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GROWING AVOCADOS IN CHILE: A FOCUS ON ORCHARD SYSTEMS, FRUIT SET AND SIZE

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SUMMARY

During the past years the Chilean Avocado Industry has shown significant growth. Some reports mention that more than 2,500 hectares per year have been planted in some of the recent years. This growth has made Chilean growers face a new challenge; maintain profitability in a difficult market situation. Growers have adopted different strategies to succeed this challenge. The main objective of the Chilean growers today is to reach high productivity with the lowest cost of production per kilo. This paper summarizes strategies and field practices used by our group for avocado production in Chile.

Key words: avocado, Chile, planting distances, pruning, fertilization, pollination

INTRODUCTION

Chile has clear advantages and ideal conditions for producing avocados. The Mediterranean Subtropical climatic conditions, the quality and availability of water, the alternative of growing avocados in very steep slopes, the low incidence of pests, the conditions for producing good quality and market accessibility are very important facts to consider. Additionally the vision of the growers has been the basis for the success reached until now.

The strong growth shown by the Chilean Avocado Industry in the past years is mainly based on the high profitability shown by this crop, which is mainly pushed by a very attractive market situation and advantageous conditions for growing avocados. These facts have driven Chile to be the third largest avocado producing country in the world, and the largest exporter of avocados. Today the area planted with avocados is greater than 27,000 hectares. In 2004, more than 2,500 hectares were planted with avocados (Table 1).

Table 1. Evolution of Chilean Area planted with avocados (thousands of hectares) Source: MAGDAHL (2004) based on data from CIREN, ODEPA & FEDEFRUTA.

Year	1980	1985	1990	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Area	6.2	7.1	8.2	12.1	13.3	16.8	18.3	20.3	21.2	22.3	23.4	25.1*	27.6*

* Estimation

This growth has had a big impact on the Chilean industry, which has grown from 2.7 million cartons (11.2 Kg) in the 1999 -2000 to near 11.5 million during the last season.

In the coming years the projections of growth for the Chilean volumes are very high, and some estimates indicate that in 2008 Chile should be producing 260,000 tones (MAGDAHL, 2004).

On the other hand, more than 90% of the Chilean exports have the US as destination market. With the actual volumes Chile can cause a difficult market situation, especially in some years and in some sizes. Added to this is the authorization for Mexico to export avocados to most states of the US.

Today the Chilean Industry is facing a big challenge; maintain profitability with the increasing volumes and competition in the destination markets. There are many strategies at the grower level that can be implemented to survive under this more and more competitive conditions.

STRATEGIES

Under today's scenario, production efficiency is the most important issue growers should focus. This means yield is not the only fact to consider anymore, fruit size has a major impact in grower's returns on the past years. So growers must keep high productions and big fruit sizes at the lowest cost per kilo. In order to aim for this goal, growers must be really focused on productions practices. The practices that will have a big impact in their returns are:

Irrigation
Nutrition
Pruning
Pollination.

The main issue with these practices is how to approach them and be successful in all, so none becomes a limitation in achieving the established goal. There are some elements on each one of them that will be discussed later on.

For the new plantings, the main strategy, besides the ones mentioned before, is to get into full production as soon as possible. Therefore high density plantings have shown to be the best alternative for growers. These high density plantings are planned to be definitive and pruning in this orchards is a vital tool to maintain productivity stable through the years. Also in the last year ultra high density has been done in some orchards in Chile with very promising results.

PHENOLOGY

Phenology is one of the most important things a grower should know and understand. It is worth to mention because the base of all field practices should have a phenology base, so every cultural practice must be understood and based on the phenological model, so growers can anticipate the effect of their actions and prevent bad practices to occur. Knowing how their trees behave during the year, when they grow, when they

flower, etc, is the key tool for successful management. Using phenology in a holistic approach is definitely the key to orchard management. Hass phenology in Chile was first studied in the early 1990's in the Quillota area (Figure 1).

