).

Canes should be cut at the base to ensure that the trellis holds the fruit. A severe reduction of the foliar area should be avoided to prevent the weakening of the plant. It is important to keep 40% of the leaves so that the plant continues being vigorous (Scholefield *et al*, 1978). If the canes are cut late, there is more time for the drying stage, and a darker, lower quality fruit is obtained (Sarooshi and Roberts 1978). The cutting of the canes can be done by hand or mechanically (Sarooshi and Roberts, 1979).

Reducing 60% of the leaf area of the canopy during the grapes ripening stage affects the yield and growth of the vine (Whiting, 1992). According to Christensen *et al*. (1970) and Whiting (1982) the yield decreases 10% when the reduction of the leaf area caused by the cuts of the canes exceeds 60%. This level is critical and should not be exceeded. Other alternatives to reduce the negative effects of using DOV are the reduction of the frequency of cuts, and the use of different architectures of the plant. Several varieties of hybrids are currently being evaluated in South Africa and California. These varieties could produce dry fruit without cutting the canes, that is to say, while the fruit is still connected to the plant (Whiting, 1982).

Chapter II

Local Research on Superior Seedless

II.1 Introduction

By reading this chapter, the reader will be able to understand the results of the work carried out in the San Juan EEA (Agricultural Experimental Station), INTA (National Institution of Agricultural Technology, on the Superior Seedless variety between the 2010 and 2013 seasons. Superior Seedless is a table grape variety, which depending on the year and market conditions, it is destined to the production of raisins.

In the last ten years, the table grape market has had a progressive decline from 72 million kilograms to less than 10 million kilograms per season. Thus, the Flame Seedless and Superior Seedless varieties, among the most important ones to the production of table grapes, were mainly used to produce raisins. The high costs of production and situations of low profitability were the trigger for technicians linked to the sector to start looking for technological alternatives that saved labor. Among the alternatives, the international bibliography cited the Dry On Vine system (DOV), and the first local studies started to be carried out.

The DOV system is only used in 50% of the productive area (compared to the *'parral* trellis system'); the hypothesis was that the use of DOV systems in San Juan could reduce the production of raisins. Another hypothesis was that a potential fall in the production would be compensated for by the profits that the system would produce by saving the costs involved in harvesting

Another assumption was that the DOV system, due to the cuts during the vegetative stage, would weaken the plant (fall of the reserve content and / or decrease of the leaf area). It was known that the system would produce an increase of the drying times and that it could modify the drying yields, but the way and the magnitude were not known.

This chapter will allow the readers to answer some of these questions, only about the Superior Seedless variety, since with the activities explained in the Materials and Methods section, we sought:

a) to measure the yield per hectare with both systems to produce raisins: the traditional one and DOV;

b) to measure the fresh / dry weight ratio;

c) to measure drying times;

d) to obtain a leaf area equation;

e) to measure the Ravaz index; calculate the ratio of leaf area to fresh weight of fruit;

f) to measure the total nitrogen content in branches in the third season;

g) to measure the times of the stages in the drying process, and h) to estimate the wages per hectare paid in both systems.

II.2 Materials and methods

The study was carried out in the San Juan Agricultural Experimental Station (EEA) of the National Institute of Agricultural Technology (INTA), Pocito, a district located in the south-central part of the province of San Juan, during the 2011, 2012 and 2013 seasons.

Figure 1: Location of the farm.
Source: Google Earth, version 6.0.

The research was carried out in a Superior Seedless vine with a distance of 3 x 3 m (1100 plants/ha). A completely randomized design with three treatments and five repetitions was used, the experimental unit being a plant. To select the vines, the pruning weight of 20 plants was taken into account. The average value found was 5.8 kg with a standard deviation of 1.14 kg, which created a range of 4.66 kg to 6.94 kg. The plants outside the normal range were discarded. Finally, a treatment was assigned to each plant (experimental unit) by drawing lots.

Table 3: Measurement of pruning weights and selection criteria according to SD = 1.14.

Plant	Weight	Range		Criteria
1	5.3	4.66	6.94	Normal
2	5.12	4.66	6.94	Normal
3	3.82	4.66	6.94	Change
4	4.98	4.66	6.94	Normal
5	3.96	4.66	6.94	Change
6	5.12	4.66	6.94	Normal
7	5.88	4.66	6.94	Normal
8	6.94	4.66	6.94	Normal
9	5.82	4.66	6.94	Normal
10	6.75	4.66	6.94	Normal
11	5.12	4.66	6.94	Normal
12	5.78	4.66	6.94	Normal
13	5.12	4.66	6.94	Normal
14	6.75	4.66	6.94	Normal
15	7.64	4.66	6.94	Change
16	6.46	4.66	6.94	Normal
17	8.04	4.66	6.94	Cambio
18	5.88	4.66	6.94	Normal
19	6.94	4.66	6.94	Normal
20	5.82	4.66	6.94	Normal

Table 4: Pruning weight per plant

S-E			
13/ 7.64 kg	14/ 6.46 kg	15/ 8.04 kg	15´/
12/ 5.78 kg	11/ 5.12 kg	10/ 6.75 kg	10´/ 4.64 kg
7/ 5.88 kg	8/ 6.94 kg	9/ 5.82 kg	9´/
6/ 5.12 kg	4/ 3.96 kg	4/ 4.98 kg	4´/ 4.68 kg
1/ 5.3 kg	2/ 3.96 kg	3/	3´/ 3.82 kg
N-W			

As it was mentioned before, three treatments were performed (T1, T2 and T3) with five repetitions each. The distribution of the pruning elements in the treatments was carried out by counting the bud per plant.

Table 5. Bud distribution in spurs and guides by treatment.

Treatment	Plant number	Canes buds	Spur buds	Total Buds
1	10´	110	10	120
1	12	77	28	105
1	11	77	28	105
1	10	88	28	116
1	9	88	32	120
2	2	132	20	152
2	3	143	20	163
2	5	143	20	163
2	13	143	22	165
2	14	143	20	163
3	1	99	30	129
3	4	88	30	118
3	6	99	28	127
3	7	99	30	129
3	8	88	32	120

Treatment 1 (Control or T1): normal pruning of 10 canes (10 buds on average) and 10 spurs, with a total of 120 average buds per plant. Traditional drying was carried out (in the sun): grapes were laid on a plastic mesh on rocks/gravel, turning them over after 7 days.

Treatment 2 (T2): pruning with 10% of spur buds for renewal wood (10-14 spurs) and 90% of cane buds for the production using DOV system (10-11 canes of 10 buds). An imaginary line that divided the plant on the southwest (spurs) and northeast (canes) was established according to the research purposes. On harvest day cuts[2] were made at the base of the canes with fruit.

Treatment 3 (T3): pruning with 30% of spur buds for renewal wood (18-22 spurs) and 70% of cane buds for production using the DOV system (8-9 canes of 10 buds). An imaginary line that divided the plants on the southwest (spurs) and the northeast (canes) was established, according to the research purposes. On harvest day, cuts were made at the base of the canes with fruit. The harvest was made when the grapes reached 21° brix. To carry out the distribution of the pruning elements in the treatments, a bud count per plant was carried out.

[2] After the berries accumulated enough soluble solids, in T2 and T3, canes were cut above the third or fourth basal knot with the pruning shears. Clusters of secondary shoots were also hung on the wires of the *parral*.

The variables evaluated were:

- Drying time.
- Ratio of percentage between fresh weight and dry weight of the grape.

Controls were performed on the dehydration process every two days in the traditional drying (T1) and weekly in the DVO system (T2 and T3).

At harvest time, the degree of dehydration of the fruit was evaluated physically and visually.

Table 6. Location of the vines in the study plot.

S-E		
T3	T2	T3
T2	T1	T2
T2	T3	T3
T2	T1	T2
T1	T3	T1
N-W		

II.2.1 <u>Determining fresh weight. dry weight. yield and drying time</u>

II.2.1.1 <u>Fresh weight</u>

T1. A traditional harvest was carried out using harvest boxes of 10 kg that weighed 1.4 kg. and the net weight per plant was determined with a precision weighing scale of 150 kg.

T2 y T3. The fresh weight was determined in an indirect way. A cut was made at the base of the canes. The number of clusters was counted and the fresh weight per plant was determined by the average weight of 40 clusters. The volume of 15 clusters was also measured and they were related to the density according to their sugar content.

II.2.1.2 <u>Dry weight</u>

For all the treatments, raisins with moisture content close to 16% (visual and physical determination) were picked (T1) or harvested (T2 and T3) in 10 kg plastic boxes and they were weighed with a 150 kg precision scale.

II.2.1.3 Yield

The yield was determined by means of the quotient between the two variables (fresh weight and dry weight in kg) for each treatment.

II.2.1.4 Drying time

T1. The number of days that elapsed between laying the grapes in the sun and picking up the raisins from the mesh was counted.
T2 and T3. The number of days elapsed since the cut at the base of the canes was counted until the raisins were harvested.

II.2.2 Estimating the wages required

T1. The execution time of the tasks was recorded: a) harvesting; b) laying grapes in the sun; c) turning them over and d) picking them up from the mesh (s/m^2).
T2 and T3. The execution time of the tasks was recorded: a) cane base cut. and b) bunches harvest. The time of harvest was added to the time of the process of laying the spur clusters in the sun.
These tasks were done by two unqualified people. The results for each treatment were affected by a factor of 220 that led to an equivalent of wages per hectare (1100/5).

II.2.3 Measuring the nitrogen content in branches

The nitrogen content was measured with branches samples, after using DOV for three seasons. In this case, after the 2013 pruning, a sample of 10 branches was taken (1 cm for each branch of the internode where the cluster is) of each repetition and each treatment.
Then they were taken to the laboratory where they were dried in a heater for 72 hours until they reached constant weight; then they were ground). After that the Kjeldahl technique to measure total nitrogen was applied.

II.2.4 Method of measuring the leaf area

A model to estimate the leaf area (LA) for the Superior Seedless variety was developed by estimating the length of 30 shoots and measuring the leaf area with a leaf area meter that belongs to the San Juan EEA INTA.

Subsequently, during veraison, the length of four shoots per plant was measured (two from the spur sector and two from the cane sector), and the number of shoots per plant was counted. Then the LA per plant was calculated with the regression equation obtained when building the model.

The data were analyzed by using the variance (ANOVA) and for the separation of the mean, the Tukey test was used. Infostat program version 1.1 (INFOSTAT F.C.A, Cordoba National University, Argentina) was used.

II.3 Results

II.3.1 Descriptive statistics: fresh weight, dry weight and yield

During the 2011 cycle, the fresh weight variable presented an average of 12.67 kg to 15.37 kg for the three treatments. The maximum value found was 22.46 kg for T1 (traditional pruning), followed by T2 and T3 (21.5 kg and 17.72 kg, DOV systems). The highest standard deviation was observed in T1: 6.02 with a standard error of 2.69. With respect to the dry weight, the mean of T2 and T3 (1.89; 1.88) is similar, while T1 showed a value of 41% higher (3.21). The yield in raisins in the three treatments (Traditional and DOV) has an equivalent average that goes from 0.2 to 0.23 with a standard deviation of 0.02 to 0.04 and a maximum standard error of 0.02 for T2.

Table 7. Descriptive Statistics: values found in the year 2011.

Treatment	Variable	n	Mean	SD	Var(n-1)	SE	CV	Min.	Max.	Median
1	Fresh weight	5	15.37	6.02	36.24	2.69	39.16	8	22.46	18
2	Fresh weight	5	12.67	5.88	34.63	2.63	46.46	7.26	21.5	13.36
3	Fresh weight	5	13.36	3.38	11.43	1.51	25.31	8.72	17.72	13.36
1	Dry weight	5	3.21	1.09	1.2	0.49	34.05	1.92	4.48	3.66
2	Dry weight	5	1.89	0.93	0.86	0.42	49.19	0.82	3.35	1.9
3	Dry weight	5	1.88	0.84	0.71	0.38	44.78	0.96	3.17	1.57
1	Drying Ratio	5	0.21	0.02	2.60E-04	0.01	7.59	0.2	0.24	0.21
2	Drying Ratio	5	0.16	0.06	3.90E-03	0.03	40.13	0.11	0.26	0.14
3	Drying Ratio	5	0.14	0.05	2.90E-03	0.02	37.49	0.07	0.21	0.13

With respect to the variables fresh weight and dry weight for T1, T2 and T3 during the 2012 cycle, the relationship between T2 (DOV) and the control is 1/5, while for T3 (DOV) it is 2/9. The maximum fresh weight per plant was achieved in the control (29.98 kg). The minimum was also recorded in the control with 9.59 kg of fresh weight. The difference of maximum fresh weight between T3 and the control was 8.22 kg. The highest dry weight per plant was recorded in T3 (5.745 kg). T3 registers the highest amount of kg of dry weight: 24.905 kg. There is a difference of 10.065 kg with the control.

A difference of 1.45 kg in the fresh weight of spur clusters was observed between T2 and T3 (DOV for both). The difference in dry weight between both treatments (T2 and T3) is lower, since only 0.28 kg was recorded.

Regarding the fresh weight, the minimum values vary from 9.59 kg (T1 Traditional System) to 17.7 kg (T3 DOV 30% - 70%), and the maximum values vary from 21.76 kg (T3) to 29.98 (T1). The difference in T3 with respect to the control in the average value is -1.09% and, in T2 (DOV 10% -90%) with respect to the control of -7.73% (Table 8).

The dry weight of T3 was 30.6% greater than that of T2, and 12.8% greater than T1 (Traditional System). The lowest average value was recorded in T2. The minimum weight of the lowest value was obtained in T1 (1.83 kg), with a difference of 86% with respect to T3. The maximum values are similar (from 5.75 kg to 5.18 kg), and show a variation of 11% (T3 with respect to T2) (Table 5).

Table 8. Descriptive statistics for the fresh weight variable (kg/plant). 2012.

T	Variable	n	Mean	SD	SE.	VC	Min.	Max.
3	Fresh weight	5	19.96	1.47	0.66	7.37	17.7	21.76
2	Fresh weight	5	18.62	4.53	2.03	24.32	12.47	22.34
1	Fresh weight	5	20.18	8.32	3.72	41.22	9.59	29.98

Table 9. Descriptive statistics for the dry weight variable (kg/plant). 2012.

T	Variable	n	Mean	SD	SE	VC	Min.	Max.
3	Dry weight	5	4.48	0.87	0.39	19.48	3.41	5.75
2	Dry weight	5	3.43	1.49	0.67	43.43	2.04	5.18
1	Dry weight	5	3.97	1.52	0.68	38.26	1.83	5.62

The average Ravaz index for T1 is 8.36 kg of fruit per kg of wood; in contrast, T3 has a ratio of 17.18. The lowest Ravaz index is recorded for T1 (4.04) and the highest value for T3 (28.63). This indicates that T3 (DOV 30% - 70%) is the treatment with a higher proportion of cuts or less wood (Table 10).

The average secondary shoot weight is from 0.21 kg (T2) to 0.3 kg (T1). The minimum weight of secondary shoots is observed in the DOV treatments with 0.08 kg (T3 and T2), and the maximum value is recorded for T3 (0.95 kg) (Table 11).

Table 10. Descriptive statistics for the Ravaz index variable (kg of fruit/kg of pruning wood). 2012.

T	Variable	n	Mean	SD	SE	VC	Min.	Max.
3	I Ravaz	5	17.18	7.36	3.29	42.85	8.29	28.63
2	I Ravaz	5	12.52	2.91	1.3	23.28	9.42	16.92
1	I Ravaz	5	8.36	3.89	1.74	46.57	4.04	13.32

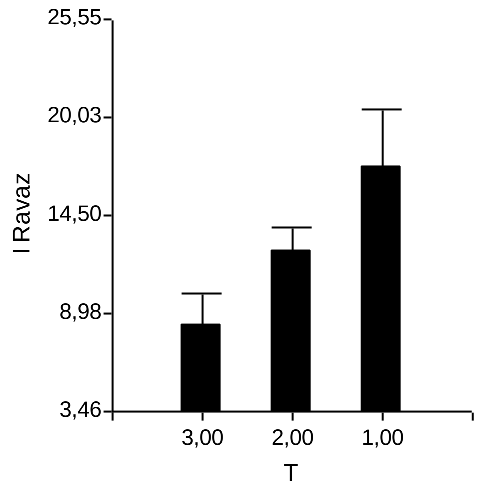

Figure 2. Ravaz index calculated for the 2012 season.

Table 11: Descriptive statistics for the secondary shoots weight variable (kg). 2012.

