Agricultural
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Institute

Research and Development on **Grapevines**

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Welcome

Pedro Bustos Valdivia
National Director
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One of the main sectors of agricultural importance at the national level corresponds to viticulture. The national area dedicated to the cultivation of the vine (Vitis vinifera) in Chile corresponds to 203,957 hectares, of which 141,918 ha correspond to vines for wine production, 53,523 ha to table grapes and 8,516 ha to grapes for pisco production , taking advantage of the great diversity of climates that our country.

Since its foundation in 1964, our institution has supported the development of national viticulture. Since 1967 INIA has been developing research on fruit and vines, which helped lay the foundations for this important activity in the agricultural sector.

Research in INIA covers various fields including basic and applied research in the areas of plant protection, genetics, biotechnology, physiology, development of productive tools, vineyard management, soil, nutrition, irrigation, viticulture and heritage rescue.

For example, after years of working in viticulture and thanks to the visionary vision of Dr. Jorge Valenzuela Barnech (QEPD), in 1987 INIA created its first program of table grape breeding, with the aim of reducing Chile's dependence of foreign varieties and have their own material adapted to the different agroecological conditions of the country. This is how in 2005 the first two Chilean table grape varieties, called Ilusión-INIA and Isela-INIA, are obtained.

Jorge Valenzuela B.
Agricultural Engineer, Dr.
Founder of
the INIA Grape
Breeding Program.

Currently, the Institute is advancing steadily in the generation of new table grape varieties, together with the Biofrutales Consortium, and with the co-financing of the Corporation for the Promotion of Production (CORFO), obtaining three new varieties, destined for the export market: Iniagrape-one, INIA-G2 and INIA-G3, these two in the process of registration and recent release.

Similarly, another important point that marks our institutional work is the sustainability of this industry, in the medium and long term. Although we have great advances, there are also a series of challenges that we must solve, such as the generation of tolerant rootstocks under conditions of environmental stress, to arrive with quality fruit and condition that allow to support a trip of almost two months in cold chambers to the new and distant markets that we can access today thanks to the commercial opening promoted by our authorities.

But without a doubt, the biggest challenge that moves us as a scientific body created for the agricultural development of Chile is climate change. We know that temperatures increased and rainfall decreased, directly affecting the productivity and competitiveness of the item. Therefore, our efforts, in addition to genetic improvement, have been focused on developing adaptive agronomic strategies to a phenomenon that is here to stay.

I can proudly say that after two decades of work, INIA has managed to contribute to the strengthening of our country's agri-food sector, offering multiple technologies and key innovations in increasing productivity and competitiveness. Likewise, we have generated more resistant fruit trees, of high performance, adaptable to different types of stress and with better nutritional quality.

In this sense, we will continue to fulfill a fundamental role in the field of national viticulture, especially in table grapes, because we not only develop technology, but also make it available to the country's agriculture.

History

The Agricultural Research Institute (INIA) is a private, non-profit, private law corporation, linked to the Chilean Ministry of Agriculture. It is financed mainly through public funds, based on an agreement with the Undersecretary of Agriculture, in addition to competitive research, technology transfer and extension projects, both public and private, as well as agreements and sale of technological products.

The Institute was founded in 1964 and currently has around 1.000 specialized workers for the development of research, technology transference and extension at the service of Chile's Agri-food sector.

View

- Be a leading institution in the generation and transference of knowledge and sustainable technologies for innovation in the Agri-food sector.

Mission

- Generate knowledge and strategic technologies at global scale, to innovate and improve the Agri-food sector competitiveness.

Chronology

1964 to 1973.
The INIA conformation and the first relevant results of its work

The coordination of the agricultural research in the country was a main goal in order to coordinate agricultural research in the country, to maximize available economic and human resources. Hence, INIA begun working on genetic improvement (cereals and potatoes), agronomic control, pest control and soil fertility.

1974 to 1983.
The successful introduction of Technology Transference in Chile

The Institute's work was focused on increasing the agriculture competitiveness. To expand its territorial scope, new dependencies were added to the existing ones. The GTT Program was created, aimed at incorporating technologies into the national agricultural sector, especially in small to medium-sized producers, in order to satisfy the national consumption needs.