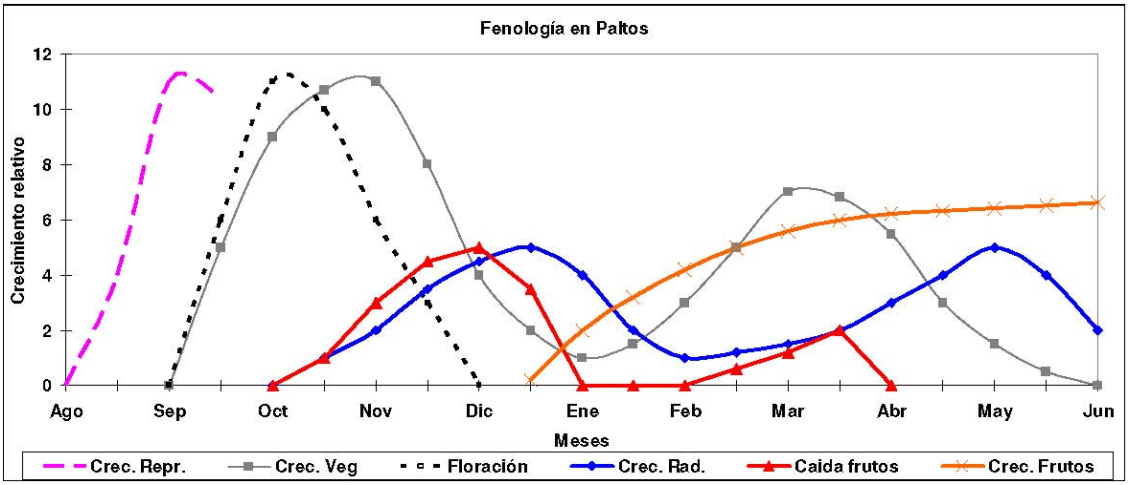

Figure 1. Hass Avocado Phenology in Quillota, Chile (MENA, 2004a)

The above model is established for the Quillota area, which is the traditional avocado growing area in Chile. Phenology models for some of the new production areas have not been developed yet, and many growers are doing their own phenological studies.

Now that we can see how trees behave in Chile, we can discuss how some of the management tools have been and are being used in Chile. Comparisons between Chilean and New Zealand phenological models can be found in MENA (2004a).

IRRIGATION

Under Chilean climatic conditions, irrigation is a must. Summers are dry and rain occurs only during winter. In most production areas, annual rainfall is normally not higher than 250 mm. Therefore irrigation is the most important production factor in Chile.

More than 80% of the orchards have pressurized irrigation, with micro sprinklers and micro jets the most common irrigation systems. The use of drippers, according to the latest statistics, represents near 20% of all irrigation systems.

For scheduling the irrigation, many growers use evaporation pans. The crop coefficients for the central area of Chile were determined after a 3 year research in which 4 different amounts of water were tried. The recommended crop factors are shown in Table 2.

When using this method for scheduling irrigation, some other method to monitor water status in the soil or water status in the tree must be used. These methods and their advantages and disadvantages are:

Manually inspecting the soil profile: The oldest way to monitor water status in the soil. Used by many growers on a weekly basis. It's very important to measure what is going on in an area with high root concentration. The soil inspected area must be large enough and for correct interpretation requires experience and training to

avoid mistakes.

Tensiometers: probably are one of the most used system worldwide. They were used for many years in Chile, and were replaced when the evaporation pan was introduced. But when only climatic considerations are taken, some surprises in the soil like over-irrigation and saturation can be found. After some years tensiometers where installed back in the orchards, put together with visual inspection of the soil (by hand) and today they are one of the most useful tools growers have in their orchards. One thing to keep in mind with tensiometers is the correct installation and the interpretation of the readings. Tensiometers must be installed where a high concentration of healthy roots are found. Many orchards have been irrigated with tensiometer readings lower than -10 cb. When digging a hole in these orchards, excess of water can be found, roots show asphyxia symptoms and trees start showing the first symptoms of stress and root rot after one or one and a half years. On the other hand, when irrigating with tensiometers readings from 25 to 35 cb, roots start getting active and white again and trees become healthy and productive.

Table 2. Crop Coefficients for Hass Avocados (Gardiazabal *et al*., 2005).

Month	Kc
January	0.72 – 0.75
February	0.72 – 0.75
March	0.72 – 0.75
April	0.72
May	0.72
June	0.72
July	0.72
August	0.72
September	0.72
October	0.72 – 0.75
November	0.72 – 0.75
December	0.72 – 0.75

* 0.75 is recommended during summer months for hot areas.

