

AGRONOMIC EVALUATION AND PROPAGATION OF NEW ROOTSTOCKS AND AVOCADO VARIETIES IN DIFFERENT AGRO-CLIMATIC ZONES OF CHILE

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In Chile, the avocado crop is in third place regarding seeded area and in sixth place as to volume of exported fruit according to official statistics. However, in terms of technology, it shows several difficulties that cause its productivity to be under the optimal level in relation to its potential. The main limiting factors affecting this crop nowadays are as it follows: saline soils; presence of carbonates; incidence of avocado root rot caused by the *Phytophthora cinnamomi* fungus; replanting and use of seedling rootstocks. Therefore, enhancing the levels and quality of fruits produced is urgent. To do this, the selection of good rootstock is essential to make a plantation successful.

Through the implementation of the first program of introduction, selection and propagation of avocado rootstocks in Chile carried out by the Faculty of Agricultural Sciences of Pontificia Universidad Católica de Valparaíso, together with Chilean companies between 2002 and 2005, the first avocado Germplasm bank with promising plant material of rootstocks and varieties was created. In addition, the use of etiolation and layering technique began to be implemented. Subsequently, the University was awarded with this continuity project in December 2005, for a period of seven years, in order to continue, validate and define the use and propagation of clonal avocado rootstocks in our country. In this stage, a total of 20 companies both national and international participate. The use of this tool will allow increasing the profitability of the crop, generating benefits for the industry of this species.

Key words: evaluation, selection, rootstocks, cloning, Chile.

EVALUACION AGRONÓMICA Y PROPAGACIÓN DE NUEVOS PORTAINJERTOS Y VARIEDADES DE PALTO EN DISTINTAS ZONAS AGROCLIMÁTICAS DE CHILE.

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En Chile el cultivo del palto ocupa el tercer lugar en superficie plantada y se ubica en el sexto lugar en relación al volumen de fruta exportada según cifras oficiales. Sin embargo, a nivel tecnológico presenta varias dificultades que determinan que su productividad se encuentre en niveles subóptimos con respecto a su potencial. Las principales limitantes que enfrentan hoy el cultivo son: suelos salinos, presencia de carbonatos, incidencia de la tristeza del palto causada por el hongo *Phytophthora cinnamomi*, replante y utilización de portainjertos de semilla. En consecuencia, urge aumentar los niveles y calidad de la fruta producida, para ello la elección de un buen

portainjerto es un aspecto clave que puede definir el éxito o fracaso de una plantación.

Mediante la implementación del primer programa de introducción, selección y propagación de portainjertos de paltos en Chile realizado por la Facultad de Agronomía de la Pontificia Universidad Católica de Valparaíso junto con empresas del sector entre los años 2002 a 2005 se forma el primer Banco de Germoplasma de palto con material vegetal promisorio de portainjertos y variedades y también se comienza a implementar la técnica de etiolación y acodo. Posteriormente, en el mes de Diciembre del año 2005 la Universidad se adjudica este proyecto de continuidad por un período de siete años de manera de continuar, validar y definir la utilización y propagación de portainjertos clonales de palto en nuestro país. En esta etapa participan un total de 20 empresas tanto nacionales como internacionales. La utilización de esta herramienta permitirá aumentar la rentabilidad del cultivo generando beneficios para la industria de esta especie.

Introduction

In Chile, there is still no certainty and consent among historians and scientists on the way and period of time in which this fruit species was introduced in our territory. Some information indicates that this would have occurred through the transport of seeds from the Andean valleys during the second half of the 19th century. Anyhow, the marketing of the crop in our country has been developed for more than 50 years, being currently one of the most consolidated horticultural industries. Official records place this crop in the third place regarding the area planted with fruit trees. Chile is the third avocado producing country and the first avocado exporter in the world, exporting 75% of the total produced. However, the growing of this species presents several technological difficulties such as the presence of clay soils, salinity, carbonates, not very deep soils, high incidence in some soils of the pathogenic fungus *Phytophthora cinnamomi* which causes avocado root rot, and replanting problems, among others. In addition, the commercial orchards are mostly on seedling rootstocks, where those of Mexican strain are mainly used. This causes that orchards have a high heterogeneity in their levels of production.

All this eventually results in the potential production of this species in our country being in suboptimal levels. Some years ago, this aspect was not important due to mainly two situations: first of all, the conditions of the market were rather stable and promising; therefore, in spite of having productivity problems, the crop was projected as profitable and additionally the plantations were established in soils without major limiting factors, that is, plane and fertile soils. Despite the previously mentioned, the current conditions of the market and growing have changed; the greater competitiveness faced currently by the industry and the movement of the crop to areas with edaphic limiting factors require nowadays the use of tools such as rootstocks, in order to be more efficient in the yields.