T	Variable	n	Mean	SD	SE	VC	Min.	Max.
1	Secondary shoot weight	5	0.3	0.14	0.06	47.38	0.13	0.51
2	Secondary shoot weight	5	0.21	0.11	0.05	51.49	0.08	0.36
3	Secondary shoot weight	5	0.28	0.37	0.17	132.38	0.08	0.95

The pruning weight in T1 (Traditional System) is 1.66 times higher than in T2 (DOV 10% - 90%) and 1.83 times higher than in T3 (DOV 30% - 70%). The maximum is 2.74 kg (T1) and the minimum 0.76 kg (T3) (Table 12). The average weight of fresh fruit does not correspond directly to the dry weight between treatments. The highest average value is 20.18 kg and it is found in T1. The highest mean value in dry weight was observed in T3 (4.48 kg) (Tables 8 and 9).

The highest Ravaz index recorded in T3 (DOV) has a correspondence with the lowest weight value of pruning (1.35 kg) and a fruit weight of 19.96 kg. The lower Ravaz index, on the other hand, has the highest pruning weight (2.48 kg) for a fruit weight of 20.18 kg.

The weight of secondary shoots shows less variation between treatments (42.8% difference) than the weight of pruning (83.7% difference).

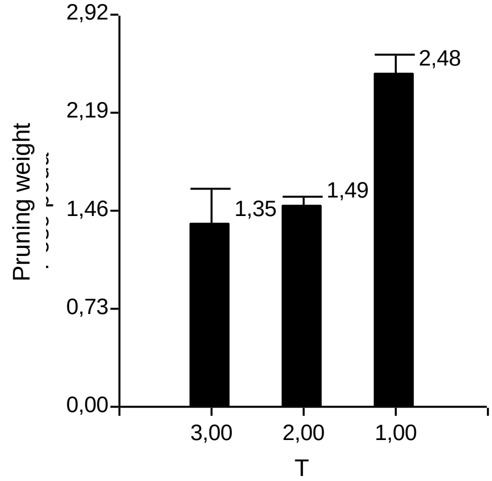

Figure 3. Pruning weight (kg) 2012 season.

Table 12. Descriptive statistics for the pruning weight variable (kg). 2012.

T	n	Mean	SD	SE	VC	Min.	Max.
1	5	2.48	0.34	0.15	13.75	1.93	2.74
2	5	1.49	0.18	0.08	12.11	1.32	1.72
3	5	1.35	0.62	0.28	46.12	0.76	2.38

For the ratio fresh weight / dry weight variables it was observed that 3.5 kg to 6 kg of fresh grapes are necessary to obtain 1 kg of raisins.

Table 13. Descriptive statistics for the ratio fresh weight / dry weight variable. 2012.

T	n	Mean	SD	Min.	Max.
1	5	1/5	0	1/5	2/9
2	5	1/5	0.07	1/5	1/4
3	5	2/9	0.04	1/6	2/7

With respect to the drying time, T1 (Traditional System) was laid in the sun on January 25. 2013, and was picked up on February 14 which determined a drying time of 20 days. On the other hand, T2 and T3 (DOV) took 52 days between the day the canes were cut (January 25) and the harvesting day (March 18). Therefore, the drying time was 32 days longer in the DOV treatments.

II.3.2 Fresh weight:

Volumetric determination and average cluster in DOV system (T2 and T3)

The volumetric determination of a cluster was 395 ml and that of 40 clusters was 185 ml. The average of these values (not comparable by procedure) was 290.16 ml[3]. With regard to the °Brix value, the weights correspond to 427.39 g and to 200.52 g respectively (reference values). The average weight of 40 clusters was 290.5 g. This value is more representative so it was considered the reference value.

Table 14. Indirect volumetric estimate of the Fresh Weight in the DVO system (T2 and T3).

Clusters	Measurement (cm3)	
1	395	cm^3
15	2780	cm^3
Cluster volume	290.16	cm^3
Average weight. (Vol. x density)	313.96	G
Brix teórico a cosecha	19.5	ºbrix
Average Brix. Wednesday 01/16)	18	ºbrix
Rate of Brix accumulation	0.33	ºbrix/day
Density	1.082	g/cm^3
Average weight		
40 clusters	11.62	Kg
Weight of one cluster	0.2905	Kg

Table 15: Fresh weight

Treatment	Repetition	Fresh weight
1	1	22.46
1	2	18.12
1	3	18
1	4	8
1	5	10.28
2	1	7.2625
2	2	7.2625
2	3	13.363
2	4	21.497
2	5	13.944
3	1	13.363
3	2	8.715
3	3	11.9105
3	4	17.7205
3	5	15.106

[3] The 40 clusters were measured in a continuous way, that's why the error was bigger than measuring only one cluster indirectly; this is the reason why the values are so dissimilar.

II.3.3 Analysis of the variance for fresh weight. Dry weight and relation

Table 16. Analysis of the variance for the fresh weight variable (kg). 2011-2012 cycle.

Variable	N	R^2	R^2 Aj	CV
Fresh weight	15	0.06	0	37.95

During the 2011-2012 cycle, we observed that the value of the correlation coefficient (R^2) is 0.06 and the coefficient of variation (CV) is 37.95. This indicates that the degree of adjustment of data is low, and its values are not comparable. The p-value is 0.7051 so there are no significant differences between treatments. However, T1 (Traditional System) shows a higher average than T2 and T3 (DOV).

Table 17. Variance Analysis Table (SC type III) for the fresh weight variable. 2011-2012 cycle.

F.V.	SC	Gl	CM	F	p-value	
Model	19.74	2	9.87	0.36	0.7051	
Treatment	19.74	2	9.87	0.36	0.7051	
Error	329.21	12	27.43			
Total	348.96	14				

Table 18. Test: Tukey Alpha:=0.05 DMS:=8.83792.

Treatment	Mean	n	
2	12.67	5	A
3	13.36	5	A
1	15.37	5	A

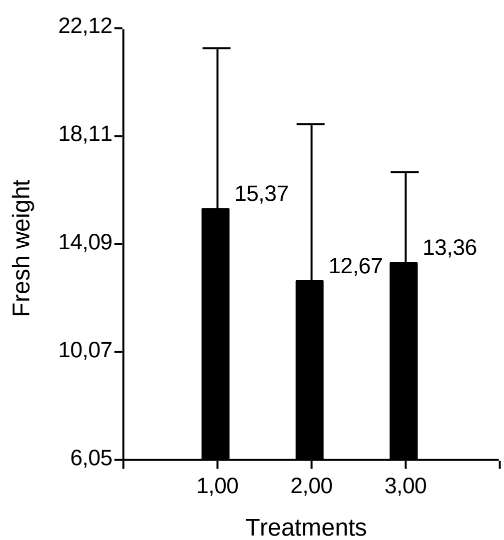

Figure 4. Difference of Fresh Weights (kg) between the three treatments. 2011-2012 cycle.

Regarding the dry weight variable. a similar behavior was observed in terms of the statistics used and no significant differences were observed between treatments.

Table 19. Dry weight. 2011-2012 cycle.

Treatment	Repetition	Dry weight
1	1	4.48
1	2	3.66
1	3	3.78
1	4	1.92
1	5	2.22
2	1	1.895
2	2	0.82
2	3	1.91
2	4	3.35
2	5	1.47
3	1	0.96
3	2	1.567
3	3	1.51

Table 20. Analysis of the variance for the dry weight variable (kg). 2011-2012 cycle.

Variable	N	R^2	R^2 Aj	CV
Dry weight	15	0.19	0.06	30.47

Table 21. Variance Analysis (SC type III). 2011-2012 cycle.

F.V.	SC	Gl	CM	F	p-value
Model	2.18	2	1.09	1.44	0.2746
Treatment	2.18	2	1.09	1.44	0.2746
Error	9.09	12	0.76		
Total	11.27	14			

Table 22. Test:Tukey Alpha:=0.05 DMS:=1.46833.

Treatment	Mean	n	
2	2.33	5	A
3	3.03	5	A
1	3.21	5	A

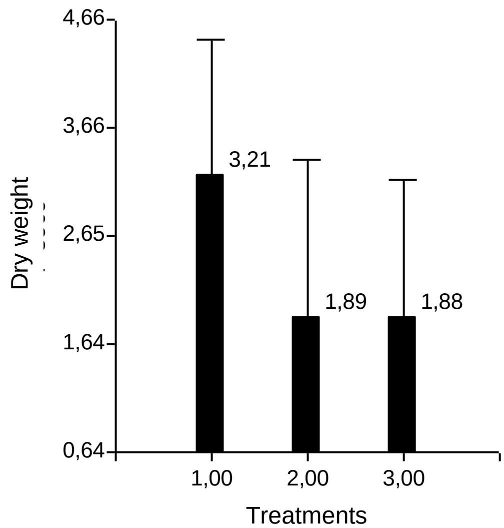

Figure 5. Dry weights (kg) for the treatments. 2011-2012 cycle.

For this variable no significant differences between treatments are observed, either the traditional drying system with respect to the DOV behaves in a similar way.

Table 23. Raisins yield. 2011-2012 cycle.

Treatment	Repetition	Yield
1	1	0.19
1	2	0.20
1	3	0.21
1	4	0.24
1	5	0.21
2	1	0.26
2	2	0.11
2	3	0.14
2	4	0.15
2	5	0.10
3	1	0.07
3	2	0.18
3	3	0.13

Table 24. Analysis of the variance for the yield variable. 2011-2012 cycle.

Variable	N	R^2	R^2 Aj	CV
Yield	15	0.2	0.07	12.63

Table 25. Table for the Variance Analysis (SC type III).

F.V.	SC	Gl	CM	F	p-value
Model	2.20E-03	2	1.10E-03	1.53	0.2557
Treatment	2.20E-03	2	1.10E-03	1.53	0.2557
Error	0.01	12	7.20E-04		
Total	0.01	14			

Table 26. Test:Tukey Alpha:=0.05 DMS:=0.04528.

Treatment	Mean	n	
2	0.2	5	A
1	0.21	5	A
3	0.23	5	A

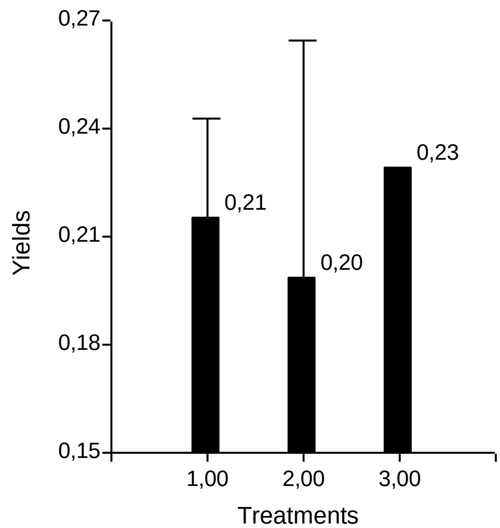

Figure 6. Drying yield. 2011-2012 cycle.

For the 2012-2013 study cycle, the fresh weight variable for the fruit does not have significant differences for T2 and T3 (DOV) with respect to T1 (Traditional System) (Table 27). A percentage variation can be observed between the major mean and the lowest mean of 8.37% with a p-value of 0.8918 (Table 28).

Table 27. Analysis of the variance applied to the fresh weight variable (kg). 2012-2013 cycle.

F.V.	SC	GL	CM	F	p-value
Model	7.08	2	3.54	0.12	0.8918
Treatment	7.08	2	3.54	0.12	0.8918
Error	367.49	12	30.62		
Total	374.58	14			

Table 28. Fisher test applied to control. Treatments 2 and 3. Cycle 2012-2013.

Test: LSD Fisher Alpha:=0.05 DMS:=7.62577			
T	Fresh weight mean (kg)	n	
2	18.62	5	A
3	19.96	5	A
1	20.18	5	A

Different letters indicate significant differences (p<= 0.05)

The p-value for the dry weight variable is higher than 0.05, so there are no significant differences between treatments (Tables 29 and 30). Since the fresh weight and dry weight are not significantly different, neither is their ratio.

Table 29. Analysis of the variance applied to the dry weight variable. 2012-2013 cycle.

F.V.	SC	GL	CM	F	p-value
Model	2.75	2	1.37	0.78	0.481
T	2.75	2	1.37	0.78	0.481
Error	21.17	12	1.76		
Total	23.91	14			

Table 30. Fisher test applied to control. Treatments 2 and 3. 2012-2013 cycle.

Test: LSD Fisher Alpha:=0.05 DMS:=1.83022			
T	Dry weight mean (kg)	n	
2	3.43	5	A
1	3.97	5	A
3	4.48	5	A

Different letters indicate significant differences (p<= 0.05)

The Ravaz index shows significant differences between T1 (Traditional System) and T3 (DOV 30% -70%). In this case T3 is 2.05 times higher than T1. The ANOVA presents a p-value of 0.0541.

Table 31. Analysis of the variance applied to the Ravaz Index variable. 2012-2013 cycle.

F.V.	SC	GL	CM	F	p-value
Model	194.93	2	97.47	3.76	0.0541
T	194.93	2	97.47	3.76	0.0541
Error	311.35	12	25.95		
Total	506.28	14			

Table 32. Fisher test applied to control. Treatments 2 and 3. 2012-2013 cycle.

Test: LSD Fisher Alpha:=0.05 DMS:=7.01914				
T	Ravaz index mean	n		
1	8.36	5	A	
2	12.52	5	A	B
3	17.18	5		B

Different letters indicate significant differences (p <= 0.05)

The variable weight of secondary shoots does not present significant differences between the treatments, according to what both tests indicate.

Table 33. Analysis of the variance applied to the variable Weight of secondary shoots (kg) 2012-2013 cycle.

F.V.	SC	GL	CM	F	p-value
Model	0.02	2	0.01	0.18	0.835
T	0.02	2	0.01	0.18	0.835
Error	0.69	12	0.06		
Total	0.71	14			

Table 34. Fisher test applied to control. Treatments 2 and 3. 2012-2013 cycle.

Test: LSD Fisher Alpha:=0.05 DMS:=0.33076			
T	Mean of secondary shoots weight (kg)	n	
2	0.21	5	A
1	0.28	5	A
3	0.3	5	A

Different letters indicate significant differences (p<= 0.05)

The ANOVA for the pruning weight variable expresses the existence of significant differences between the treatments with a p-value of 0.0023 (Table 35). The Fisher test indicates that there are no differences between T1 (Traditional System) and T2 (DOV 10% -90%), but there are differences between T1 (Traditional) and T3 (DOV 30% -70%) being T3 1.83 times higher than T1 (Table 36).

Table 35. Analysis of the variance applied to the variable pruning weight. 2012-2013 cycle.

F.V.	SC	GL	CM	F	p-value
Model	3.77	2	1.88	10.56	0.0023
T	3.77	2	1.88	10.56	0.0023
Error	2.14	12	0.18		
Total	5.91	14			

Table 36. Fisher test applied to control. Treatments 2 and 3. Cycle 2012-2013.

Test: LSD Fisher Alpha:=0.05 DMS:=0.58209				
T	Mean. Pruning weight (kg)	n		
3	1.35	5	A	
2	1.49	5	A	
1	2.48	5		B

Different letters indicate significant differences (p<= 0.05)

The following table shows the relationship between pruning weights with respect to treatments. The highest pruning weight almost 2.5 kg was observed in T1 (Traditional). The lowest pruning weight (1.35 kg) was observed in T3 (DOV 10% -90%).

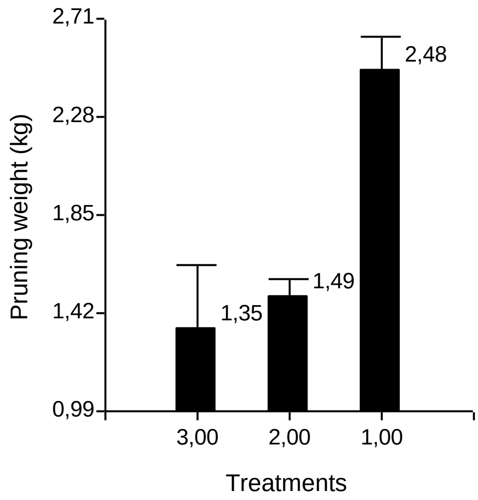

Figure 7. Pruning weight for treatments T3-T2 and T1 respectively. 2012-2013 cycle.

II.3.4 Total nitrogen content in branches for the third season of cuts

The analysis of the variance for the variable of the total nitrogen content does not present significant results; the p-value was 0.5522. The mean varies from 0.71 to 0.77 being higher in T1 (Traditional System) and lower in T2 (DOV 10% -90%).

Table 37. Analysis of the variance applied to the variable nitrogen content.

F.V.	SC	GL	CM	F	p-value
Model	0.01	2	4.30E-03	0.62	0.5522
Treatment	0.01	2	4.30E-03	0.62	0.5522
Error	0.08	12	0.01		
Total	0.09	14			

Table 38. Tukey test applied to the variable nitrogen content.