Neutron Probes: This system was tried in Chile a few years ago but calibration of the equipment was very difficult, mainly due to the high variability of soils present in our Orchards.

LVDT Dendrometers: They keep continuous measurements of trunk diameter and the growth or contraction can be used as indicator related to stress status. The readings of these instruments are difficult to integrate and use as an irrigation scheduling tool. They do not integrate the water content in the soil and therefore can induce commonly over-irrigation. Probably during the next years as research advances they can become a useful tool for growers. Today they are more

recommended for research, even though there are some trends to use them as an irrigation management tool.

Pressure Chamber: This method determines the water potential in the leaves. Just like the previous method they can be complementary to other instruments like evaporation pans or tensiometers. The optimum potentials and the leaf sampling method for the Quillota area are being determined by ongoing research.

IRRIGATION FREQUENCY

During the past years, there have been big differences in irrigation practices between growers. Some growers have implemented very high frequency irrigation practices with more than 20 pulses per day. The basis of this is keeping water close to the roots so they make no effort on getting it, but probably forgetting about soil oxygenation.

On the other hand, other growers have adopted a completely different strategy, allowing the trees to absorb an important volume of water from the soil, before wetting it again. This last practice under the Chilean soil conditions allows the roots to be exposed to higher oxygen levels and therefore they show less problems of root rot. Many of these growers consider the "tank" of water that the soil represents, and irrigate only when ⅓ of the available water has been consumed. This means that under most of Chilean conditions irrigation is done 2 to 3 times per week during summer months.

During the last 3 years research comparing pulse irrigation with the usual irrigation (after ⅓ of the available water was consumed) was carried out. For setting up the pulse irrigation treatments (1, 3, 7 pulses per day) 3 lines of anti drainage drippers per row were used. Dendrometers were also used to measure trunk diameter every 5 minutes. After 3 years, none of the pulse irrigation treatments was better than the micro sprinkler control (Table 3).

Table 3. Crop and number of fruits per tree and fruit weight with different irrigation frequencies in two different years.

Treatment	Kg/tree 2003	Fruits/tree 2003	Fruit weight 2003	Kg/tree 2004	Fruits/tree 2004	Fruit weight 2004
Microsprinkler	69.6 a	385 a	186.7	79.7 a	470 a	174.3 a
3 pulses/day	70.3 a	398 a	181.8	81.3 a	524 a	162.2 b
7 pulses/day	61.3 ab	352 ab	184.8	59.8 b	368 b	168.5 a
1 pulse/day	43.9 b	246 b	180.3	71.7 ab	518 a	139.8 c

NUTRITION

Fertilization has also shown to be one of the most important factors in avocado production. Besides nitrogen, in Chile the most commonly applied nutrients are zinc and boron, both usually appear low or in the lowest part of the normal range in the leaf

analysis.

Nitrogen:

The most important nutrient applied in Chile is nitrogen. Correct timing and amount of nitrogen is the base of high production in avocados. The timing of nitrogen application we are proposing has a relation to the best results obtained by Dr. Carol Lovatt's research (LOVATT, 2001). Under this scheme the dates and percentage of the annual dose are the following:

April – May:	40%
October:	30 – 40%
January:	20 – 30%

With this nitrogen distribution, we have seen better sizes, better productions and lower alternate bearing in our orchards.

The amounts of nitrogen applied vary according to the variety (GARDIAZABAL, 2004). The recommended ranges of nitrogen amounts per hectare are:

Hass:	150 to 250 K/ha
Fuerte:	0 to 150 K/ha
Bacon:	0 to 100 K/ha
Zutano:	50 to 150 K/ha

Phosphorus and Potassium:

Visual symptoms of phosphorus and potassium has never been seen in avocado orchards in Chile, even though we have found in some specific orchards low levels of potassium in the leaf analysis. Therefore visual symptoms is not useful to determine potassium deficiency.

Some growers use phosphorus and potassium in their orchards, but nobody has proven yet that in most orchards they are needed in a nutrition program.