Prospecting and Introduction of projecting material

The selection and obtaining of clonal rootstocks represent one of the most complex challenges of modern fruit growing, since it requires a long-term deep progressive research on a series of physiological, agronomic and edaphic environmental variables. It is demonstrated that the use of rootstocks is essential for substantially improved yields, quality of fruits and crop farming in edaphically-restricted locations. The worldwide selection of avocado rootstocks has been carried out in a very few countries and has been mainly focused in the search of rootstocks resistant or tolerant to pathogenic fungus *Phytophthora cinnamomi*. Since 2002, the Faculty of Agricultural Sciences of Pontificia Universidad Catolica de Valparaiso, through the execution of two FONDEF-PUCV projects, selects and prospects in the main production areas of our country an important number of national ecotypes of avocado trees with potential use as rootstocks which usually have tolerance to *P. cinnamomi*, acclimatisation to salinity conditions and high levels of production (Figure 1 and Tables 1 and 2). In addition, prospecting and selection of ecotypes with potential use as new varieties are made, presenting characteristics similar to commercial Hass variety.



Figure 1: Prospecting and Selection in Chile of projecting Ecotypes with potential use as rootstocks and avocado tree varieties

Table 1: List of the main ecotypes prospected and selected in Chile with potential use as new avocado rootstocks

Number of Selected Ecotypes	Potential Characteristics of Resistance or Tolerance	Selection Zone
2	Tolerance to Asphyxia and <i>Phytophthora cinnamomi</i>	North Zone
1	Tolerance to Asphyxia and <i>Phytophthora cinnamomi</i>	Centre North Zone
1	Tolerance to replanting conditions	Centre North Zone
3	Tolerance to Salts	North Zone
3	Productivity	North Zone

Table 2: List of the main prospected and selected ecotypes in Chile with potential use as new avocado varieties

Number of Selected Ecotypes	Characteristics	Selection Zone
2	Fruits of very good taste, early harvest	North Zone
1	Hass type but earlier.	North Zone

In 2005, the procedures for the protection of one of the prospected ecotypes are started and vegetative material is sent to the University of California, Riverside in the US for analysis.

In addition to the selection of national projecting material, between 2002 and 2006, rootstocks and avocado varieties have been introduced; these were developed and validated by important Centres of Research and Propagation of this species, such as: University of California, Riverside (USA); Volcani Center Institute (Israel); Salvador Sánchez Colin Foundation (Mexico); Brokaw Nursery (USA) and Westfalia Technological Center (South Africa). The material entered from foreign countries was subjected to a quarantine regime for a period of two years. Once the first mother plants from the promising national and international material were propagated and obtained, they were planted as from 2004 in the avocado-collecting orchard of the Faculty of the Agricultural Sciences, creating the first Avocado Germplasm Bank in our country. This Bank has currently more than 60 varieties, ecotypes and/or rootstocks.

Implementation of the Clonal Propagation Technique

From year 2002 to date, several experiments have been conducted in order to implement and develop the etiolation and layering technique in our country for the clonal propagation of projecting and/or promising material obtained nationally or overseas.

The main objective of the trials of the propagation area is to incorporate and improve the different stages of the etiolation and layering technique, considering that this technology is more specialised and expensive than the traditional propagation system. On a first stage, different avocado varieties available in Chile have been evaluated to be used as potential nurse seeds, analysing agronomic variables of vigour such as germination percentage and growth velocity. The effect of different variables and managements, including pruning, pinching, are under evaluation, as well as the effect of the topophysis in the management and improvement of clonal scions. One of the most important and critical stages of the technique is undoubtedly the stage of rooting. Therefore, as from this year, the first experiments have been implemented with the main objective of evaluating the response in the formation process of adventitious roots in the main clonal rootstocks such as Dusa, Duke 7 and Toro Canyon (Figure 2).



Figure 2: Implementation and development of the etiolation and layering technique at the Faculty of Agricultural Sciences of Pontificia Universidad Católica de Valparaíso

Early Evaluations of Clonal Rootstocks under controlled conditions

Researches in other species verify that the architecture developed by plants in nurseries forms the base to produce new growths on field and that a strong correlation is detected between the anatomy of roots, produced by the different rootstocks, and functioning of roots, in terms of water and nutrient absorption. Due to this, the project also proposes morphological, anatomical and physiological evaluations under controlled conditions, permitting the early definitions of the particular characteristics of the different rootstocks which will be evaluated under field conditions. The morpho-anatomical studies have allowed visualising clear differences in the architecture and histology of the roots between clonal and seedling rootstocks, as well as differences within one group (Table 3).

Table 3: Anatomical Characteristics of clonal rootstocks Duke 7 and Toro Canyon. Percentage Distribution of stele and cortex in clonal roots of 1 and 2 mm in diameter.