Test: Tukey Alpha:=0.05 DMS:=0.13982			
Treatment	Mean. Nitrogen content	n	
2	0.71	5	A
3	0.75	5	A
1	0.77	5	A

Different letters indicate significant differences (p <= 0.05)

II.3.5 Drying time

In 2012, traditional drying of grapes in the sun (T1) on a plastic mesh took 17 days. The DOV system (T2 and T3) took 61 days to reach the same level of moisture content (16%). This implies a 72.3% higher time than the control.

Table 39. Drying time (days)

Drying time for T1		Drying time for T2 and T3	
Laying-in-the-sun date	January 20	Cutting date	January 20
Picking up date	February 06	Harvesting date	March 21
Total time (days	17	Total time (days)	61

In 2013, the drying process for treatments T1, T2 and T3 began on January 25th. The control (T1) took 20 days between the stage of laying the grapes in the sun and the picking up stage (February 14). Harvesting the raisins for T2 and T3 (DOV) took place on March 18th; therefore, the drying period for the DOV system was 52 days long.

II.3.6 Calculating the leaf area model for Superior

To develop the model 30 shoots were measured from 34 cm to 296 cm length with an average of 98.25 cm. The leaf area of the shoots varies from 815 cm^2 to 6,020 cm^2 with an average of 1,953.66 cm^2. The result of the linear regression analysis between these two variables is a regression coefficient (R^2) of 0.91 which indicates that the degree of adjustment of the data is high and its values are comparable (Table 40 and Figure 8).

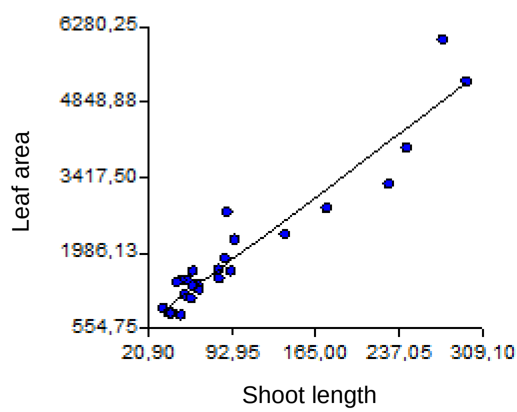

Figure 8. Relationship between leaf area (cm^2) and shoots length (cm) in Superior Seedless.

Table 40. Linear regression analysis for the leaf area variable of Superior Seedless.

Variable	N	R^2	R^2 Aj
Area	27	0.91	0.91

The model created for the length of shoots variable is significant with a p-value lower than 0.0001 (Table 41). In the regression analysis the y-intersection has a value of 327.58; and the slope has a value of 16.55. The regression equation obtained for the Superior Seedless variety is: LA (Leaf Area) = 327.58 + 16.55 x shoot length (Table 42).

Table 41. Variance analysis table (SC type III) for the variable length of shoots in Superior Seedless.

F.V.	SC	gl	CM	F	p-value
Model	41,573.040	1	41,573.040	249.49	<0.0001
Length	41,573.040	1	41,573.040	249.49	<0.0001
Error	4,165,738	25	166,629.52		
Total	45,738.778	26			

Table 42. Regression coefficients and associated statistics for Superior Seedless.

Coefficient.	Est.	SE	LI (95%)	LS (95%)	T	p-value	CpMallows
Constant	327.58	129.5	60.87	594.28	2.53	0.0181	
Length	16.55	1.05	14.39	18.71	15.8	<0.0001	240.94

II.3.6.1 Superior Seedless leaf area

The leaf area of the plants in treatment 1 ranges from 52,777.52 cm^2 to 115,357.71 cm^2. In the plants of treatment 2 the leaf area ranges from 52,546.92 cm^2 to 130,129.13 cm^2. With regard to the vines of treatment 3, the leaf area ranges from 44,120.1 cm^2 to 129,987.91 cm^2. The analysis of the variance for the leaf area of the control, treatments 2 and 3, shows a p-value of 0.5817. Therefore, there are no significant differences.

Table 43. Table for the Variance Analysis (SS type III) for the leaf area variable between treatments 1. 2 and 3 in Superior Seedless.

F.V.	SC	GL	CM	F	p-value
Model	1,178,386.295	2	589,193.148	0.57	0.5817
Treatment	1,178,386.295	2	589,193.148	0.57	0.5817
Error	1,2469E+10	12	1,039,092.654		
Total	1,3647E+10	14			

Treatment 2 was observed to be the one with the largest leaf area with an average of 90,257.07 cm^2, followed by treatment 1 with an average of 76,964.4 cm^2. Finally, treatment 3 was the one with the smallest leaf area with an average of 68,744.85 cm^2.

The analysis of the variance for the leaf area that relates the zone of spurs of treatments 2 and 3 indicates that there are significant differences with a p-value of 0.03. The leaf area of the spur zone of treatment 2 is larger than that of treatment 3 according to the Tukey test.

Table 44. Table for the analysis of the variance (SC type III) for the leaf area variable of the spur zone between treatments 2 and 3 in Superior Seedless.

F.V.	SC	gl	CM	F	p-value
Model	835,553.947	1	835,553.947	6.19	0.0376
Treatment	835,553.947	1	835,553.947	6.19	0.0376
Error	1,079,620.556	8	134,952.570		
Total	1,915,174.503	9			

Table 45. Tukey Alpha Test: = 0.05 DMS: = 16,941.67 between the spur zone of treatments 2 and 3 in Superior Seedless.

Treatment	Spur leaf area (cm^2)	n		
3	13,557.45	5	A	
2	31,839.18	5		B

Different letters indicate significant differences (p<= 0.05).

II.3.6.2 Ratio leaf area (cm^2) and harvest weight (kg) in Superior Seedless

In the Superior Seedless variety, the ratio of the leaf area per gram of fruit ranges from 2.25 cm^2/g to 8.17 cm^2/g with an average of 4.20 cm^2/g. In treatment 1 the minimum value is 2.25 cm^2/g the maximum value is 8.18 cm^2/g and the average is 4.46 cm^2/g. In treatment 2 the minimum ratio is 3.99 cm^2/g, the maximum is 6.06 cm^2/g, and the mean is 4.74 cm^2/g. Finally, treatment 3 has a minimum of 2.49 cm^2/g, a maximum of 6.4 cm^2/g, and a mean of 3.42 cm^2/g (Table 45).

Table 45. Descriptive statistics for the variable leaf area / fruit weight in Superior Seedless.

Treatment	Leaf area for fruit weight (cm^2/kg)	D.E.	CV	Min.	Max.
1	4.46	2.5	56.1	2.25	8.18
2	4.74	0.9	18.93	3.99	6.06
3	3.42	1.67	48.8	2.49	6.4

There are no significant differences in the ratio of leaf area to fruit weight (cm^2/ kg) between treatments since the p-value is 0.5015 (Table 46).

Table 46. Table for the analysis of the variance (SC type III) for the variable leaf area / fruit weight in the Superior Seedless variety.

F.V.	SC	Gl	CM	F	p-value
Model	4.8	2	2.4	0.73	0.5015
T	4.8	2	2.4	0.73	0.5015
Error	39.4	12	3.28		
Total	44.2	14			

II.3.7 Estimating harvest times and wages. 2011-2012 cycle

T1 (Traditional System) demands 179 hours for harvesting the grapes, laying them in the sun, turning them over and picking them up; harvesting demanded 55% of the total time, followed by the laying-in-the-sun stage (28%). For treatment 2 (DOV 10% - 90%) 71 hours were estimated for cutting (46% of the total) picking up and harvesting spur clusters. 97 hours were calculated for T3 (DOV 30% -70%) for the same tasks as in T2. Cutting accounted for 56% of the total. For T2 and T3 the tasks of picking up and harvesting spur clusters demanded similar times 20 hours on average.

Table 47. Harvesting, laying-in-the-sun, turning over and picking up times.

Times: Control (T1).					
Times	Beginning	End	Total (5 Plants)	Total min/ha	Total h/ha
Harvesting	7:22	7:49	0:27	5940	99:00:00
Laying	8:16	8:30	0:14	3080	51:33:00
Turning over	15:00	15:04	0:04	880	15:03
Picking up	14:00	14:04	0:04	880	15:03
Total time					**179:40:00**

Table 48. DVO times (T2 and T3); time for cutting, picking up and harvesting spur clusters (spur clusters harvesting).

T2 Time				
Time	Beginning	End	Total (5 Plants)	Total h x has
Cutting	10:10	10:19	0:09	33:33:00
Picking up	13:50	13:58:13	0:05	18:51
Spur cluster harvesting	14:05	14:10	0:05	18:51
Total				**71:15:00**
T3 Time				
Time	Beginning	End	Total	
Cutting	10:48	11:03	0:15	55:55:00
Picking up	14:00	14:06:00	0:06	22:22
Spur clusters harvesting	14:30	14:35	0:05	18:51
Total				**97:08:00**

Table 49. Comparison of hours demanded by each system.

Hours	T1	T2	T3
Harvesting	99.00	33.00	55.00
Laying-in-the-sun	51.33	0.00	0.00
Turning over	14.67	0.00	0.00
Picking up	14.67	31.17	22.00
Spur cluster harvest time	0.00	18.33	18.33
Estimate	179.67	82.50	95.33

The traditional system requires 22.46 representative wages/ha[4] to produce a complete harvest (harvesting, laying-in-the-sun, turning over and picking up). The DOV system requires between 10.31 wages and 11.92 wages for the tasks of cutting, harvesting spur clusters and picking up. T1 needs 54% more wages than T2 and 47% more than T3. The control uses 8.25 wages for laying-in-the-sun and turning over, representing 74% of the average total wages required by DOV. Another interesting aspect is that the harvest of the control is 66% and 44% higher with regard to the wages paid for cutting in the DOV systems T2 and T3, respectively.

Table 50. Estimating wages for the three treatments: T1, T2 and T3, for harvesting, laying-in-the-sun, turning over, picking up and harvesting spur cluster time.

Wages	T1	T 2	T 3
Harvesting	12.38	4.13	6.88
Laying-in-the-sun	6.42	0.00	0.00
Turning over	1.83	0.00	0.00
Picking up	1.83	3.90	2.75
Spur cluster harvesting	0.00	2.29	2.29
Total	22.46	10.31	11.92

II.3.8 Results of estimating harvest times between treatments. 2012-2013 cycle

The longest stage of the process in the traditional system is harvesting, which took about 29 minutes (46%), followed by picking up the raisins which took 16 minutes (25%). The other stages such as turning over (13%) and laying-in-the-sun (16%) did not exceed 14 minutes. The total time of the stages of the harvesting process in the traditional system was 1 hour 3 minutes 39 seconds.

The execution times of the processes for the control and for treatments T2 and T3 (DOV). It can be observed that the control is the one that takes longer: 1 hour 3 minutes, being

[4] It refers to the “wage" calculated for the study, made/done by two unqualified people. It does not represent a real variable. From now on, the word "wage" will be taken in reference to representative wages.

49% longer than T2 (DOV). The latter recorded a time of 32 minutes 55 seconds. The time difference between the traditional method and T3 (DOV) is 39%.

Regarding the time required to carry out the stages of the DOV process added to the harvesting, laying-in-the-sun, turning over and picking up spur clusters, there is no difference in the time used to perform the tasks in both treatments (DOV T2 and T3). In relation to the task of cutting the canes, there is a minimum difference of 3 minutes 19 seconds in T2 (DOV 10% -90%) over T3 (DOV 30% -70%). The time used to harvest the raisins is 10 minutes longer in T3 than in T2; with respect to the total time, there is a difference of 5 minutes 50 seconds of T3 with regard to T2 to perform the activities mentioned above. The cutting time of canes plus raisins harvesting covers between 80% and 82% when the 2 systems (DOV + Traditional) are combined. In T2 and T3 the time of harvesting, laying-in-the-sun, turning over and picking up spur clusters represents between 18% and 20% of the total execution time for the combined DOV system. Even if there is a combination of systems, T2 generates a time saving of 36.5% while T3 generates a time saving of 27%.

Summary

Applying the DOV system does not lead to a decrease in crop yields if the load is adjusted to the capacity of the plant. More than 40% of the wages is saved so the system can generate profits even if there is a small drop in production. After DOV has been used for three seasons, there is no weakening in the vegetative expression since the leaf area does not become smaller and there is no decrease in the nitrogen content of canes. The drying time increases (around 50 days) so raisins will be exposed to climatic risks until they are harvested. This increase in time is associated with a higher quality. The application of DOV may increase the competitive aptitude of Argentina through strategies to reduce costs and increase the quality of its products.

Chapter III

Local Research on Flame Seedless

III.1 Introduction

As mentioned above in the introduction to Chapter II, Flame Seedless is a table grapes variety that can be used to make raisins and, occasionally, must. At present it is the main variety destined to the production of raisins, followed by Superior Seedless, Sultana and Arizul.

After studying the Superior Seedless variety, we saw the need to study the behavior of the Flame Seedless variety using DOV. On this occasion, the workers' wages were also studied through simulations and field measurements; it was thought that there could be a response to the difference in load (higher or lower number of buds per plant) and a difference in distribution (long pruning versus short pruning). It was assumed that DOV weakens the plant and generate a decrease in yields per hectare. The hypotheses proposed for the study, among others, are the following:

The DOV system, with respect to the traditional drying system, generates higher quality raisins, allows a reduction of wages in the drying process without affecting the yield or leaf area if different distributions of buds and different degrees of grape ripening occur.

DOV produces a decrease in the leaf area that weakens the plants due to a more limited opportunity to capture light, when the pruning system is modified and severe cuts are made in the canopy during the summer.

The DOV system allows a reduction of wages in the harvest and drying stages; besides, it generates raisins of a higher quality; however, DOV is associated with a lower yield in production compared to the traditional raisin production system.

In this way, the objectives formulated in this stage were:

a) to determine yields per hectare between the traditional system and DOV for Flame Seedless;

b) to determine drying yields and drying times;

c) to evaluate different loads and pruning distributions;

d) to evaluate the leaf area and physiological indicators; and

e) to evaluate cutting moments with lower and higher Brix graduations.

Throughout chapter III on the Flame Seedless variety, the reader will be able to answer the questions that were posed as hypotheses at the beginning of the studies.

III.2 Materials and methods

The study was carried out on the farm called '*Leviand SA'* located on Road 12. Km 28. Zonda district. in the province of San Juan. Argentina.

Figure 8. Location of the property. Source: Google Earth. Version 6.0.

The Flame Seedless variety was used to undertake this study in a *parral* with a planting frame of 3 x 2 (1,666 plants / ha). The soil is stony on the surface and sandy at depth. It has drip irrigation. A completely randomized design with six treatments and six repetitions was used, being one plant the experimental unit (36 plants in total).

III.2.1 Design

The load was adjusted according to the pruning weight. The pruning weight of six vines (16%) was measured, and the average pruning weight and the standard deviation were calculated, determining a range of variation that was used to adjust the minimum and maximum load (Pimentel Gomes, 1978; Triola, 2009). A middle row with no treatment was left surrounding the plots of land.

III.2.1.1 2013-2014 treatments

a) Control: traditional pruning (short and rich pruning), spur and cane with 16 guides of 6 buds (96 buds) + 20 spurs. Total: 136 buds per plant for a pruning weight equivalent to 3 kg of wood.

b) Treatment 1 (DOV): Long and rich pruning[5]. Sector for fruit production with 6 canes of 20 buds (120 buds) + 20 buds in the sector for wood. Total: 140 buds per plant. Clusters from the spur sector were eliminated.

c) Treatment 2 (DOV): Long and medium pruning. Sector for fruit production with 6 canes of 15 buds (90 buds) + 20 buds in the sector for wood. Total: 110 buds per plant. The clusters of the **spurs** sector were eliminated

d) Treatment 3 (DOV): Long and rich pruning. Sector for fruit production 10 canes of 12 buds (120 buds) + 20 buds in the sector for wood. Total: 140 buds per plant. The clusters of the spurs sector were eliminated.

e) Treatment 4 (DOV): Medium and poor pruning. Sector for fruit production 6 canes of 10 buds (60 buds) + 20 buds in the sector for wood. Total: 80 buds per plant. The clusters of the spurs sector were eliminated

f) Treatment 5 (DOV): Short and rich pruning. Sector for fruit production 15 canes of 8 buds (120 buds) + 20 buds in the wood producing sector. Total: 140 buds. Clusters of the spur sector stayed.

III.2.1.2 2015-2016 treatments

a) **Control**: traditional pruning, spur and cane with 13 guides of 8 buds (100 buds) + 10 spurs. Total: 120 buds per plant for a pruning weight equivalent to 3 kg of wood.

b) **Treatment 1A (DOV)**: Long pruning. Sector for fruit production with 5 canes of 20 buds (100 buds) + 20 buds in the sector for wood. Total: 120 buds per plant. Clusters from the spur sector are eliminated. Harvest 18 brix.

c) **Treatment 1B (DOV)**: Long pruning[6]. Sector for fruit production with 5 canes of 20 buds (100 buds) + 20 buds in the sector for wood. Total: 120 buds per plant. Clusters from the spur sector are eliminated. Harvest 22 brix.