Currently we have a research comparing N, Zn and B v/s N, P, K, Ca, Zn, Mg and B fertilization programs. After 3 years, no major differences were observed and we are keeping an eye on next year's results to see if there is any production or fruit quality differences.

Zinc:

This micronutrient is commonly deficient in our growers' leaf analysis. For many years we used foliar sprays of zinc sulfate to solve the problem. After having no results in decreasing the symptoms in the orchards, we changed to soil applications of zinc sulfate, applying manually in 8 – 10 holes per tree up to 8 kilos/tree (in the most deficient orchards) during one year with very good results. Today we apply 200 – 300 Kilos of zinc sulphate per hectare through the irrigation system and after 5 years of continuous application we are seeing promising results (GARDIAZABAL, 2004).

Boron:

Boron is a very important micronutrient. It is closely related with cellular division and meristematic activity. It is of much relevance during the pollination process. In our soils, boron level is usually low and soil pH (usually above 7) does not help to it's absorption by the roots. Every year growers apply 5 – 8 grams of boric acid per square meter of canopy. Application is usually done manually, spreading a line of boric acid in the area wetted by the micro sprinkler.

PRUNING

Pruning has become a very common practice among Chilean growers (MENA, 2004b). Low yields and small sizes were beginning to be a big problem in some orchards. Until 10 yeas ago, planting distances did not require pruning as a very important tool. Many of these planting patterns were squared patterns and ranged from 10 x 10 m to 6 x 6 m or 4.25 x 4.25 m. The last one considered the elimination of a diagonal line to end with a 6 x 6 m distance. After experiencing the results of high density during the first years, growers did not want to remove the extra tree they planted and competition between trees stared to create the first problems. Overcrowding caused the trees to grow only in the tops and production tunnels were formed in every orchard. Even though in the first years of this situation production remained normally high, fruit size was reduced and picking costs and accident risks increased with the height of the tree.

Today pruning has two different focuses, the first one is the pruning of overcrowded orchards, and the second one is to maintain good light penetration, and therefore good production and fruit size in high density orchards designed for pruning and that have not become overcrowded yet.

OVERCROWDED ORCHARDS

When overcrowding has become a problem, the solution or the type of pruning required to get out of that situation depends on the planting distances. Each orchard requires a different approach depending on their particular situation.

In very low density orchards (100 – 200 trees/ha), where trees have become tremendously tall, the first step is to bring the height down, to the height equivalent to 70% of the distance between rows. In very low density orchards, the height can be lower if a maximum height for harvest is considered. It is very important to paint the last 30 cm of the cut branches with paint + Naphthalene acetic acid (1% a.i.) to avoid only top re-growth to occur. The branches not exposed to the sun after several years must be painted white to avoid sunburn and lack of lateral re-growth. It is essential to leave as much foliage as possible in this type of pruning because it will permit some flowers to set and fruit will help control the vigor of the vegetative response.

After one year, the main idea is to form pyramidal trees that show good light interception up to the center of the tree.

In higher density orchards (250 – 400 trees/ha) the main objective is to form hedgerows. In this type of orchard, we form one side of the hedgerow per year. The first year must coincide with high flowering so that, once again, fruit becomes a big help in controlling

vigor. If too much material needs to be removed to form the hedgerows, pruning must be performed early in the season so that the empty space in the branches can be filled again with new growth and this new growth can be pruned at the end of the summer to obtain less vigorous growth and more flowers the next spring. This re-growth management is very important because it adds “complexity” to shoots and refills with new growth the branches.

HIGH DENSITY ORCHARDS

In high density orchards, planned for pruning and that have not become overcrowded yet, pruning is focused on maintaining light penetration in the tree and in forming the trees to the desired pine shape. In these orchards, pruning is not necessary until year 3 or 4. Any pruning done before will have a negative impact on productivity. Pruning must start when canopies between rows are 1 to 1.5 meters apart from each other, and the removed material is that who limits light interception by the inner foliage. This light pruning is usually done late in the summer so that the response in growth is delayed by low temperatures and shorter day length.

In most cases pruning can be done both mechanically and manually. In Chile manual pruning is more common because one can choose what branch to cut or remove and also because most of the orchards are planted on hillsides.

POLLINATION

Pollinators:

The benefit of using pollinators and pollinizers has been worldwide demonstrated (ISH AM, 2004a; ISH AM, 2004b; ARPAIA & HOFSHI, 2004).