1984 to 1993.
The INIA transforming forces

The Institute has significantly contributed to the agricultural development of Chile, based on the generation of new plant varieties exhibiting increased yields to the farmer as well as higher quality for agribusiness, with the diversification of fruit growing with a clear view towards to exportation, intensively working on pests and diseases of national economic impact, demonstrating evident improvements in livestock production, generating technological packages according to the needs of the time, adopting and strongly transferring agricultural and livestock technologies throughout Chile, and expanding its presence in regions.

1994 to 2003.
The economic opening of Chile and the contribution of INIA to exportation

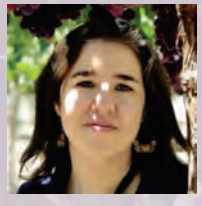
INIA assumed the challenge of presenting alternatives to paved a competitive and diversified agriculture, based on quality; with technologies capable of accounting for the profitability narrowness present in the most of national productive items.

2004 to 2019.
Science and modernization at the service of a more sustainable and competitive agriculture

INIA, it is the most important research institution of the ministry of agriculture, further strengthened its bond with private sector as well as allied institutions at national and international level, which is evident in the formation of several technological centers, consortiums, networks and strategic alliances, expanding INIA's participation in the search for solutions for the different productive items such as agricultural and livestock, aquaculture and food.

With an agile institution, strongly focused towards to customers; with a team of people who know how to do things well; with high technical capacity and experience in the development and operation of research and transfer projects; with a leadership that conveys confidence to productive sector, national agroexporter and community. Those are the new times we are living.

Grapevine Breeding, Genetics and Biotechnology



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Fingerprinting of cultivars: a service for the whole chain production

Patricio Hinrichsen

The correct ID of every single plant is a requisite for any research activity and/or productive process. As our team was part of the Consortium for the development of microsatellite markers (VMC) ca. two decades ago, we had the chance to implement this marker technology, that we have applied for different purposes, including mapping, gene flow studies, crossings efficiency control, paternity tests, etc.

May be one of the most interesting applications, however, has been the implementation of an (informal) fingerprinting service used up to now and among others by breeders, growers, nurseries, regulatory agencies (SAG in Chile), as well as the court. This platform has been used as a model, being applied also to many different horticultural crops. The analyses are based on the smallest possible number of markers, e.g., the set of six SSRs proposed originally by the IGGP International Consortium, now we are moving to the set of nine SSRs proposed by other researchers

Table grape breeding program

Paola Barba

Table grapes are a relevant component of Chilean economy. In Chile, table grape production is shaped by consumer's preferences, agricultural demands and our own geographical reality. As principal markets for Chilean table grapes are located overseas the fruit have to be in perfect conditions up to 60 days after harvest, which is not a requirement on other table grape producer regions such as California, Italy or Spain. As result, many table grape varieties are not suitable for Chilean producers. This provides a motivation for breeding new varieties tailored to our environment, national producer's demand and international consumer's preferences.

Plant breeding is a number's game. The possibilities of finding a progeny that combines the best of both parents are low, especially in fruit breeding where quality at harvest and condition after cold storage increases the list of requirements. Among the quality preferences, seedlessness, elongated shape, equatorial diameter over 18mm, firmness, crunchiness and a healthy appearance are

more common, being the greenness of the rachis a good indicator of a healthy perception. Although these characteristics can be improved with agronomical practices, there is high genetic component within these traits. As example, 'Red globe' and 'Thompson seedless' differ on the size of their seeds and berries, traits that can be passed to their progeny. These differences have been exploited on grapevine breeding programs around the world.

INIA begins the table grape breeding program in the early 1990. Later, in 2012, the table grape breeding program (PMG) becomes part of the technology consortium INIA-Biofrutales and expands the development of genetic diversity by traditional methods, through direct crossings between parents with diverse traits of interest. Every year, about 500 clusters are emasculated and pollinated. Depending on whether the female parent is seeded or seedless, seedlings are obtained by direct germination or by embryo rescue *in vitro*. These seedlings are pre-selected in the greenhouse using the molecular marker p3_VvAGL11, which predicts the appearance of seeds in the fruit with an efficiency of more 80% in the genetic germplasm used by the program.