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[5] Long pruning: canes of more than 15 buds. Medium pruning: canes of 10 buds. Short pruning: canes of 8 buds. Rich pruning: 140 buds / plant. Medium pruning: 110 buds / plant. Poor pruning: 80 buds / plant.

[6] Long pruning: 20 buds/plant. Medium pruning: 12 buds/plant. Short pruning: 10 buds/plant.

d) **Treatment 2A (DOV)**: Medium pruning. Sector for fruit production with 8 canes of 12 buds (96 buds) + 20 buds in the wood sector. Total: around 120 buds per plant. Clusters from the spur sector are eliminated. Harvest 18 brix.

e) **Treatment 2B (DOV)**: Medium pruning. Sector for fruit production with 8 canes of 12 buds (96 buds) + 20 buds in the wood sector. Total: around 120 buds per plant. Clusters from the spur sector are eliminated. Harvest 22 brix.

f) **Treatment 3 (DOV)**: Short pruning. Sector for fruit production 10 canes of 10 yolks (100 buds) + 20 buds in the wood producing sector. Total: 120 buds. Clusters from the spur sector stay. Harvest 22 brix.

The nodes had to be adjusted in all cases according to the pruning weight at a rate of 40 buds per kilogram of wood produced.

III.2.3 Measurements

III.2.3.1 Measuring fresh weight and dry weight per plant and determining the drying ratio

The measurement with brix degrees was carried out to determine the most convenient harvest time (21º). An average weight of 40 clusters was calculated to correct the estimated fresh weight of the DOV treatments. Immediately, cuts were made at the base of shoots-branches (T1-T5). Traditional harvest and laying-in-the-sun were carried out in the Control, measuring the fresh weight / plant. For T1-T5, once the desired moisture content was reached (close to 16%), the raisins were weighed, and the drying period was measured.

III.2.3.2 Drying time

The harvest was gathered on January 16th, 2014 for all treatments. The drying time for the Control was taken from laying the grapes in the sun until picking them up. For T1-T5, this was done from the time the shoots were cut until the raisins were harvested.

III.2.3.3. Estimating wages for harvesting, laying-in-the-sun, turning over, and picking up

During the whole process, the working execution times were measured: harvesting, laying-in-the-sun, turning over, and picking up for the Control (traditional drying); and cutting for harvesting the raisins for T1-T5 (DOV). These measurements were expressed by means of percentages and wages per hectare. A factor of 555.33 was estimated, and it comes from dividing 3 plants/worker with respect to 1,666 existing plants in one hectare. The result was minutes per hectare which later became hours per hectare and wages per hectare.

III.2.4 Measuring the leaf area (LA)

A model was constructed to estimate the leaf area taking the length of 30 shoots and measuring the leaf area with a leaf area meter (owned by the San Juan EEA INTA), for the Flame Seedless variety. Subsequently, during veraison, the length of four shoots per plant was measured (two from the spur sector and two from the cane sector), and the number of shoots per plant was counted. Then the LA per plant was estimated with the regression equation obtained.

III.2.5 Statistical analysis and data processing

The Infostat program was used and an analysis of descriptive statistics of position (mean, minimum, maximum, median, quartiles) and dispersion (coefficient of variation, variance, standard deviation, error) was performed. For the variables related to yield and leaf area, a variance analysis was used. Descriptive methods, data tables and radial diagrams with attribute categories per raisin were used to analyze time and quality with the 2013 Excel program.

III.3. Results

III.3.1 Descriptive statistics: fresh weight and dry weight per plant and drying yields: 2013-2014 and 2015-2016 cycles

The average weight of 40 clusters was 433.85 g. The mean for the estimated fresh weight variable ranges from 30.80 kg to 47.00 kg in the sample. The maximum value found is 50.76 kg for T3, followed by T2 and T5 (50.33 and 44.46 kg). The highest standard deviation (8.47) is observed in T2, with a standard error of 4.88 (table 51).

During the 2013-2014 cycle with regard to the dry weight, the average values in the sample range from 5 kg to 12.9 kg per plant. The maximum value is 14.8 kg for T1 (long and rich pruning[7]), and the minimum is 3.8 kg for T5 (short and rich pruning). The standard deviation shows a difference of 44% between the highest and lowest values of the sample. The standard error, on average, is 0.8. The coefficient of variation is within normal values (11 to 23).

Table 51. Descriptive statistics for the fresh weight variable in kg / vine. 2013-2014 cycle.

T	n	Mean	D.E.	E.E.	CV	Min.	Max.
0	3	32.3	6.1	3.5	19.0	25.3	36.9
1	3	36.2	8.5	4.9	23.4	26.5	42.1
2	3	41.7	8.5	4.9	20.3	33.4	50.3
3	3	47.0	5.4	3.1	11.5	40.8	50.8
4	3	30.8	4.7	2.7	15.2	25.6	34.7
5	3	37.9	6.8	4.0	18.1	30.9	44.5

Table 52. Descriptive statistics for the dry weight variable in kg / plant. 2013-2014 cycle.

T	n	Media	SD	SE	VC	Min	Max
0	3	7.3	1.4	0.8	19.0	5.8	8.4
1	3	12.9	1.8	1.0	13.6	11.3	14.8
2	3	12.6	1.7	1.0	13.5	10.7	13.9
3	3	12.4	1.0	0.6	8.3	11.6	13.6
4	3	8.4	1.1	0.7	13.4	7.1	9.1
5	3	5.0	1.2	0.7	24.7	3.8	6.2

During the 2015-2016 cycle, when adjusting the nodes homogenizing the number of buds in the treatments, the situation was evaluated in the face of differences in the pruning configuration (short or long pruning with equal number of nodes). Let’s remember that the difference between the groups of the treatments A and B is given by the sugar content; the groups A were cut with 18 brix and the B groups were cut with 20 brix.

[7] The criterion for long pruning and wealth in pruning has to be verified in the Materials and Methods section of this chapter.

The average value of the dry weight ranged between 3.71 kg/vine and 6.13 kg/vine. The maximum values are found in T1A (long pruning), with values of 4.59 kg/vine to 6.13 kg/vine. The minimum value of the variable is in T2B (medium pruning) with 3.16 kg/vine, and the maximum in T1A with 7.21 kg/vine. The lowest average values were found in the control with 4.44 kg/plant (traditional pruning system), and in T3 (short pruning) with 3.71 kg/vine (10 canes of 10 buds per cane).

Table 53. Descriptive statistics for the dry weight variable (kg / plant). 2015-2016 cycle.

Treatment	n	Mean	D.E.	E.E.	CV	Min.	Max.	Median
T1A	3	6.13	0.97	0.56	15.83	5.34	7.21	5.83
T1B	3	4.59	0.81	0.46	17.89	3.69	5.3	4.51
T2A	3	4.59	1.62	0.93	35.22	3.46	6.45	3.88
T2B	3	5.2	2.03	1.17	38.97	3.16	7.21	5.22
T3	3	3.71	0.05	0.03	1.41	3.65	3.74	3.73
Te	3	4.44	1.24	0.72	27.96	3.27	5.74	4.3

III.3.2 Analysis of the variance for the fresh weight and dry weight variables (per plant). and drying yield for the 2013-2014 and 2015-2016 cycles

Regarding the fresh weight per vine no significant differences were observed between the treatments since the p value calculated is higher than the level of significance (Tables 54 and 55).

Table 54. Analysis of the varianza for the dry weight variable (kg / plant) cycle 2013-2014.

Variable	N	R²	R² Aj	CV
Fresh weight	18	0.49	0.28	18.12

Table 55. Table for the Variance Analysis (SC type III). 2013-2014 cycle.

F.V.	SC	gl	CM	F	p-value
Model	543.28	5	108.66	2.34	0.1061
T	543.28	5	108.66	2.34	0.1061
Error	558.03	12	46.5		
Total	1101.31	17			

During the 2015-216 study cycle, regarding the dry weight variable per vine, significant differences were observed between the treatments T5 (short and rich pruning) and T1 (long and rich pruning), T2 (long and medium pruning) and T3 (medium and rich pruning). T5 had the lowest dry weight, while T1, T2 and T3 (pruning of more than 10 buds) showed the highest values. The control (short pruning) presented similar values to those in T5 (short pruning) (Tables 57 to 59).

Table 57. Analysis of the variance for the dry weight variable (kg/vine). 2015-2016 cycle.

Variable	N	R^2	R^2 Aj	CV
Dry weight (kg)	18	0.88	0.82	14.33

Table 58. Table for the Analysis of the Variance (SC type III). 2015-2016 cycle.

F.V.	SC	gl	CM	F	p-value
Model	164.97	5	32.99	16.85	<0.0001
T	164.97	5	32.99	16.85	<0.0001
Error	23.5	12	1.96		
Total	188.47	17			

Table 59. Test: LSD Fisher Alpha: = 0.05 DMS: = 2.48930.

T	Mean. Dry weight (kg/vine)	n			
5	5.01	3	A		
0	7.33	3	A	B	
4	8.39	3		B	
3	12.41	3			C
2	12.59	3			C
1	12.87	3			C

For the ANOVA of the raisins yield variable there is a low coefficient of variation (8.48%), and a level of significance lower than 0.0001. The greatest differences for the variable are observed between T1 (lower relation) and T5 (higher relation). The control has a higher drying ratio than the DOV T1, T2, T3 and T4 and a drying ratio lower than T5.

Table 60. Raisin yield (kg fresh grape / kg dry grape).

Treatment	Dry ratio (fresh/dry)
T0	4.4
T1	2.8
T2	3.3
T3	3.8
T4	3.7
T5	7.6

Table 61. Analysis of the variance for the yield variable.

Variable	N	R^2	R^2 Aj	CV
Drying ratio	18	0.97	0.95	8.48

Table 62. Table for the Variance Analysis (SC type III).

F.V.	SC	Gl	CM	F	p-value
Model	45.37	5	9.07	69.25	<0.0001
T	45.37	5	9.07	69.25	<0.0001
Error	1.57	12	0.13		
Total	46.94	17			

Table 63. Test: LSD Fisher Alpha: = 0.05 DMS: = 2.48930.

T	Mean. Drying ratio (kg/kg)				
1	2.79	A			
2	3.3	A	B		
4	3.67		B		
3	3.79		B	C	
0	4.41			C	
5	7.65				D

During the 2015-2016 season, the load was adjusted to 120 buds for all treatments, leaving different distributions of buds (long, short and medium pruning). The analysis of the variance for the dry weight variable does not show significant differences between the treatments, so it can be stated that when the loads are the same, the use of DOV for long and short pruning does not generate a decrease in the yields (Table 65).

Table 64. Table for the analysis of the variance for the dry weight variable in kg/vine. 2015-2016 cycle.

Variable	N	R^2	R^2 Aj	CV
Dry weight (Kg)	18	0.34	0.06	26.92

Table 65. Table for the analysis of the p-value variance. 2015-2016 cycle.

F.V.	SC	gl	CM	F	p-value
Model	10.11	5	2.02	1.23	0.3529
Treatment	10.11	5	2.02	1.23	0.3529
Error	19.7	12	1.64		
Total	29.81	17			

Table 66. Tukey test applied to the dry weight variable. 2015-2016 cycle.

Treatment	Mean. Dry weight (kg/plant)	n	
T3	3.71	3	A
Te	4.44	3	A
T1A	4.5	3	A
T2A	4.59	3	A
T2B	5.2	3	A
T1B	6.13	3	A

The analysis of the variance for the fresh weight variable (estimated) does not show significant differences between the treatments, as well as for the dry weight.

Table 67. Table for the analysis of the variance for the fresh weight variable in kg / plant. 2015-2016 cycle.

Variable	N	R^2	R^2 Aj	CV
Fresh weight (kg/plant)	18	0.29	4.10E-04	24.85

Table 68. Table for the analysis of the p-value variance. 2015-2016 cycle.

F.V.	SC	gl	CM	F	p-value
Model	172.41	5	34.48	1	0.4575
Treatment	172.41	5	34.48	1	0.4575
Error	413.22	12	34.43		
Total	585.63	17			

Table 69. Tukey test applied to the dry weight variable. 2015-2016 cycle.

Treatment	Mean (kg/plant)	n	
T3	19.2	3	A
Te	21.63	3	A
T1A	22.85	3	A
T2A	23	3	A
T2B	26.36	3	A
T1B	28.67	3	A

III.3.3 Drying time

In the 2013-2014 cycle, traditional drying in the sun (T0) was completed in 20 days. The DOV system (T1 to T5) took 31 days to reach the same level of moisture content (16%). This implies that DOV needed 11 more days of drying; therefore, a time ratio of 35.5% higher than the control (Table 70).

Table 70. Drying times. 2013-2014 cycle.

Drying time T0		Drying time T1 to T5	
Laying-in-the-sun date	16/01/14	Cutting date	16/01/14
Picking up date	05/02/14	Harvest date	15/02/14
Total of days	20	Total of days	31

During the 2015-2016 cycle, there was a cut in the canes of the DOV treatments for group A (with 18° Brix) on February 1st 2016, group B, which corresponded to the treatments with 20° Brix, was cut on February 5th 2016. The raisins were harvested on March 22nd; for groups A and B they were harvested on March 27th without major variations between the date when canes were cut and the date when the raisins were harvested, taking 51 days for both groups.

The control (traditional production of raisins) was harvested on February 5th 2016, and picked up on February 19th with a drying time of 14 days. The DOVs took longer due to the weather conditions of the cycle: 72% more or 37 additional days.

III.3.4 Flame Seedless leaf area

III.3.4.1 Calculation of the model to determine the leaf area in Flame Seedless

The length of the shoots varied between 53 cm and 255 cm, and the length of the secondary shoots showed values from 0 cm to 70 cm. This implies the existence of total lengths from 53 cm to 290 cm, with a mean of 153. 73 cm. The minimum leaf area of the shoots is 1,216.4 cm^2 and the maximum is 8,662.3 cm^2, with a mean of 3,316.53 cm^2. On the dispersion chart that shows 30 samples, there are points away from the adjustment line (Figure 15). The analysis of the variance for the leaf area variable in cm^2 also indicates that there are no significant differences between the treatments.

Table 73. Table for the analysis of the variance for the leaf area variable in cm^2.

Variable	N	R^2	R^2 Aj	CV
Leaf area cm^2	18	0.62	0.47	22.98

Table 74. Analysis of the p-value variance.

F.V.	SC	gl	CM	F	p-value
Model	2,34123E+11	5	46824558239	3.97	0.0534
Treatment	2,34123E+11	5	46824558239	3.97	0.0534
Error	1,41577E+11	12	11798080789		
Total	3,757E+11	17			

When analyzing the relationship between the leaf area variables in cm^2/g of fruit, significant differences were observed between the treatments T1A (long pruning) and T3 (short pruning). The rest of the treatments show an intermediate behavior. In this case, long pruning has a lower relationship between the leaf area and the weight of the fruit per plant; that is why long prunings are convenient with respect to short prunings (T3). Let's remember that T3 was pruned at 120 buds, as well as T1A (equal amount of pruning), but with a similar distribution of buds than in a conventional pruning (15 canes of 8 buds per cane).

Table 75. Table for the analysis of the variance for the leaf area (LA) variable cm2 / g fruit.

Variable	N	R^2	R^2 Aj	CV
LA/g	18	0.62	0.47	29.45

Tabla 76. Table for the analysis of the p-value variance.

F.V.	SC	Gl	CM	F	p-value
Model	797.32	5	159.46	3.96	0.0236
Treatment	797.32	5	159.46	3.96	0.0236
Error	483.31	12	40.28		
Total	1280.64	17			

Table 77. Tukey test applied to the leaf area / fruit weight / plant variable (cm2/g).

Treatment	Leaf area / fruit weight (cm^2/g)	n		
T1A	10.77	3	A	
T2A	15.67	3	A	B
T2B	20.09	3	A	B
Te	26.3	3	A	B
T1B	27.52	3	A	B
T3	28.93	3		B

Different letters indicate significant differences (p<=0.05)

The leaf area per plant for Flame Seedless presents values ranging between 6.36 m^2 and 28.6 m2. The average value is 15 m^2 / plant with a standard deviation of 6 m^2 (Table 78).