In Chile the use of honeybees is very common and growers usually place 8 – 10 hives/ha in mature orchards. The most common method is placing 50% of the honeybees when flowering begins and the other 50% at full flowering.

Also since Dr. Ish Am’s visit last year, we are leaving some weeds such as mustard in the orchards, as pollen sources for the bees to feed the hive and keep it vigorous and helpful for the grower.

Another helpful tool is to place in the orchards small opened containers filled with water so that the bees have fresh available water near the hives.

Pollinizers:

As of pollinizers, in Chile the most popular pollinizer for Hass is Edranol. GARDIAZABAL & GANDOLFO (1995) demonstrated that when Bacon, Zutano, Rincon and Hass supernumerary trees were placed in the orchard as pollinizers, the most common pollen donors were Edranol and Zutano (Table 4).

Edranol was preferred because it flowers heavily every year; the flowering period coincides better with Hass later in the season when temperatures for fruit set are better.

Today we are testing other pollinizers such as Ettinger, and the combination of different

pollinizer varieties trees in the orchards.

Today Chilean growers commonly use 11% of Edranol trees in their orchards as pollinizers and higher pollinizer concentrations are currently under research.

Table 4. Interaction between different pollen donating parents (GARDIAZABAL & GANDOLFO, 1995).

	% of parental pollen of the fruits				
Treatment	Hass	Zutano	Rincon	Edranol	Bacon
Hass Control	21.6	16.8	2.6	32.1	26.9
Hass/Hass	35.5	11.6	2.3	18.5	32.1
Hass/Rincon	15.3	30.8	10.1	19.9	23.9
Hass/Edranol	7.7	2.2	0.4	76.9	12.8
Hass/Zutano	2.6	74.1	3.1	1.9	18.4
Hass/Bacon	16.3	12.1	3.9	15.3	52.5

ORCHARD PLANNING

Today, the highest percentage of the new plantations is located on hillsides. Many of these orchards are planted on hills with slopes steeper than 60%. This means that no mechanical practices can be done. Keeping this in mind, road design plays a fundamental role in operational efficiency. They are also important as many of these orchards, because of high soil variability and high levels of clay, are planted on ridges. Frequent roads are required to conduct water and prevent erosion. Usually on hillsides, roads not further than 50 m away from each other are placed, so that workers are not required to walk much between the first and the last tree of the row.

The last relevant issue to discuss is high densities. In the past years the Chilean industry has quickly changed to high density plantings. As mentioned before, 10 to 15 years ago Chilean growers planted Hass at planting distances of 6 x 6m or 4.25 x 4.25 m. Today, new projects must enter full production as soon as possible. This early production is probably one of the most relevant factors in making a new project successful and economically viable for the grower.

Today, we can talk about high densities and ultra high densities. The most common distances used today in Chile are 6x3 m and 6x2 m (555 to 832 trees/ha). These planting systems consider pruning as a management tool for keeping the trees well illuminated and productive. As we have seen in many cases, as we move from 6x4 m to 6x3 m or 6x2 m, due to higher competition within the row, less pruning is required and trees maintain higher production between years.

The latest densities for the Chilean Industry are based on a system developed by Reuben Hofshi in California. Under this scheme we are planting orchards at 3 x 3 m. This system requires a completely different tree shape, as we are moving from pine shaped trees to cylindrical shaped trees. These trees are planned not to be higher than 2 meters, and tree diameter must not be bigger than 2 meters. These densities are

based not only on high production during the first years, which is basic for a successful project, harvesting and other cultural activities are highly simplified as lateral access between trees is inherent to the design (HOFSHI, 2004). Further details of this ultra high density system can be found in different articles published by Reuben Hofshi in www.avocadosource.com.

CONCLUSIONS

The challenge faced by the Chilean Industry these days, can be successfully passed trough if growers keep their orchards productive and big sizes predominate in their production. To achieve these results growers must understand the avocado growing cycle and manage their trees according to their requirements. Under this scheme phenology study and understanding is vital to remain productive and profitable.

Production facts such as irrigation, nutrition, pollination and pruning are vital to obtain and maintain high and profitable productions.

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