Each year, the PMG plants a variable number of 4,000 to 6,000 new vine genotypes, which are cultivated, evaluated, selected and propagated in a three-stage cycle. In this process the evaluations are increasing in complexity, to characterize their response to agronomic management in different locations in Chile, as well as their postharvest behavior. After 10 to 15 years from the crossing, table grape selections can be registered as a variety and transferred to program partners.

To date, the PMG INIA-Biofrutales has registered three varieties: In 2012 Maylen ® (Iniagrape-one cv.) A black, elegant, mid-season grape, which stands out for its flavor and postharvest of more than 60 days, of great acceptance in distant markers such as Korea, China and Japan. Recently (2019) two new varieties are added to the results of the program: INIA-G2 cv. (selection 68,158) of attractive red color and harvest time similar to Thompson Seedless, and INIA-G3 cv. (Selection 2047) of pink color, loose clusters, highly productive, and that stands out for its muscatel flavor at harvest and postharvest.

The development of new varieties of table grapes in Chile, tailored for our agricultural needs is critical. Development on varieties requires multiple years of testing in our territory, resulting in cultivars adapted to our climatic conditions. Given the multiple years of testing in Chilean vineyards, and the development of cultural practices, Chilean varieties could be a more reliable investment compared with introduced cultivars

Rootstocks development for abiotic stress tolerance

Andrés Zurita

This aim of this research line is: (1) developing Rootstocks from naturalized and autochthonous *Vitis* genotypes, and (2) screening and understanding putative mechanisms for abiotic stress tolerance, in particular those increased by Climate Change conditions in Northern Chile.

For enhancing performance and tolerance of grapevine cultivars to abiotic stresses, interactions among them and rootstocks are been assessed from pot to field experiments. Under abiotic constrains such as water deficit, salinity and boron, typically from hyper-arid regions, *Vitis* cultivars grafted onto Rootstocks are being analyzed at multi-scale proxy (from tissues to field) considering rootstock-driven effects on functional traits at phenology, morphology, physiology, and molecular level. With such approach, we have isolated candidate naturalized rootstocks, which positively influence scion growth responses, expression of productivity potential / attributes of each cultivar for diverse productive purposes such as wine, pisco or table grapes, allowing rootstocks usage as strategy to cope with increasing environmental challenges due to climate change

New breeding technologies in fruit crops: development of new cultivars of vines and stone fruits tolerant to fungi and viruses

Humberto Prieto

During the last decade, new technologies have emerged to support the genetic improvement of plant species that have been called New Breeding Technologies (NBTs), which consist of technologies that involve molecular and genetic components, in order to contribute to genetic improvement. The approximations of the NBTs in vines, require of previous developments and in their majority, these are of high technical complexity. For example, new trends in cisgeny, RNA-dependent methylation and nuclease editing require the existence of efficient cell regeneration systems. Using as a technological floor the somatic embryogenesis of vines, in this project we have implemented various technologies linked to NBTs including RNAi, cisgeny / intrageny, and CRISPR-Cas edition. Through them, we have developed our first prototype individuals focused on the development of resistance to fungal and viral diseases. Additionally, we have generated new vectors for gene transfer using "plant-derived transfer DNAs", which has allowed us to generate a new tool for genetic engineering of vines, using only elements of the vine genome

New prototypes of grapevine resistant to fungal diseases developed by gene edition

Humberto Prieto

Through the NBTs habilitation project, we have demonstrated the feasibility of using viral DNA replicons for the expression of CRISPR / Cas9 gene editing elements in vines. This technology has the advantage of allowing gene editing without necessarily generating transgenic individuals. The individuals generated by these works allowed the formation of potentially edited plants, in genes of susceptibility to fungal diseases. These plants have been both transgenic and also non-transgenic. The final condition of the individuals comprising both populations obtained, in which the interruption of disease susceptibility genes is expected, must be characterized both at the molecular level and at the phenotype level. Thus, this project will select the best edited prototypes evaluating, and at the same time evaluate its behavior against fungi

Rescue, characterization and valorization of minor varieties in old vineyards from Chile

Patricio Hinrichsen

The Chilean wine industry was based from the very beginning on cultivars supposedly brought from Iberic Peninsula by Spaniard conquerors; then, since the mid XIX century, a new wave of "fine cepages", mostly French, were used to settle new vineyards, accompanied with the Europeanization of the viticulture, mostly in central valleys close to Santiago.