Table 78. Descriptive statistics applied to the leaf area variable per cm2 plant

Variable	n	Mean	SD	Var(n-1)	SE	VC	Min.	Max.
Leaf area cm^2	18	156080.99	60418.75	3650425900	14240.84	38.71	63661.64	286648.83

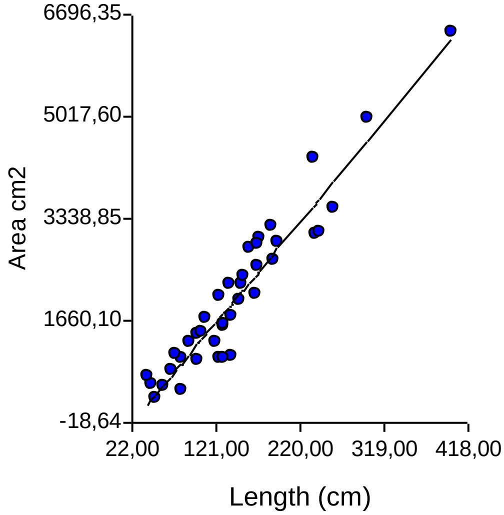

Figure 10. Linear regression between the length of the shoot (m) and the lead area (cm^2).

Table 79. Leaf area values per shoot for the calibration of the linear regression.

Shoot N°	Length (cm)	Area (cm^2)
1	110	1678.8
2	260	3513.1
3	130	1559
4	140	1061.3
5	68	820.91
6	172.5	2997.7
7	400	6396
8	100	1431.8
9	80	522.52
10	240	3075.8
11	160	2835
12	120	1311
13	80	1036
14	45	599.2
15	195	2933
16	50	389
17	75	1090.7
18	125	1041
19	40	740
20	100	986.98
21	130	1033.4
22	300	4969.4
23	60	577
24	150	1999
25	137	2244
26	104	1472
27	236	4322
28	186	3191
29	126	2046
30	190	2648
31	170	2910
32	170	2563
33	90	1299
34	243	3095
35	167	2085
36	152	2269
37	153	2375
38	139	1718
39	130	1579

The regression performed for the leaf area (LA) variables versus shoot length expresses an adjustment level of 91% for 39 observations. A y-intersection of -385.53 and a slope of 16.68 are found. **LA = -385.53 + 16.68 * L.**

Table 80. Analysis of the linear regression to calculate the leaf area in Flame Seedless.

Variable	N	R^2	R^2 Adjusted
Area	39	0.91	0.91

Table 81. Analysis of the variance for the parameters of the linear regression equation.

Coefficient	Statistics	SE	LL (95%)	UP (95%)	T	p-value	CpMallows
Constant	-385.53	141.58	-672.4	-98.67	-2.72	0.0098	
Length	16.68	0.86	14.93	18.43	19.3	<0.0001	363.65

Table 82. Analysis of the variance for the parameters of the linear regression equation.

VS	SS	DF	Square Medium	F	p-value
Model	57526544.1	1	57526544.1	372.43	<0.0001
Length	57526544.1	1	57526544.1	372.43	<0.0001
Error	5715149.6	37	154463.5		
Total	63241693.7	38			

III.3.5 Estimating harvest times and calculating wages

During the 2013-2014 season, the Control demanded 46 minutes 39 seconds to perform the tasks of harvesting, laying-in-the-sun, turning over and picking up; the harvesting demanded 55% of the total time, followed by turning over with 27%. This is the treatment that took longer, and was taken as a comparison parameter to determine the possibility of saving time with respect to the DOV drying system.

For treatment T1 (DOV, long and rich pruning) 30 minutes 25 seconds were estimated between cutting and harvesting clusters; harvesting represented 73% of the total time. A reduction of 35% of the time involved was achieved with respect to the traditional drying system. T2 treatment (DOV long and medium pruning) took 25 minutes 36 seconds, which means 45% less. T3 treatment (medium and rich pruning) took 24 minutes 30 seconds or 47% less. For T4 treatment (medium and poor pruning) a time of 19 minutes 40 seconds was recorded, which means 58% less time than when using a traditional system. For T5 treatment (short and rich pruning) 26 minutes 37 seconds were recorded between the cutting and picking up stages, being the slowest of the DOV treatments, although it was possible to save 43% of the time in a comparison to the traditional system. Harvesting turned out to be the task that demands more time for the traditional drying system and for DOV (Table 83).

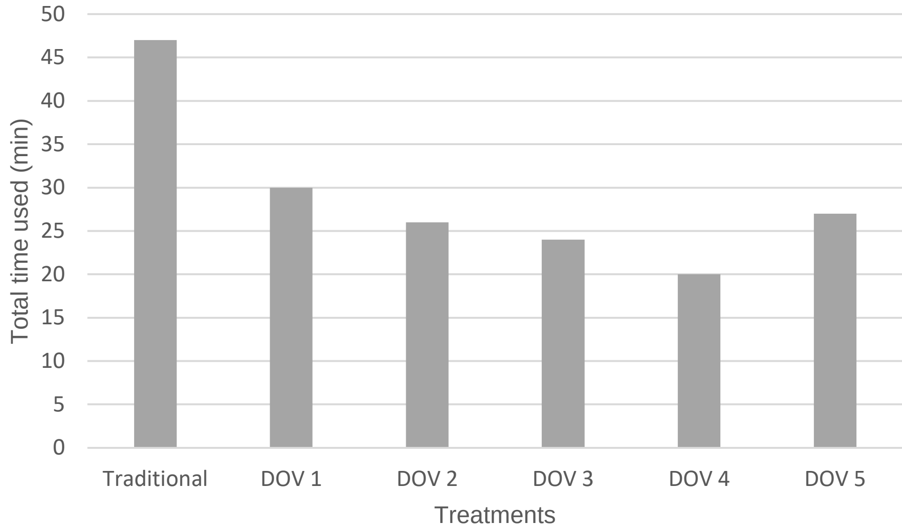

Figure 11. Time (minutes) for each treatment.

Table 83. Distribution of time and percentages of phases of the harvesting process for the different treatments.

Treatment	Operation	Time in minutes	%
Control	Harvesting	0:25:48	55%
	Laying down in the sun	0:06:43	14%
	Turning over	0:12:35	26%
	Picking up	0:01:33	4%
	Total	0:46:39	100%
DOV1	Cutting	0:08:18	27%
	Raisin harvesting	0:22:07	73%
	Total	0:30:25	100%
DOV2	Cutting	0:05:03	20%
	Raisin harvesting	0:20:36	80%
	Total	0:25:39	100%
DOV3	Cutting	0:05:09	21%
	Raisin harvesting	0:19:21	79%
	Total	0:24:30	100%
DOV4	Cutting	0:06:39	34%
	Raisin harvesting	0:13:01	66%
	Total	0:19:40	100%
DOV5	Cutting	0:07:51	29%
	Raisin harvesting	0:18:46	71%
	Total	0:26:37	100%

For the years 2013-2014, the traditional system required 46.3 representative wages/ha[8]. To produce a complete harvest, the DOV system requires between 22 wages/ha and 34 wages/ha for cutting, spur clusters harvesting, and picking up. The control uses 30 wages/ha for harvesting, and 23 wages for laying-in-the-sun and turning over which represent 64% and 48% of the total costs, respectively. Taking into account the fact that for a complete harvest a DOV system requires an average of 29 wages/ha, then a traditional production system requires about 18 additional wages/ha for the same purpose. Harvesting represented 73% of the average costs.

Measuring the execution time for harvesting tasks for DOV, and the traditional system of production of raisins during the 2015-2016 cycle indicates that, with respect to a maximum level of consumption of wages in the traditional system, DOV leads to savings of more than 50%.

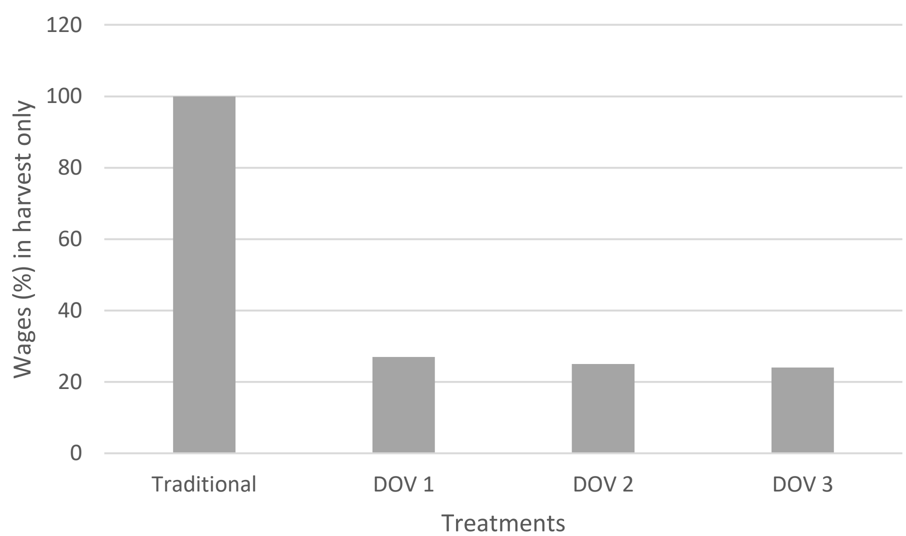

Figure 12. Relative percentage of consumption of wages between traditional raisin production system and DOVs.

The labor time per stage of the process were translated into wages/ha with a conversion factor. For the stages of grape harvesting, laying-in-the-sun, turning over and picking up the raisins, the traditional system needed the equivalent of 98 wages/ha. The DOV systems needed between 23.4 and 26.2 daily wages/ha for cutting canes and harvesting the raisins (Table 84).

[8] 8. "Representative wages" refer to the wages calculated for the study for the job done by two unqualified people. It does not represent a real variable. From now on, the word "wage" will be taken to refer to representative wages.

Table 84. Wages during the process of production of raisins using DOV and a traditional system.

Treatmet	Wage/ha	%
Tradicional	98.6	100%
DOV1	26.2	27%
DOV2	24.7	25%
DOV3	23.4	24%

Table 85. Moisture content (%) for the DOV groups A (harvest with 19 brix) and B (harvest with 20.5 brix).

Moisture	A	B	Difference	Days
08 March	19	20.5		
18 March	15.5	16	0.5	1.11
Gradient	0.35	0.45		

According to data from the Chamber of Foreign Trade, the costs arising from the processes verified in the industry in San Juan, DOV achieves higher drying ratios than those achieved by traditional systems; DOV also has a percentage of discard 100% lower than those registered for traditional systems.

Table 85a. Comparative data between DOV and traditional systems.

Tasks	DOV	Traditional
Traditional harvest	n/a	yes
Transport to the drying shed	n/a	yes
Drying ratio (fresh weight-dry weight	3.8 kg	4 /4.2 kg
Drying process secadero	n/a	yes
DOV harvest manual / mechanical	yes	n/a
Transport to processing plant	yes	yes
Substandard	4% al 6%	8% al 12%

Source: Chamber of Foreign Trade of San Juan. CACEX.

The savings made by using the DOV system, according to data from the same source mentioned above, vary between 62% and 67% depending on the type of harvest (manual or mechanized). This is so because the DOV system does not require the stages of laying-in-the-sun, turning over, picking up, and taking the grapes to the drying shed.

Table 85b. Savings the DOV system allows to make (expressed in percentages).
Source: Chamber of Foreign Trade of San Juan.

Saving costs by using DOV expressed in %	62.80%	With manual harvesting
	66.70%	With mechanized harvesting

Sumary

In response to the hypotheses that were raised at the beginning of Chapter III, it can be affirmed that the DOV system does not weaken the plant. The leaf area does not become smaller (vigor indicator), and the plant finds a strategy to replace it. The system, by itself, does not produce a decrease in yield. Low yields will occur when the pruning is poor (fewer buds) or when the canes are short.

A decrease in wages for the harvesting stage, from 40% to 60%, is generated by a reduction in the number of stages of the process. This is a very important factor regarding the competitive advantages to be developed as a strategy to win international markets and to compete globally.

We have observed that the DOV raisins are of a better quality, However, it must be admitted that in years of heavy rains the quality of any type of raisin will be affected (either DOV or traditional).

The drying time, as in Superior Seedless, takes longer. However, as Flame Seedless is a smaller grape, this time in normal weather is shorter, from 25 to 35 days, even 45 days according to the cutting season of canes.

The DOV system does not alter the drying yield. There is an effect of the load (regulation of buds in pruning) that will determine a higher or lower yield. For this reason, it is advisable to make measurements to calculate the pruning according to the capacity of the plant. The distribution of the buds has an important effect: long prunings with more than 15 buds per cane, and 4 to 6 canes are recommended.

Given the high fertility of basal buds in Flame Seedless, the producer must decide, depending on the load, whether or not to eliminate the clusters in the wood production area.

In situations of good soil, without nematodes, phylloxera or salinity, it is not necessary to use rootstocks as the plants show signs of high vigor. It is important to adjust watering and fertilizers correctly.

Chapter IV

Quality

IV.1 Introduction

Quality, a subjective concept, refers to the ability of an object to satisfy implicit or explicit needs according to a parameter or to the fulfillment of quality requirements (Deming, 1982; Juran, 1993; ISO, 2000). Quality is related to the perceptions of each individual to compare one thing to another of the same species and to several factors such as culture, product or service, needs and expectations that influence this definition (Feigenbaun, 1990). Crosby (1987) defines *quality* as the compliance of the specifications or compliance with the requirements. For his part. Deming (1982) understands that the main motivation of a company is to make a product that has no flaws, that is uniform and at a low cost.

Quality management is a dynamic process that seeks to evaluate and to monitor that quality criteria are met and at the same time to improve it in a continuous way according to market demands (Durán, 1992). Companies perform this type of management to adapt themselves to the business environment that is very competitive. Therefore, to attract customers they must conceive higher quality products (Giraldo, 2011).

The process of evolution in the quality criteria generated changes that modified the sense of this concept. At present it has become a requirement of the product that is used as a strategic factor of organizations to maintain and gain market positions (Ishikawa, 1988).

The final quality of the raisins depends on a series of factors, including the raw material, variety, drying process, packaging, time and storage conditions among others. In turn, the consumer defines 'quality' through attributes such as sweetness, appearance (color, shape, defects and cleanliness), texture, acidity, nutritional quality and hygiene (Molina, 2011).

According to the Ministry of Agriculture, Livestock, Fisheries and Food (2006), raisins of different varieties differ in their attributes according to the characteristics of the species Vitis vinifera L., without admitting mixtures. Physical and chemical properties are also evaluated, such as: moisture (16% - 18%); presence of peduncles and pedicels; moldy, damaged, discolored and fermented raisins; raisins with sugar crystals, undeveloped, with strange vegetal matter and/or mineral impurities. Also, the presence of chemical contaminants such as pesticides is analyzed, and microbiological parameters are determined, such as yeast, fungi and total coliforms. Finally, the characteristics of the containers are evaluated (Secretariat of Agriculture. 2006)

The United States Department of Agriculture (USDA) has established different quality criteria based on specific parameters and classifies raisins in different grades, for varieties of raisins with and without seeds (Sultanas, Corinto, Zante or Currants, Cluster[9] and mixed). First, the USDA makes a general classification in four grades (A, B, C, and D), being category A, raisins those that fulfill all the requirements regarding the attributes of typical color, characteristic flavor and ripe grapes (80% sugar). The other categories do not meet some of these attributes (B and C), and category D does not meet any (United States Department of Agriculture, 2016).

Besides, the USDA ensures the availability of tables that detail tolerance for the flaws of raisins expressed in percentages according to weight, maximum quantities per weight, appearance and edible quality of the product. These flaws can be the presence of rachis pieces, seeds, earthy materials such as sand and gravel. Other aspects are also taken into account, for example, if the raisins have suffered mechanical damage or damage caused by sunburn, if they are moldy, and/or if they contain sugar crystallizations. These tolerances also consider some other aspects, for example, if the raisins comply with the size, moisture percentage, color, maturity and degree of development corresponding to each variety (Ibid, 2016).

Table 86. Tolerance for defects in Sultana raisins according to the USDA (2016). Source: Raisin Production Manual. Christensen, 2000.

Defects	U.S Grade A	U.S Grade B	U.S Grade C
Rachis pieces	Maximum number (for 32 ounces)		
	1	2	3
	Maximum number (for 16 ounces)		
Pedicels	25	45	65
	Maximum percentage in weight		
Sugar Crystals	5	10	15
Discolored, damaged or moldy.	4	6	9
Provided these limits are not exceeded.			
Damaged	2	3	5
Moldy	2	3	4
Deficient development or no development .	2	5	8
Lightly discolored or damaged due to fermentation or any other defect not described above.	Appearance or edible product		
	May not be affected	May be slightly affected	May only be materially affected
Grain, sand or lime	There cannot be any consequence that affects the appearance or the quality of being edible .		There cannot be more than one trace that affects the appearance or the quality of being edible

Also, there is an inspection program for raisins authorized by the Federal Raisin Marketing Order N° 989. It covers aspects of marketing and regulations for California raisins and it is managed by the Raisin Administrative Committee (RAC), through the Federal Marketing

[9] Raisins in clusters

Program of the Raisins Industry, of the USDA Agricultural Marketing Service subdivision, appointed to carry out inspections and to issue certifications (Nef, 2000).