Rootstock	Roots 1 mm in diameter		Roots 2 mm in diameter		Roots 4 mm in diameter		Roots 5 mm in diameter	
	Stele	Cortex	Stele	Cortex	Stele	Cortex	Stele	Cortex
	%	%	%	%	%	%	%	%
DUKE 7	11.2	88.8	13.2	86.8	66.7	33.3	0	0
TORO CANYON	14.5	85.5	8.4	91.6	73.4	26.6	6.8	93.2

Source: Fondef D04I1346, 2006.

From year 2005, the first trials of early evaluations of clonal rootstocks were started; these trials are aimed at two limiting conditions: salinity and asphyxia. These trials intend to early evaluate, through morphological, physiological and nutritional analyses, the behaviour of Hass variety grafted onto different rootstocks, both clonal and seedling (Figure 3).

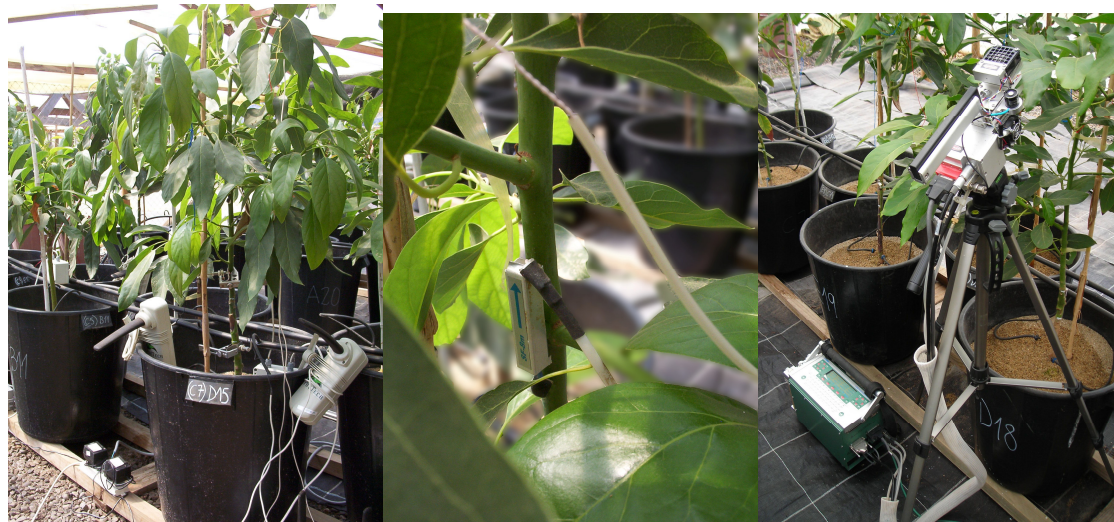


Figure 3: Early evaluation on stress caused by salts from different avocado rootstocks

Evaluation in Experimental Farms

Through the establishment of experimental farms, the present project will obtain a result of great economic-social impact, such as the characterisation of physiological and agronomical behaviour of avocado rootstocks in relation to their productivity and potential use in the main producing areas of Chile. To do that, during the autumn of 2004, the first two experimental farms were established for the evaluation of the behaviour of the Hass variety on different avocado rootstocks. One of the farms is located between latitudes 32° 50'S and 33° 10'S, in the province of Quillota, Region of Valparaiso. The thermal regime of this area usually has an annual mean temperature of 15.3°C, with a mean maximum 27°C of the warmest month (January) and a mean minimum of 5.5°C of the coldest month (July). The site is on a slope, south exposure, and the plants are established in a replanting soil and on berms (Figure 4). In this farm, 14 different avocado rootstocks were planted, including some of seedling from varieties Mexicola, Nabal, other from West-Indian strain and finally the clonal Duke 7.

The second experimental farm is located between 31°LS and 32°50'LS, in the province of Petorca, Region of Valparaiso. Its thermal regime has an annual mean temperature of 14.4°C, with a mean maximum of 26.5°C of the warmest month (February) and a mean minimum of 4.5°C of the coldest month (July). The farm is on a slope, south exposure, planted on wild soil, without berms. In this farm, 14 different avocado rootstocks were established, including some of seedling and clonal Duke 7, Toro Canyon and Merensky 2 (Figure 4).



Figure 4: General View of the experimental farms of Quillota (left) and Cabildo (right)

In September 2008, more than 16 different clonal avocado rootstocks will be established in the experimental farms, including national promising material selected, as well as rootstocks developed and validated at important research centres on this species.

In addition, and at the same time, this research includes the study and analysis of four new avocados varieties of the Hass type, developed in California and in our country in order to define its behaviour against our climate and soil conditions and to be prepared for new changes that may be produced in the markets.

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