This was the basis for the development of a wine industry with international reputation. Wine production was a rather rustic process during the colonial times but evolved into a highly professionalized activity in recent years. The first vineyards were planted almost entirely with 'Listan Prieto', a Spanish variety widely spread along the young America, with tens of synonymies ('País' in Chile).

Later on, during the XVIII century, it arrived 'Moscatel de Alejandría'; the crossing of these so-called "American founding genotypes", generated a large number of "criollo" sibling, a few of which are used nowadays to produce locally renowned musts. Others are awaiting to be "discovered", based on their individual merits. We have been working in recent years in the search for these criolla vines, mainly in the Southern valleys of Maule and Biobío. Using a standard set of microsatellite markers, a good number of previously not described genotypes have been found.

This has been possible thanks to the availability of the European Catalogue VIVC (www.vivc.de) and other germplasm databases. We have found tens of "new" genotypes, meaning that they had not been described before (mostly the criollas) or they correspond to old European varieties that were hidden among vines spread in small, old vineyards. The understanding of the history of each of these varieties and how they arrived to these latitudes is pending, as it is its productive and oenological characterization, looking for different and attractive musts

Searching for genes and markers associated to quality traits in table grape: From genetic diversity evaluation to polymorphisms validation

Patricio Hinrichsen

In the last 10-15 years, a series of projects financed by local competitive grants have been executed in relation to this issue. In general terms, their focus has been on the search for QTLs and markers associated to the most relevant table grape quality traits, such as seedlessness, berry size, rachis architecture, berry drop, acids and sugars metabolism/content, and so on.

We have developed linkage maps based on SSRs first and then based on a powerful SNPlex European platform. We have used two main sources of biological samples: contro-

lled table grape crossings provided by our own breeding program, and a collection of *Vitis vinifera* L. genotypes, that includes not only table grapes but also wine cepages and a few rootstock hybrids. The first Project dealt with the search for seedlessness genetic determinants. After 2-3 periods (projects), our team succeeded in finding a marker (P3) tightly associated to this trait. The marker is a repetitive sequence of the SSR-type located in the promoter region of the VvAGL-11 gene, previously found associated to flower/ovule determination.

This is, at a planetary level, one of the few successful markers currently in use for MAS by various table grape breeding programs. Other traits approached have been confirmed as orthodoxically polygenic, quantitative. In these cases, we have described series of QTLs and lists of the corresponding candidate genes most probably related to the phenotype under scrutiny. Also, we have done massive transcriptomic and proteomic analyses, the first based on RNAseq of contrasting individuals sampled at critical phenological moments and using particular tissues, such as berries and pedicels.

The most advanced results correspond to berry size; in this case, we identified 38 SNPs and InDels associated. Currently, we are in a advanced stage of converting those markers in SSRs, designed on the periphery (1 Mb) of the SNPs/Indels. We expect to have validated these markers in a wide genetic background in a few months from now

Development of genomic support tools for table grape breeding

Nilo Mejía

Basic quality traits for table grape are common across breeding programs, among them seedlessness, berry size, firmness, color and disease resistance.

Seedlessness is one of the favorites traits for breeding because its importance at consumer level and its easiness to breed due to the dominant effect of the trait. We developed one of the most useful markers for assisted selection of seedlessness, a microsatellite named p3_VvAGL11 that is routinely applied by several breeding programs, it helps by reducing costs or improving efficiency up to 50% at early stages of breeding.

To pursue breeding efficiency of seedlessness we recently developed complementary new SNP-based markers that can be genotyped by TETRA-ARMS PCR in small breeding programs and by qPCR-HRM that allows the application of assisted selection at increased throughput while reducing post PCR costs and processing time.