Once the raisins that come from one producer enter the processing plant, a batch of raisins is subject to an inspection to determine their degree and condition. An inspector receives a request from the USDA to identify the loads and to establish the variety. In addition, samples are taken at random, and if they do not comply with the requirements, reprocessing measures are taken or the raisins are returned to the producer. The inspector can determine, in turn, what raisins contain a high moisture level and defects such as mold. The sand that comes attached to the raisins is weighed to calculate the net weight of the load. The inspector's job is also to classify the raisins and to observe if there are any faulty or doubtful conditions, by taking samples and using a stream air classifier. Tests may include microanalysis for insects, rodents or other kinds of contamination (Kagawa, 2000).

Table 87. Entry inspection. Humidity and ripeness categories of raisins according to the USDA. Source: Raisin Production Manual. Christensen, 2000.

		Substandard %			B o better %			
Variety	**Max. Moisture %**	**Meet**	**Dockage**	**Defects**	**Meet**	**Dockage**	**Flaws**	**Méthod +**
Natural seedless*	16	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	CCDA
Golden seedless*	14	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	CCDA
Dipped seedless*	14	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	CCDA
With oleate and seedless*	14	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	CCDA
Flame Seedless	16	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	Visual
Monukka	16	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	Visual
Other Seedless varieties	16	< = 5	5.1 a 17	17.1 +	50 +	49.9 a 35	34.9 -	Visual
Zante Currant	16	< = 12	12.1 a 20	20.1 +	N/A	N/A	N/A	CCDA
Sultana	16	< = 12	12.1 a 20	20.1 +	N/A	N/A	N/A	Visual
Muscat of Alexandría	16	< = 12	12.1 a 20	20.1 +	N/A	N/A	N/A	Visual

*Includes Thompson, Delight, Emerald, Fiesta, Perlette and Superior Seedless.
+CCDA = Stream air classifier
++Ruby Seedless, Black Imperial, Beauty Seedless, Blush Seedless (dried in the sun or dipped).

The maximum moisture content allowed is 16% for all types, except for golden or dipped, treated with oleate, for which it is 14%. With the aforementioned exceptions, the maturity of Flame Seedless, Monukka, Sultana and Muscat of Alexandria is visually determined due to the wide differences in the physical characteristics of these varieties. The limitations are due to grade defects, including damage, sunburn, sugar, caramelization, mold and uncured berries. The total damage cannot be higher than 10% in weight for all categories, and no more than 5% for any category. Only 5% of any type of mold or combination of types is allowed (Kagawa, 2000).

Generally, product health categories are listed as zero tolerance or with a very low tolerance. Zero tolerance refers to the fact that the raisins carry grains of embedded sand, feathers (both domestic and from wild sources) and/or glass or other harmful materials. The presence of feathers cannot exceed four per bin, and the presence of any rock or material measuring 1/8 inch or larger is identified with a seal to help the processor remove it. With regard to contamination, it includes cluster rot, and damage caused by insects and rodents (*Ibid*, 2000).

Table 88. Inspection standards for defects in USDA incoming raisins. Source: Raisin Production Manual. Christensen, 2000.

Grade defects (limiting percentages)		Limit
A. Damage		
	Damage (includes chewed)	5% by weight
	Sunburn	5% by weight
	Sugaring	5% by weight
	Caramelization	5% by weight
	Other	5% by weight
	Total damage	10% by weight
B. Shape		5% by count
C. Defective berries		5% by weight
D. Moisture		
	Natural condition	16%
	Dehydrated	14%
Strength of the product (healthiness)		Tolerance
A. Extraneous material (visible)		
	Embedded Sand	0
	Sandburs	0
	Pods and eucaliptus leaves	0
B. Fermentation		0
C. Deleterious materials		0
	Glass, excrement, etc. Mark containers with the sign. “Not suitable for human consumption”	
D. Feathers		
	Per bin	4
	Per sweat	
E. Rocks (not a failing defect)		1
	Flag PCCs with "rocks" stamp	N/A
F. Contamination		

The inspector also checks normal characteristics such as color, taste and smell of the variety; raisins lots that contain more than 2% of a varietal type will be certified as lots of a mixed variety; the raisin processing plant does not consider them desirable.

Figure 13. Inspectors use a 24-inch hardened steel spring probe to facilitate sampling. The probe allows inspectors to pick up raisins and extract a sample that is below the surface. Photo: Jack Kelly Clark. Source: Raisin Production Manual. Christensen, 2000.

Figure 14. The sand that falls through the agitator is collected when the containers are unloaded. The sand is weighed and the average per container is deducted from the gross weight delivered.
Photo: Jack Kelly Clark. Source: Raisin Production Manual. Christensen, 2000.

Figure 15. Raisins that contain mold are separated for scoring. Mold caused by rottenness is the most common one. Photo: Jack Kelly Clark. Source: Raisin Production Manual. Christensen, 2000.

Figure 16. The raisin paste is placed in a plastic cylinder on top of a terminal and a probe from the opposite terminal is inserted into the paste. The moisture percentage is measured as the electrical resistance between the two terminals. Jack Kelly Clark's archive. Source: Raisin Production Manual. Christensen, 2000.

Figure 17. Accurate determination of the moisture percentage requires corrections to be made to compensate for temperature. The thermometer must be placed carefully in the raisin paste. Photo: Jack Kelly Clark. Source: Raisin Production Manual. Christensen, 2000.

Figure 18. Air current sorting machines are used to determine ripeness and raisin grades: "Substandard" or "B or better". They are put in order using a continuous air flow at a constant temperature and pressure. Photo: Jack Kelly Clark. Source: Raisin Production Manual. Christensen, 2000.

The raisins that have already been processed are also inspected, but the rules are different from those that apply to raisins that enter the processing plant. Inspection methodologies also differ; for example, the maximum allowable moisture is between 18% and 19% for all varieties. Grade A raisins must contain at least 80% of the characteristics of Grade B raisins (United States Department of Agriculture, 2016).

Markets such as Afghanistan, due to the way they produce their raisins, cannot compete with markets such as California because these raisins known as Aftabi are dried with techniques that do not ensure their quality; besides, they are not delivered in due time and proper form. These raisins must be washed twice due to excessive dirt, and when using raw material that is a by-product of the fresh grape for consumption, they are classified as unacceptable raisins (Lister, Brown & Zainiddin, 2004).

IV.2 Materials and methods

IV.2.1 Evaluation of raisin quality

Once the raisins were harvested, in the case of either DOV or traditional drying systems, all the raisins were processed, including those of the studies carried out with Superior Seedless and Flame Seedless (washing, drying and wax); a blind tasting was carried out with qualified staff. The quality variables measured were color, taste, skin features, seminal traces, appearance and general rating. A rating from 1 to 10 was assigned to each variable. With the data, the average value of each attribute was calculated and a radial diagram was created.

IV.3 Results

IV.3.1 Evaluating the quality of DOV Superior Seedless raisins. 2011-2012

During Superior Seedless raisin tasting, the DOV drying system (T3 and T2[10]) was compared with the traditional drying system (T1). Regarding the color variable, T3 has the highest score (8), followed by T2 and T1. The appearance is better for T2 (8.43) while T3 and T1 come second. With regard to flavor, T3 is the most remarkable. None of the treatments had seminal rudiments; therefore, they obtained the same score. The skin variable shows values of 8.5, 7.86 and 6.29 for T3, T2 and T1 respectively. Finally, according to the general score T2 was first (8.14), T3 second (8), and T1 third (7) (Table 86).

DOV treatments for all the variables that were analyzed (color, appearance, taste and skin) occupied the first or second position, while traditional drying occupied the last position.

Table 86. Results of the Seedless Superior Tasting. Cycle 2011-2012.

Treatment	Color	Appearance	Flavor	Seminal traces	Skin	General rating
Traditional T1	6.86	7.86	7.14	10.00	6.29	7.00
DOV T2	7.29	8.43	8.29	10.00	7.86	8.14
DOV T3	8.00	7.86	8.57	10.00	8.00	8.00

IV.3.2 Evaluating the quality of Flame Seedless raisins. Cycle 2013-20

In a comparison of raisins produced by using DOV and a traditional system, with respect to the color variable, there was a difference of 2% in favor of DOV. The appearance of raisins was 9% better for DOV. As for flavor, the result was favorable for traditional drying with a 4% difference. Fewer seminal traces were observed in the DOV system with a difference of 6%. The skin variable indicates that DOV raisins show an improvement of 9% compared to the traditionally dried raisins. Finally, the general score placed DOV first with a difference of 5%.

[10] The reader is reminded that T2 and T3 in this case correspond to chapter II. T2 (DOV): pruning with 10% spur buds and 90% cane buds. T3: pruning with 30% of spur buds and 70% of cane buds.

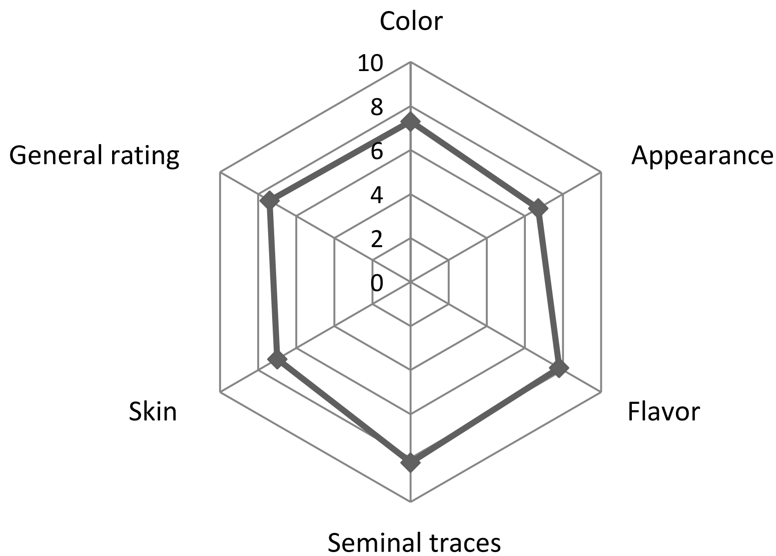

Figure 19. Radial diagram - Result of the tasting for a traditional drying system.

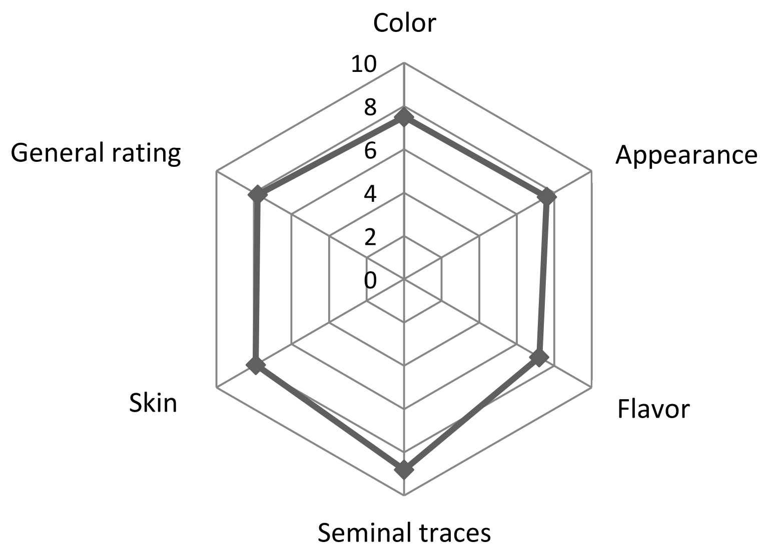

Figure 20. Radial diagram - Result of the tasting for the DOV system.

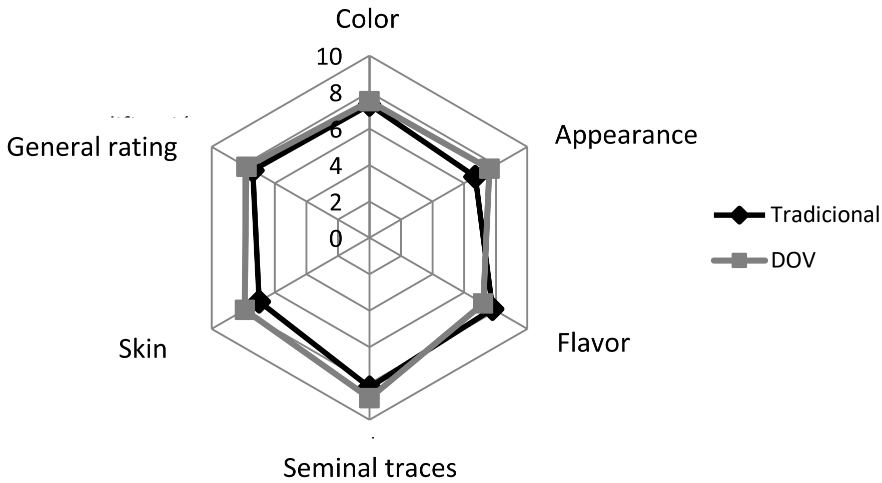

Figure 21. Comparative radial diagram: DOV and Traditional system.

IV.3.3 Evaluating the quality of the Flame Seedless raisins. 2015-2016 cycle

During the 2015-2016 season, the comparisons of raisins obtained for DOV and traditional systems indicated that in terms of color, appearance and skin, DOV raisins are better. The flavor variable was better rated in the traditional drying system. The general rating was the same for the raisins obtained using either system. During this drying season there was a 'La Niña' phenomenon, which caused a succession of rains that prolonged the drying period and, in general, produced fermentations and crystallizations, altering the normal qualities (Table 89).

Table 89. Result of the tasting of Flame Seedless. 2015-2016 Cycle.

	Color	Appearance	Flavor	Seminals	Skin	General rating
DOV	4.0	3.2	3.3	3.9	3.2	3.4
Traditional	3.1	2.9	3.6	4.1	2.9	3.4

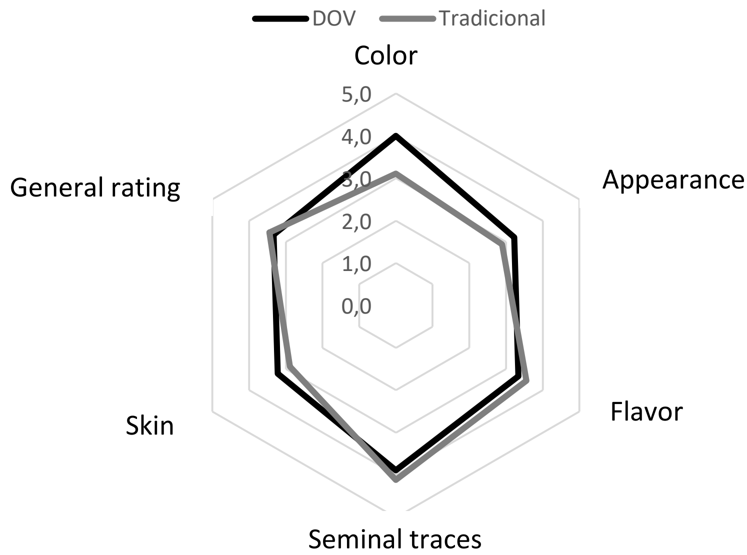

Figure 22. Radial diagram - Result of the tasting for the DOV Flame. 2015-2016 cycle.

Chapter V

Applied Technology in the Productive Sector: The Producers' Experience

V.1 Enrique Meló's experience

Enrique Meló, a vine grower and raisin producer, is one of the owners of a family business that sells raisins to foreign markets, among other items. He owns not only farms in the districts of 9 de Julio, 25 de Mayo and Sarmiento in San Juan, Argentina, but also a raisin drying shed and a raisin processing plant. Flame Seedless, Sultana and Fiesta are the main varieties he uses to produce raisins and fresh grapes.

Four years ago he heard about the Dry On Vine (DOV) system and became acquainted with it through other raisin producers (Martín Pantano and Gonzalo Huertas), and then he decided to travel to southern California, United States, to learn more about this method. In 2013, he began to carry out the first DOV experiments on his farms, motivated by the possibility of reducing the amount of labor needed for the production of raisins and the possibility of mechanization of the system. That year he modified the pruning system in two hectares of Flame Seedless, Fiesta and Sultana varieties; as he obtained an excellent result, he increased the area transformed into DOV until it reached 12 productive hectares, only with Flame Seedless and Fiesta varieties, both grafted on Paulsen (invigorating rootstock to which excellent results are attributed[11]). Since they were the ones that behaved the best, with yields ranging between 8.000 kg/ha and 10.000 kg/ha of raisins and no aging problems. In addition, on another farm in the district of 25 de Mayo, 27 ha were planted in 2015, and 5 ha in 2016 with the DOV system and the vines were grafted on Paulsen and *Cereza* variety. In these cases, a reinforced conduction structure was used due to the type and amount of wire used (six wires between rows, placed at 43 cm between wires).