On the other hand, for long time the genetic basis of complex traits like berry size or firmness remained elusive due to its highly polygenic nature and interactions with the environment. To overcome these limitations we developed a large (n > 500) biparental population crossing Muscat of Alexandrie and Crimson Seedless, this was characterized phenotypically over five and four consecutive seasons for berry size and texture respectively.

The genetic architecture describes a very complex nature, up to 14 and 32 significant, unique and stable QTLs (quantitative trait loci) for berry size and textural parameters, respectively. These QTLs explain a very significative portion of the phenotypic variation and we are validating the discovered associations in different genetic backgrounds in order to develop markers for assisted selection of theses complex traits

From QTLs to QTNs: identifying the most favorable alleles for assisted selection of quality complex traits in table grapes

Nilo Mejía

The genetic architecture of berry size and textural properties revealed the existence of multiple small effect QTLs, yet significant and reproducible.While the most significant genotype-phenotype associations are being validated in populations of different genetic backgrounds and breeding material, this research is focused in the identification of genes responsible of the underlying QTLs.

Validation will point the most favorable alleles for breeding purposes while the identification of candidates genes and their characterization at nucleotide level has the potential to unveil the molecular basis of the phenotype, enabling the development of gene assisted selection. Intragenic SNPs and SSR tightly close to candidate genes are being identified for the development of markers for assisted selection for berry size and texture.

The identification of genes and the variations that are responsible for the phenotypic variation has the potential to increase precision in the development of a predictive model and assisted selection markers for complex traits, also to establish working hypothesis for gene editing-based breeding methodologies

Genomics-supported breeding: application of high-density genotyping on the genetic improvement of quality traits of table grapes

Paola Barba

The main objective of this project is to develop knowledge and tools to aid the table grape breeding process, thought the understanding of the relationship between genotype and agronomical traits related with table grape berry and cluster quality on relevant material for INIA's breeding program: a subset of: The PMGV families and the INIA grape germplasm repository. Achieving this goal will aid the implementation of breeding tools, such as determination of trait heritability, selection of suitable parents, and identification of molecular markers linked with relevant agronomical and physiological traits, for marker assisted selection at the INIA-Biofrutales PMGV.

To achieve this goal, we developed tools for high-throughput phenotyping of table grape quality traits using computer vision. This research translated into a simple software called Berry Analyzer, which is freely available at https://github.com/PhenotypeLab/Berry_Analyzer. Using this tool, we were able to characterize around 600 grapevines over three consecutive seasons.

On the other hand, we performed genotype characterization through genotyping-by-sequencing, yielding a set of 49.311 single nucleotide polymorphisms (SNPs). This data was used to characterize population structure among PMG families and germplasm collection. It also allowed to determine the percentage of pollen contaminations and self-pollinations among families.

Genome Wide Association Analysis (GWAS) were performed to identify regions (loci) of the grapevine genome associated to relevant phenotypic characteristics. We were able to identify quantitative trait loci (QTL) for seedlessness, berry size and shape, seed number, cluster and rachis weight. Our strategy allowed us to screen a wide range of parental genotypes from the program, making them more suitable for breeding strategies. This research is one of few examples of GWAS on grapevines, making it interesting from a technological and scientific point of view.

On an agricultural context, the main objective of QTL mapping is the identification of molecular markers linked to the desired phenotype for marker assisted selection (MAS), gene stacking or parental selection. MAS allows identification of desired progeny through its DNA, before the plant reaches maturity to express the phenotype. If applied before vineyard planting, MAS could reduce the vineyard size, lower labor requirements, or help to focus breeding efforts on other traits

Plant Protection

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Establishment and implementation of an alert platform for *Lobesia botrana* in the O'Higgins and Maule regions

Nancy Vitta

The objective of this project was to implement and transfer an ecology alert system based on degree days, humidity and geographic distribution for the official control of *Lobesia botrana* in Chile for table grapes. *Lobesia botrana* is the main quarantine plague present in Chile and due to this fact, it has been given its maximum importance by the Chilean Ministry of Agriculture. High plague incidence has produced direct economic impact for production decrease as well as indirect impacts for severe commercial restriction generated. This due to high phytosanitary problems for export product at different international markets.

The present study was realized in O'Higgins and Maule regions among well-organized producers who high degree infestation in table grapes. This according to

information by PNLb form SAG (National Program of *Lobesia botrana*). Plant were monitored periodically in different selected areas. The work done was based in two models: models obtained at INIA La Platina and the other used by RPF (Red de Pronostico Fitosanitario, SAG). The INIA model determined that the minimal temperature for plague development was 9°C and maximum of 27,4°C. RPF from SAG used the Trouzeau model which considers range temperature of 10,0°C and 30,0°C. The day degree (BIOFIX) of its study as the starting point accumulation was used.

According to date obtained it on the be conducted that differences in accumulation of GD presented between monitoring stations were not being well considered (i.e. Colina and Buin). In other cases (i.e. Pirque and Olivar) they were representative. Differences may be due to factors such as variety differences, plant differences (strength, canopy shape, management factors such sun incidence over fruit) and others. Also difference in GD that was observed in result analysis between monitory station (Agromet). Another factor that can affect differences in GD is plane zones and others, thus affecting measurements as well as different microclimates

Generation of system of alerts of establishment, development and opportunity control of *Lobesia botrana* in the Atacama region, Chile

Claudio Salas

During 2008, the phytosanitary scenario of the Chilean wine sector was strongly affected by the entry of *Lobesia botrana* (Denis & Schiffermüller) (Lepidoptera: Tortricidae). The effects that *L. botrana* has on the production of vines are direct productive effects due to the destruction of the fruit by the larvae, also generating rot. On the other hand, quarantine measures have also been established by the table grape destination markets that are free of this pest, affecting production costs, both at the field and postharvest levels.

Since the beginning of the establishment of the Official Control Program (PNLB) in Chile, catches of *L. botrana* in the Atacama Region have been reduced compared to those recorded in the Central zone. For example, from 2008 to 2016 in the Atacama Region, 90 males have been captured, while in the Maule Region only during the 2015/2016 season, 462,658 individuals were captured, even though the area cultivated with vines differs greatly between the two regions. It is an important factor to consider. This implies that the climatic and agroecological characteristics of the Atacama Region prevent the establishment and normal development of the pest, and it is probable that the individuals captured in the monitoring network provided by the SAG come from fresh fruits imported from central regions south.

Due to the economic relevance of wine production for the Atacama Region as the main area of early production, it is necessary to develop alert models adapted to the climatic and ecological conditions of the Atacama Region, aimed at determining optimal conditions for establishment, development and *L. botrana* control.

Through the project, SEPEP has been generated, corresponding to software that allows evaluating the probability of establishment and development of *L. botrana* in the Atacama Region, based on biological data, meteorological data and

topography. SEPEP makes a set of preprocesses on these data generating a comparative probability map of pest survival to finally, making a regression with the catch map, create a probability of success map to be established as a pest present in the Region of Atacama

SEPEP is an executable program for Windows PC. It can operate on any version of Windows from XP to version 10. It can operate on PCs with 32bit or 64bit and does not require an installer and does not require third-party software.

The results obtained indicate that in the Atacama Region there is a low probability of establishment of *L. botrana*, with urban areas being the ones with the highest risk of establishing the pest, due to the presence of primary hosts without management. However, the probability of catches on these sites is less than 1 individual per year.

The information generated is of great importance for the region since it could be used by the national phytosanitary authority to establish areas of low prevalence and later free orchards of *L. botrana*, the foregoing with the consequent economic benefits for the export sector.

Table Grape virus research

Mónica Madariaga

Grapevine is affected by more of 44 viral species of which approximately 64% cause significant economic losses. In Chile, the main viral diseases that affect vineyards and its impact on fruit production have been determined.