It is worth noting that Enrique Meló is also conducting tests with other conduction systems: a) a cordon placed 30 cm below the master wire, and b) a modified H-system 25 cm below the main structure. In the second system, each lock has a crosshead with two wires that allow this conduction, being the system that produces better results. Meló is also testing a small white variety, which has no name, but with excellent aptitudes for DOV, and the bud break happens 10 to 15 days later than Flame Seedless or Fiesta does, and ripens before these two varieties. It is very productive, with a resistant skin and shorter drying time than that for Flame Seedless and Fiesta. Another innovation he implemented is the construction of a harvesting machine for DOV raisins that he has not been able to use until

[11] The use of rootstocks is justified when a soil problem has to be solved (salinity, phylloxera, nematodes or other problems). If the soil is normal, if it presents no impediments, no phylloxera or nematodes, the Flame Seedless variety offers optimal vigor conditions for the system so rootstocks would not be necessary.

now on a large scale since they built it in 2014, due to the inclement weather conditions of the last season.
Regarding the tasks performed, the following ones are worth mentioning: leaf and secondary shoots removal up to the first wire placed 43 cm from the master; leaving an opening of 86 cm to let the air and the sun in to favor drying and to reduce the risk of disease. With regard to pruning and tying, there are no differences in the productivity of manual work compared to the traditional system[12]. The first years the pruning was very long (inspired in the Californian systems), and at present pruning is shorter with 8 bud/cane that reach half the planting distance (1.5 m on each side), in the fruit area leaving 100 buds per plant (spurs are left in the wood sector or on the other side of the vine). Canes are cut when the grapes reach 19° brix. This year he wants to apply ethephon to Flame Seedless, since when this variety ripens its color is not uniform, which affects the final quality of the raisins.
In 2016 tests were carried out with two drying products: Sandsil DH-20, a dehydration auxiliary, and an emulsion: KCO3 + vegetable oil. In the first case, poor results were obtained, since the chemical made the color of the raisin lighter and, in the second case, the results were good regarding quality and drying time. However, the tests could not be completed due to rainy weather conditions.
The main advantage of using DOV is a better quality of the raisin, its uniform size and shape, food value and cleanliness. A disadvantage is the high moisture content of the raisins, since it is not possible to finish the drying process in the plant, which has to be completed laying them in the sun as with the traditional method[13]. In addition, Enrique Meló has noticed that windy weather conditions make some raisins fall[14].
Having noticed these problems and taking into account certain adverse weather conditions of the last seasons, Enrique Meló has considered converting the DOV vineyards into the traditional system again and leaving the 160 ha that he had originally planned for DOV under this system.

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[12] So far, locally the amount of wages that DOV pruning requires has not been evaluated. What is known is that when the system is correctly implemented, pruning takes place in advance in 50% of the area when it is time to cut canes (end of January-beginning of February), leaving the other 50% of the area for the winter, so more productivity is expected.
[13] Local studies indicate that a drying process with grapes that reach 15% - 16% humidity is possible, when the cane cutting date is not extended beyond February 5, and also when the environmental conditions are taken into account.
[14] In local studies this fall has not been observed. However, researchers at Kearny Research and Extension Center, California, indicate that there is a period in which the vascular bundle has maximum sensitivity and can fall during the fast drying stage or the first 10 days. After this period, the vascular bundle remains attached to the berry.

Enrique Meló considers that many variables must be adjusted to make DOV a successful system, especially the choice of variety, this aspect being the most important one in which time and effort must be invested. Tests and evaluations must continue regarding the application of this method. Finally, he stressed the need to solve the problem of manual labor and to find ways of increasing mechanization in viticulture, since production is becoming more and more difficult in large areas.

V.2 Marcelo Pomeranchik's experience

Marcelo Pomeranchik is a vine grower and raisins producer. He owns several farms, a drying shed and a raisins processing plant in the district of Caucete, San Juan province. The varieties he grows are 351 INTA o Arizul, Flame Seedless, Sultana and Superior Seedless to produce raisins and fresh grapes. He has been working in this field for the last 12 years.

Ten years ago he heard of and became acquainted with the DOV system on a trip to The USA, and he began to get information about it. In 2013 he began experimenting with this system on his farms, motivated by the possibility of reducing labor costs. Twelve years before he had started to harvest grapes using bins, a tractoelevator and a bins dump, a method that requires fewer workers than traditional harvest does (with boxes). Pomeranchik states that the main problem of primary and industrial productions is labor, which has aggravated in recent years.

For the past four years, he has been producing raisins using DOV with 11 ha of Flame Seedless and Sultana varieties. Training the workers, especially for cutting canes and pruning is very important to him. The main advantage of using this system is the reduction of harvest and drying costs, due to the decrease in labor. Also, from the industrial point of view, he indicates that the most important benefit is the extraordinary quality of the raisins produced using DOV, for the organoleptic aptitudes and because it facilitates the processing stage (there is no risk that the raisin may contain rests of rodents, grit, rocks and almost no raisins have to be discarded).

One of the disadvantages that Pomeranchik mentions is the high moisture content (18%) of the raisins at harvest time, which causes problems during the processing and storing stages, and which also favors the appearance of fungi and the production of ochratoxin. This substance has always existed but its amount increases with DOV. He also highlights the long drying time and the lack of knowledge about the ageing in plants.

Despite these problems, Pomeranchik plans to enlarge the area devoted to DOV, to renew the varieties that do not adapt to this system, and to implant new vineyards to use DOV, since the ones he owns today originated thanks to the transformation of the traditional pruning system into DOV. He commented that many of the farmers that provide him with raisins have started to adopt the system.

He considers that DOV is here to stay and that its use will increase a lot in the next five years, mainly because reality (labor problem) leads to the adoption of this system. Some of his recommendations based on his experience are:

Irrigation: drip irrigation is necessary; or in the case of flood irrigation, it has to be stopped a week before the cutting stage. This is because moisture in the soil delays the drying process a lot and increases the humidity of the environment favoring the action of fungi[15]. With drip irrigation the watering time should be reduced a 50%.

Pruning: after performing several tests, better results are obtained with long pruning, 4-5 guides of 12-14 buds (as long as the plant allows it, after calculating how rich the pruning is and if there is good pruning material and vigor). The benefit of this type of pruning is that canes are easier to accommodate in the wires; the shady area is smaller; there is greater exposure to the sun, more aeration and therefore the drying time is shorter. In addition, the bud break occurs later and the risk of frost is lower.

Tying: it is a fundamental task[16]. Three knots per cane should be made to prevent fruit buds from falling off. In this way, sunlight penetrates better and fungicide products can be applied after a rain or if the need arises (chlorine dioxide. sulfur + diatom).

Sugar content: care must be taken not to cut the grapes when they are fully ripe, but when they have reached between 18.5 and 20° Brix. The higher the sugar content, the higher the raisin loss.

Yield: the optimum yield should be over 7.000 kg/ha of raisins. The raisins have to ripen in advance to be able to cut them earlier.

Harvest: to be able to harvest the raisins, the moisture content must be lower than 13% both for DOV and for traditional drying, since if it is higher, processing becomes difficult.

Varieties: 351 is a late variety for DOV. Fiesta is a variety that requires delicate handling (more sensitive to diseases), but its aptitude for DOV resembles that of Sultana and Flame Seedless. Superior Seedless has a high drying time because of its thicker skin.

[15] A total reduction of irrigation may be detrimental to physiological processes. Partial irrigations using less water, or irrigating every other middle row are recommended.

[16] If the canes are long and there is enough wire in the middle, tying is not necessary, which reduces costs.

V.3 Patricio Meglioli's experience

Patricio Meglioli is an agronomist and advisor to several farms located in the districts of San Martín, Ullúm and 25 de Mayo, San Juan Province. He has worked in the wine industry for more than 20 years. Ten years ago he heard of and became familiar with the DOV system through/via the manager of the company where he worked who traveled to the United States and became familiar with the method.

In 2008 Meglioli began to carry out the first DOV experiments on the farms where he advises the farmers and on his own farm too, motivated by the possibility of reducing the problems of availability and amount of labor demanded, as well as reducing the costs of harvesting and drying. Meglioli says that it is necessary to change the way of thinking and to understand that productive systems with intensive labor are not viable. The experiments were carried out with all varieties destined to produce raisins (Flame Seedless, Sultana, Fiesta and 351 INTA); yields, drying time and dry fruit shedding were measured. Meglioli has produced raisins using DOV since 2012. He currently has four hectares with the Flame Seedless variety in DOV.

Meglioli considers the pruning stage important; for this reason, at first workers were separated and, in this way, a pruner cut the raisins only in middles with spurs, and another pruner in middles with canes. All possible spurs and long canes were left without counting the buds; tying was made after two knots at the beginning and at the end. The cutting moment occurs after several experiences when the grapes reach 19° Brix for drying to take place at the right time.

The main advantage of using this system is the reduction of costs, since it reduces the use of boxes and the construction of the drying yards. Meglioli also highlights the excellent quality of the raisins thanks to their nutritional value, cleanliness and pulp content.

Among the disadvantages, Patricio Meglioli highlights the difficulty to perform the destemming process of the raisins. He considers that all the variables that affect production using DOV, especially the ageing of plants, should be evaluated and measured. In the future, if it is possible to adjust all the variables, the number of vineyards and the use of DOV in them will increase, due to the possibility of mechanizing the process.

Among the recommendations Meglioli makes based on his experience, the following ones stand out:

a) DOV should be applied to vigorous plants, so the use of rootstocks, balanced and sufficient fertilization, irrigation management and a good preparation of the soil prior to planting are necessary, with tasks to promote radical exploration; b) with respect to the conduction system, the structure must be reinforced, with an optimal number of wires, to prevent the falling canes, and c) tests must be done on different varieties until the ones that best suit DOV are found.

V.4 Martín Pantano's experience

Martín Pantano owns farms in the districts of Santa Lucia, Angaco and San Martín, San Juan province. He currently has 40 hectares devoted to DOV applied to Flame Seedless and Sultana varieties. He has been working in this field for 12 years. He became interested in DOV when he read an article from the University of Davis, California, which led him to travel to the United States and learn about this system. The reduction of costs that the system promised led him to try it, especially because it focuses on a reduction of labor, which is currently scarce. Besides, the system is associated with raisins harvest, not grapes, that's why the harvest weight is four times lighter or four times more efficient if the harvest process is sped up.

Pantano started with some middles row, then he enlarged the area and good results encouraged him to use DOV at a large scale. He himself trained the field workers, mainly for pruning. Harvesting is a time when attention must be paid to determine the exact time to carry it out. His advice is to set a date according to the area and variety.

DOV is a flexible system, because if drying times (due to the weather) increase, the process can be finished in a traditional way[17]; also, harvest costs are lower and since raisins weigh less than grapes, harvesting is easier.

Martin Pantano mentions some disadvantages. Plants have to be vigorous because of the type of pruning involved. Therefore, he recommends the use of invigorating rootstocks. He also stresses the importance of setting the vineyard especially for DOV, since the structure is fundamental to the plant. He considers that converting a traditional vine into DOV is more difficult. In this sense, he also highlights the importance of evaluating the planting frames. In addition, he considers that a phytosanitary plan has to be specially developed for DOV. Pantano is not very sure about the correct procedure to follow regarding the fruit that comes from the wood production area.

In the future this system will be very convenient and will be more widely used. New varieties will have to be generated for San Juan capable of adapting to its agro-climatic characteristics, adjusting phytosanitary plans and cutting dates. Martín Pantano stresses the importance of setting up specific conduction systems for DOV, that is to say, setting up a structure according to the system. He suggests that traditional vineyards should not

[17] In this case, the advantages related to saving costs that the system offers are lost.

be transformed into DOV ones. He noted that the longer the charger, the greater the non-uniformity in ripening (those at the end will always have higher sugar content). He also recommends the use of invigorating rootstocks.

V.5 Julio Pacheco's experience

Julio Pacheco manages farms with vineyards in the districts of 9 de Julio and Ullúm, San Juan Province, where he grows Flame Seedless, Fiesta and Sultana varieties. Currently he has 12 ha where he uses the DOV system. He has been producing raisins for 10 years. He began his experience with Martin Pantano and Gonzalo Huertas. He was also trained by technicians in the United States. When the raisin group of the Chamber of Foreign Trade of San Juan was formed, the need to improve harvest quality and logistics arose. At the beginning DOV was applied in a few vines, as a trial, then in some furrows; today Pacheco has seven hectares in 9 de Julio and five hectares in Ullum devoted to DOV.

Pacheco started using Fiesta and Flame Seedless varieties and also tried Sultana, a variety that adapted to the DOV system easily, but due to two problems (alternation of production and virosis), DOV was discarded. He plans to improve the surface where he uses DOV, but not to enlarge it.

It is necessary to take into account the areas in which this system is applied, since the drying time may increase when there is higher relative humidity or lower temperature. In the districts of 9 de Julio and Ullum, San Juan Province, the weather conditions make its application possible. The system is versatile and allows the change from a traditional system to DOV.

Julio Pacheco indicates that pruning long canes (15 buds) without canopy management allows savings 40% of labor. Regarding pruning, it is important to know what load to leave, regulating it according to the pruning weight and bud break percentage. The DOV system poses no problems with an adequate load if correct fertilization plans are implemented and with strict phytosanitary controls. During the 2016 harvest it was necessary to finish the drying on gravel due to the cold and humid weather. When it has been decided not to thin out clusters in the wood area, it is important to carry out a different harvest, that is to say, cutting the canes area first and then harvesting the spur or wood area clusters.

Selling the raisins produced using DOV has benefits for their superior quality, better texture and appearance, as well as for their very high organoleptic characteristics. Julio Pacheco also recommends the use of invigorating rootstocks.

Lower cost, superior quality raisins (compared to the raisins produced with traditional systems), a better distribution of times and the number of people that gather the harvest are among the advantages of DOV that Pacheco mentions.

In 2013 a late frost caused a great loss of part of the production; however, in those vineyards with DOV the levels of loss were lower, with a production rate of 28.000 kg/ha, compared to 8.000 kg/ha in traditional grapevines. Pacheco does not consider the structure of conduction an inconvenience and indicates that it must be firm (master wires 19/17 and secondary ones 17/15), leaving two secondary wires per middle row to tie canes correctly[18].

Pacheco thinks there are no disadvantages, but there are critical points, among which he mentions the moment when canes are cut according to variety and area. In addition, he points out that there is a shedding process produced by a dehydration of the pedicel that is aggravated due to the presence of strong winds[19]. He adds that this is an expanding system that needs to be tried on new varieties and areas, cutting dates and rootstocks.

As a recommendation, Julio Pacheco highlights the importance of making a good adjustment of the load based on the percentage of sprouting and measurement of the pruning weight. If charges are too long, with more than 15 buds, sprouting problems arise. It is very important to separate properly both the fruit area and the wood area, creating good ventilation. In his opinion. Pacheco states that fertilization does not vary in a DOV system if it is calculated according to yield and soil analysis[20].

V.6 Gonzalo Huertas's experience

Gonzalo Huertas uses DOV on his 25 ha farms of Sultana, Flame Seedless and Fiesta. He has been applying this system for six years. In 1996 he saw the system for the first time in an informative video of California. Then he traveled to the United States to learn about DOV, but he only started experimenting on this system on his farms only 6 years ago. He started using DOV in some middle rows, and good results led him to increase the area year after year until covering 25 ha with DOV with the Flame Seedless. Sultana and Fiesta varieties. He applied the system motivated by a better quality of the raisins and by

[18] Tying is not advisable in the original systems and with adequate vigor.

[19] Matthew Fidelibus, a researcher at the University of California, indicates that this period of sensitivity occurs during the first stage of drying and can last around 10 days.

[20] In a DOV system about 50% of the leaf area and part of the wood are eliminated in summer. For this reason, the plant cannot recover the nutrients from those leaves that fall, so the plant loses the substances it has stored in the canes up to that moment. This leads to a hypothesis according to which DOV systems are more demanding in terms of nutrient consumption, according to INTA professionals.

the reduction of harvesting costs that the system promised. Gonzalo Huertas has observed that year after year there is less availability of manual labor on the farms; as a consequence, there is a higher demand for manual labor and this has made it become more expensive.

DOV produces raisins of a better quality because they have no gravel (from the drying mesh), no dirt; besides, the destemming in the plant is better and easier to make. Regarding pruning costs, Huertas indicates that they are lower due to the distribution of canes. The system also allows the optimization of the use of agrochemicals with a lower incidence of diseases due to greater aeration. Its approximate pruning configuration is in 7 canes of 15 buds for a yield of 23,000 kg/ha for the Sultana variety.

It is important to establish a cut-off date for canes and not to determine it exclusively by the brix degrees; otherwise, the drying period may be longer with the risk of not reaching the necessary moisture level to harvest the raisins without having to take the raisins to the drying yard.