Our project is focused on developing a virus-free -plant platform of vine varieties and rootstocks. So far, we have demonstrated by PCR (Polimerase Chain Reaction), that the most frequently viruses found in grape are Grapevine virus A (GVA), Grapevine leaf roll virus associated virus-1 (GLRaV-1), Grapevine leaf roll associated virus-2 (GLRaV-2), Grapevine leaf roll virus associated virus-3 (GLRaV-3) and Grapevine fan leaf virus (GFLV), which have a prevalence among 21% and 26%, while Grapevine rupestris stem pitting associated virus have a 74% of prevalence. On the other hand, the presence of Grapevine virus B (GVB) was not determined.

Our virus-free-plant platform consists of *in vitro* plant thermotherapy and meristem culture. The results have been successful, since all clones that have entered this process, have been released from viral infections. However, the efficiency depends on the genotype and the virus that the plant presents. In this way, the regeneration rate was between 46 and 73%. We could also verify that Grapevine leaf roll associated viruses (GLRaVs) were the easiest to eradicate, since an efficiency of 90% was obtained. GVA and GRSPaV were the most recalcitrant because they had efficiencies close to 40%

Biological control *Lobesia botrana* with microbial pesticides

Eduardo Tapia

Since 2016, we have developed environmentally friendly strategies for the control of the *Lobesia botrana* vine moth that mainly affects vines, blueberries and plums among other hosts and is also listed as a pest under mandatory control since April/2018 by the Agricultural and Livestock Service (SAG) for being a quarantine pest (Resolution No. 2,109 Exempt).

In the case of *L. botrana* in vines, within its life cycle we find a winter diapause of approximately 5 months where there is no chemical or biological management to control this and other vine pests. In addition, the main sources of reinfestation of this pest are found in nearby urban sectors of small, medium and large grape producers, reaching an area of approximately 155,000 ha.

Therefore, the Entomology/Biotechnology Laboratory of the Institute of Agricultural Research (INIA) La Platina together with the National Program of *Lobesia botrana* (PNLb) of the SAG decided to perform laboratory and field tests to explore the possibility of using the entomopathogenic fungus (HEP) *Beauveria pseudobassiana* RGM 1747 for the control of *L. botrana* pupae in winter diapause. Once the *in vitro* and semi-field evaluations were approved in winter, a proof of concept was developed in the field, also in the winter stage with a natural infestation of the pest where a 51% efficiency in the urban sector was achieved with a basic formulation the Metropolitan Region (Altimira *et al*., 2019).

With the results obtained from this study, it was nominated for a competitive fund of the Foundation for Agrarian Innovation (FIA) where, once the 36-month project was awarded from May 2017 to March 2020 (PYT- 2017-0182) where studies were conducted to improve production, formulation and field evaluation.

In a first stage, 10 HEPs of the Beauveria and Metarhizium genera were identified molecularly, their pathogenicity was evaluated on *L. botrana* pupae and they were scaled to 5 L according to their ability to grow in liquid media reaching concentrations of 200 g/L of wet biomass , both for *Beauveria* and *Metarhizium*, to be formulated as inverse emulsions and/or wettable powders while maintaining their pathogenicity on pupae.

The inclusion of biotechnology tools allowed to reduce production times from 4 months in solid state to one month in liquid (considering its formulation). In a second stage, there have been two seasons of winter evaluation in the experimental field of vines of INIA La Platina, La Pintana, RM and two in the sector of Placilla, Region of O'Higgins. In addition, an essay is being developed in the urban sector of Olmué, Valparaíso Region, the results of which are expected by February 2020, where the experimental work of the project ends.

In the cases of Pintana and Placilla, the evaluation of biopesticides with male captures of *L. botrana* has been complemented once the winter season has ended with pheromone traps. Efficiencies in Pintana reached 77.5% efficiency with *Beauveria* with a decrease in catches of 53% and 75% efficiency with *Metarhizium* with a decrease in catches of 90%. In Placilla, 67% efficiency was achieved with *Beauveria* with a decrease in catches of 58% and 58% efficiency with *Metarhizium* with a decrease in catches of 54%.

The results of the FIA project have resulted in a national patent application (INAPI 201802396) where the formulation of the selected HEPs and their applications on *L. botrana* pupae in vines is protected

Generation of strategies for the control of eriophyoid mites (Acariformes: Eriophyoidea) in the table grape production of Elqui Valley, Chile

Claudio Salas

In the last seasons, the national viticultural sector has registered an increase in the damages caused by mites of the Eryophidae family, highlighting those registered in the Coquimbo Region.