Nowadays, Huertas is working on lower cost conduction structures by braiding the master wires (17/19) to achieve greater rigidity and to use fewer obstacles (savings), guiding the vines with rods used as tutors and a 3.60m x 1.80m plantation frame. The variety that best adapts to the DOV is Fiesta because it has high yields, good color and dries in the vineyard on time and posing no problems. Flame Seedless has color problems and Sultana has problems of virosis and alternation of production. An important aspect is tying the guides so that winds do not cause shelling. An invigorating rootstock has to be used so that production does not decline over time. Another interesting alternative is Cereza rootstock.

Together with Martin Pantano and Julio Pacheco, Gonzalo Huertas is convinced that DOV increases the quality of the fruit and reduces harvesting costs; that's why the area cultivated to use DOV will increase in San Juan province. He does not have serious criticisms regarding the system and says it is necessary to study varieties and specify cutting dates of guides according to the different areas. All interviewees indicate that drip irrigation facilitates the implementation of the system because it helps control humidity inside the vineyards.

V.7 <u>INTA's experiences</u>

INTA began studying the use of DOV in 2010 and readers will be able to draw their attention to everything related to specific data such as yields, drying periods, vegetative expression, estimate of wages and quality in chapters II, III and IV of this manual.

The DOV system was developed for varieties with low basal bud fertility, such as Superior Seedless, Fiesta or Sultana. In San Juan, Flame Seedless is the most important variety of grapes for the production of raisins, but it does not meet this requirement, that's why a complication arises in the system: the elimination of clusters in the wood production area. The following figures show that the production of fruit concentrates on one middle row, leaving the area that produces shoots or wood aerated (at the beginning of the season). This makes phytosanitary treatments easier, made every other middle row, which in turn allows fruit control.

Figures 23 and 24. DOV, separation of the fruit and wood areas during flowering. San Juan.

The arm should not be removed in the wood sector. When the plants age, no growth will occur; this implies no production in the next season.

Figure 25. Plant with little vigor without any cordons to one of its sides.

The drying process starts immediately and the first signs of dehydration are observed the following day. When the canes are cut, there may be flaws and uncut shoots which will delay the drying process. Three days after the cuts, it is convenient to make a check, and to control the cane cuts. This is the moment when there is greater contrast and when the uncut canes are easily found.

Figures 26 and 27. Shoots that have not started the drying process due to flaws in the cane cutting process.

If there are no support wires, when the canes are cut, they will fall to the ground. DOV cannot be implemented without enough wire.

Figure 28. DOV vineyards without support wires.

There should be no gray areas: the separation of the canopy area must be perfect: the canes on one side and the spurs or base buds on the other side; and vice versa in the next cycle. This is applicable to vineyards which have been transformed into DOV.

Figure 29. DOV vineyard with a clear separation of canopies: production of wood and fruit.

No raisins fall to the ground during the harvest. If there are poorly located clusters some loss will occur: the same loss that occurs when grapes are harvested. When pruning is calculated and the load is regulated, there is no decline in production. Tying is not necessary, because after the cut, the shoots will be trapped between the supporting wires.

Figure 30. Clusters of raisins in a plant using DOV.

V.8 The experience from California

The United States has 204,000 acres and specific grape varieties to produce raisins, all of them in California mostly in Fresno (138,000 acres). This country is constantly evolving all the links of the productive chain starting with the genetic development of varieties destined for raisins (currently eight specific varieties), different types of trellises of their vineyards, tools for a mechanized harvest and high yield production lines with important technological advances that ensure the quality and food safety of the product. In turn, at an international level, the added value achieved is one of the highest for its different presentations, packaging, variety of products (raisins with yogurt, chocolate, mix of nuts) and recipe development.

The geographic area where raisins are produced is in the center of California from Fresno to Sacramento, and it is in contact with several development centers of the University of Davis, California. The harvesting and drying activities are carried out from mid-August to mid-September covering mechanized harvests and traditionally manual harvests. Due to its magnitude, this industry is developed all year round to be able to supply the domestic and the external markets.

The researcher Matthew Fidelibus of the Kearny Research and Extension Center, indicates that varieties such as Selma Pete and Fiesta would produce raisins very well adapting to our environmental conditions. It should be noted that Sultana is not a variety that adapts to DOV because of both its low yields and alternation of production, related perhaps to viruses and to inadequate pruning practices, since Sultana produces better yields with long canes.

Fidelibus admits that Flame Seedless is an important variety for Argentina; however, he says that for the DOV system, the high fertility of basal buds is not a desired factor. In this situation, he recommends a sustainable management plan and tests to detect problems. Arizul, in his opinion, is a very late variety, which is why it would not complete the drying process.

Diamond Muscat (DM) can be an interesting variety to try in Argentina if there was a market for Muscat raisins. This variety has not grown in California, precisely because there was no market demand. DM presents some peculiarities; like Flame Seedless, it is fertile in its basal buds and the following question is always asked: what to do with the clusters that come from spurs and basal buds of canes.

Fidelibus indicates that the use of rootstocks may be necessary in Argentina. It is common for a decay to occur when vines in their own roots are used. Vigorous plants that resist the fact that the canes are cut every year are necessary. As shown in the following figure, Open Gable is one of the most widely used conduction systems in California, which is also used in the production of table grapes. Its main advantage is that it allows the mechanization of cane cuts and harvest of raisins. Its only disadvantage lies in the costs of implantation. California uses a 3.6 m frame between rows (space that allows long canes to generate) and 1.6 m between plants. It can be corroborated that plants show excellent vigor in their cultivation conditions.

Figures 31 and 32. DOV system in California implemented in Open Gable.

As the photo shows, in California the cane cuts are made with pruning shears.

Figure 33. Canes cuts using the DOV system.

According to Matthew Fidelibus, cutting canes is a simple process and he describes it in the following way:

1) The vines must be healthy, vigorous and well formed.

2) When short canes are used (those he observed in his visit to Argentina), with five or six buds, they must be tied; otherwise, they will not be supported by the wires. A suitable criterion is to make a long pruning and to avoid tying.

3) When it is time to sever he recommends taking a grape sample, measuring the weight and determining the Brix degrees.

4) The canes are cut off, leaving or foreseeing the generation of the shoots for the next season.

5) In California, the canes have 15 to 20 buds and they are cut on the third or fourth bud. Since they are low basal fertility varieties, no clusters without dehydrating are left; no clusters must be harvested manually, either.

6) Fidelibus indicates that canes with five or six buds would be inefficient with respect to the load when having to leave one or two buds for the production of shoots for the next season.

Chapter VI

Final Recommendations

VI.1 Key to building a DOV system

To build a DOV system, the following steps are suggested under the assumption of two situations: 1) when the vineyard has been set up and the plant has four branches, and 2) when the new structure has to be set up.

Situation 1: Let's suppose that the vineyard has been set up with four arms.

1) The arms of the plant will be supported by the master wires. For this reason and because the canopy needs to be separated in two horizontal planes, it will be necessary to evaluate the position of the arms and to eliminate those that are in the separation area of the canopy.

2) Before pruning starts, the load of the plant has to be determined. The pruning weight and bud break percentage are measured. The vegetative expression is also taken into account (shoot length, internode length, number of secondary shoots per shoot).

3) The criterion of the pruning weight will be to leave 35 to 40 buds per each kilogram of wood. The time when the measurement was made has to be kept in mind. If it is done very early or when the leaves fall, the arms will contain water and the weight will be higher.

4) With respect to the bud break percentage, the technique implies, first, to count the number of buds left by the pruner in the previous cycle; and second, to count the number of effective shoots (of cane + spur), discarding secondary shoots. Then the quotient is obtained between the number of shoots per plant and the number of buds per plant.

5) Criteria for the sprouting percentage: if it is higher than 100% it indicates that the plant has a larger capacity to feed the number of buds that the pruner left the previous year, and a richer pruning will be possible (an increase in the number of buds per plant); if it is lower than 100%, it indicates that the plant has a smaller capacity to feed the number of buds that the pruner left the previous year and a poorer pruning will have to be performed (a decrease in the number of buds per plant).

6) If a direct observation shows that 1) the sprouts are two meters long or longer, 2) if the internodes are longer than 15 cm, and 3) if there are more than three secondary shoots per sprout, this will indicate that the plant is vigorous for its environment so the number of buds per plant has to be increased.

7) Finally, the measurements have to be repeated a minimum of 10 times, establishing three load ranges (maximum. medium and minimum). The ranges should be constructed based on average values of all measurements.

8) For example, on average, a group of vines weighed 5 kg (an equivalent to 175 buds per plant); however, the sprouting percentage was 100%; the previous year, the pruner

had left 110 buds, the shoots are up to 5 m long, the internodes are longer than 15 cm and there are more than three secondary shoots per sprout. It is not possible to leave 175 buds; nor can the pruning criterion of the previous year (110) be respected; therefore, it would be logical to decide on an average of the averages, leaving around 140 buds per plant; a richer pruning is done, but without reaching extremes.

9) Once the number of buds to leave per plant or group of plants or type of expression has been calculated, the pruning equation must be defined: number of canes and buds per cane + number of spurs with 1 bud.

10) Criterion to separate wooden buds from fruit buds: the proportion of buds normally left per spur is respected. For example, if a spur is normally left (by definition two buds) per cane and the pruning was calculated for 140 buds, they can be distributed in 12 canes with 10 buds + 10 spurs = 140 buds.

10) The spurs will be left towards one side of the middle row for wood production), and the canes, towards the other side (middle row for the fruit production).

11) Let's remember that a lower number of long canes will always be convenient. For example, 6 canes with 20 buds would be better than 10 canes with 12 buds.

12) Then comes the selection of the canes that remain and of those that will be eliminated. The arms in the division area must be eliminated (those that are located on the main wire that divides the plant into two).

13) If there is no alternative, since the only arm is in the division area, only the canes that are perfectly oriented towards the middle row of fruit production will be left. Over time, an arm within the wood area and/or fruit area has to be formed, but not in the division area of the canopy.

14) When there are loading elements on the division area the shoots may grow towards the wrong sector and this will cause problems when cutting the canes to begin the grape drying process (February).

15) If the plant is new (4-5 years), it will be convenient to turn the plant 45º. In this way the four main arms will remain within the wood/fruit production areas (two on each side) and they will have moved away from the main wires where the crown is traditionally formed.

16) Then, having chosen the main cordons, the canes are selected and positioned in the fruit production area and the short spurs (1 bud) in the wood production area are left.

17) There must be at least two support wires on each side of the plant. If these wires do not exist (for example, if there is only one), the guides will fall to the ground and production will be lost.

18) The plants have to be vigorous (shoots longer than 1.5 m). If they are not, the canes will not be able to hold themselves between the wires and will fall to the ground.

19) The system has been designed so that tying is not necessary. Due to their length, the canes are supported by the wires after the cuts are performed, even if the weather is windy. Failure to meet one of the two requirements (two wires and/or shoots longer than 1.5 m) tying is necessary.

20) When the grapes reach a convenient degree of ripeness the canes are cut as close as possible to the main arm. In this operation, it must be taken into account that 50% of the winter pruning is being performed earlier. The cut will be such that a new spur with one bud, or only base buds will be left.

21) After three days, the cut should be checked to watch green shoots that were not cut the first time cutting was done.

22) The process of severing, a simple and fast task, should start in 4-6 cuts.

23) The cuts should not be made after the first days of February. If the cutting takes place later, there is a serious risk: the period of dehydration becomes longer (due to a drop in temperature and an increase in the probability of summer rains).

24) Irrigation is advisable before making the cuts and/or perform the last irrigation (March) only in the middle row that corresponds to the wood production. This is done in this way so that the relative humidity inside the vineyard does not increase, reducing the rate of dehydration and delaying drying.

25) No watering would damage the fruit bud formation processes of the next cycle.

26) Once the raisins have reached the minimum moisture content (14%), harvesting and storing with aluminum phosphide treatment can be carried out.

Situation 2: Setting up a new structure.

1) We suggest that a cuadrilateral cordon (H) should be assembled.

2) The ideal thing to do would be to build a Californian structure called Over Head, in which the cords are located 20 cm below the wire structure. This way allows the mechanization of the cane cuts by creating a separation or space between the cord and the structure that holds the canes.

3) DOV can only be applied when the support structure is completely formed.

4) To optimize the space per hectare there should not be more than 50 cm between the cords.

5) The Open Gable or Shaw systems allows the mechanization to cut canes and to harvest, but they are extremely expensive.

6) All the criteria regarding vigor and handling between the wood and fruit sectors are the same as those indicated for Situation 1.

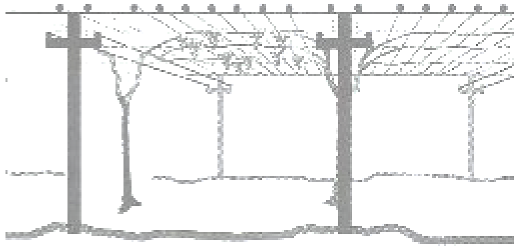

Figure 34. Over Head System. Source: 1st International Table Grapes and Raisins Symposium. Lecture by Matthew Fidelibus, researcher at the University of California.

VI.2 What must not be done: common mistakes

1) Under no circumstance can DOV be applied in plants that do not have their branches completely formed.
2) The DOV system is not recommended under conditions of low vigor as a consequence of soil, irrigation or management problems that will have to be solved before even considering the use of DOV.
3) One should not over demand the plant, so it is not advisable to leave the calculated fruit and to leave the fruit that has grown in the wood production sector.
4) The wood production sector must allow 5-8 vigorous shoots to grow and ripen. When these shoots do not exist, it is because a mistake was made when calculating the pruning and a very rich pruning was carried out.
5) When the shoots are cut to start the drying process, some shoots remain uncut, Cuts should be made as close as possible to the cordon.
6) An excessive number of buds should not be left in the wood production area; 5-8 shoots are necessary, no more than that.
7) A load structure (arm or cordon) should always be left in the wood sector during the conversion; if not, there will be no production on that side during the next cycle.
8) Arms must not be left in the middle area of the plant (above the main wire); they will always hinder the separation of canopies. It is preferable to eliminate poorly located arms gradually. This problem exists only with vineyards; it could not happen in systems with cordons.
9) If there is vigor, tying is not necessary.
10) Watering should not be stopped after the cuts. The amount of water has to be reduced.
11) Cutting should not be made late. It must occur when there are still conditions for drying to occur. It should not be made after the first days of February.

12) DOV should not be attempted if there is not at least a pair of support wires on both sides of the main wire.

VI.3 Current status of the process to adopt DOV technology.

The DOV system produces economic benefits in terms of labor savings during the raisins production stage by avoiding grape harvesting, laying-in-the-sun, turning over, and picking up. Raisins are of a better quality, cleaner, without physical contaminants and easier to process.

However, there are serious risks linked to a poor application of the technology: failure in the calculation of the bud load and in the distribution of the load elements; bad cuts (for excess or defect); delay in the cutting period; application of the system in weak plants, among others. Another risk is related to the decrease in plant reserves caused by severe summer pruning. The level of reserves when DOV has been used for more than 5 years must be evaluated.

It is necessary to study drying curves in the field for different places and varieties. This will allow the construction of a regression model that, according to humidity and temperature data, will allow to predict the exact moment of cutting canes or, at least, to establish the deadline to carry out this task.

The use of drying products is an alternative that could shorten the drying period and, consequently, risk the raisin production system. However, their effect on the quality of raisins and their effectiveness in DOV systems is not known. It is necessary to increase the knowledge of drying drugs, application doses, moments of use and effect on quality.

In DOV systems, ochratoxin could develop, linked to fermentative processes according to drying conditions. This could affect the quality of the product; however, it is not known if DOV generates conditions for the development of this toxin.

Last and most importantly, work should be done on new varieties and on the characteristics that would improve the production of quality grapes for international markets. The use of this technology will allow the raisin sector in San Juan to gain international markets due to the competitive advantages linked to the use of the DOV system because of a reduction in production costs and an increase in product quality as an income strategy.

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Abbreviations:

EEA: Estación Experimental Agropecuaria - Experimental Agricultural Station.

INTA: Instituto Nacional de Tecnología Agropecuaria – National Institute of Agricultural Technology.

INV: Instituto Nacional de Viticultura – National Institute of Viticulture.

The DOV technology represents a real strategy to generate costs savings, optimization of the use of the soil and it is associated with better quality raisins. These factors, taken as a competitive advantage, will allow a greater aptitude and better access to international markets. This book contains information about: general aspects of DOV and other systems of raisins production; local research on Superior Seedless and Flame Seedless varieties (drying times, yields, leaf area and paid wages); quality of DOV raisins; the local producer´s experiences; criteria to set up DOV systems and recommendations.

Dry on vine San Juan´s experiences

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