Two species of eriophyoid mites associated with the vine, *Calepitrimerus vitis* (Pagenstecher) and *Colomerus vitis* (Narepa), are cited for Chile. The losses generated by these species in orchards depend on the type of damage caused by each of these species and / or races that infest and feed on primordial inflorescences and apical meristems, generating significant economic losses.

The lack of knowledge in the identification of these eriophyoid mites and in the preparation of efficient phytosanitary programs by farmers and agricultural professionals, has fostered at local level increases in the number of applications with the consequent economic and environmental impact.

The objective of the present investigation is to determine, through the taxonomic identification by specialists of the group, the species and races that affect the regional viticultural production. It also seeks to determine the efficacy of different acaricidal molecules and phytosanitary programs. All the above in order to provide regional viticulture with efficient management programs for eriophyoid mites that are adapted to local conditions

Host response of grape rootstocks to plant parasitic nematodes under replant conditions

Pablo Meza

Nematodes are microscopic animals can cause major damage to table and grapevine, reducing yield and healthy roots. The use of natural resistance of crops to PPN is one of the most economic and environmentally sound method for managing of these pathogens.

The main goal of this project was to evaluate the host response of Paulsen, Harmony and Ramsey, rootstocks to plant parasitic nematodes (PPN) under replant conditions. The research was conducted in Experimental Center of Investigation INIA-La Platina, between 2015 and 2019.

Nematode population was composed by *Pratylenchus* spp., *Xiphinema americanum* s. l., *Mesocriconema xenoplax, Trichodorus, Hemicycliophora* sp., *Helicotylenchus* sp. and other parasitic genus. During each season of evaluation soil samples were taken at early spring, summer and postharvest. Data were analyzed using a generalized linear model (GLiM) with a Poisson distribution and a log link function.

After three seasons of evaluation, we found that Harmony and Paulsen rootstocks can reduce the population of PPN, but only Ramsey showed significant statistical differences ($p \leq 0.05$) with ungrafted varieties, limiting considerably the population of PPN. The results obtained on this investigation can contribute to development one integrated management strategy to PPN on the grape production process

Prospection of grapevine trunk diseases

Daina Grinbergs

The goal of this area is determining the main species of trunk pathogens that affect wine and table grape vineyards, with emphasis on patrimonial cultivars, studying their epidemiology for establish strategies to manage and prevent. Trunk diseases surveys were carried out in Itata and Cauquenes valleys, mainly on patrimonial cultivars, in 2018 and 2019. Fungal pathogens were isolated in culture media from cultivars like País, Torontel, Moscatel, Carignan and Ovoide.

The associated symptoms, such as yellowish spongy necrosis with brown margins, blackish stitches and hard dark V-shaped lesions, were recorded. To date, the laboratory has 205 wood fungal isolates, from both Ascomycota and Basidiomycota groups. The most frequently isolated fungi were from the Botryosphaeriaceae family, with *Diplodia seriata*, *D. mutila*, *Neofusicoccum* spp. *Botryosphaeria* sp., as the most common.

The second group in importance was the Basidiomycete, with *Inocutis* sp. as the most isolated, and a third group with pathogens such as *Seimatosporium* spp. and *Phaeoacremonium* sp. Prospections are still carrying out, as well as pathogenicity tests and virulence assessments on the isolated fungi

Evaluation of susceptibility *in vitro* to different fungicides of *Botrytis cinerea* isolates from table grapes in the central valley of Chile

Sylvana Soto y Patricia Rebufel

Gray mold caused by the plant phytopathogenic fungus *Botrytis cinerea* Pers., infects the table grape during flowering, staying dormant until harvest or postharvest where it begins to show its symptoms. In conditions of high humidity and temperature this fungus also affects, herbaceous organs and inflorescences, as stem infection of tissues. For control should be applied fungicide mainly in bloom, veraison and pre-harvest. Should be alternated active ingredient (a.i.) to avoid the generation of resistance.

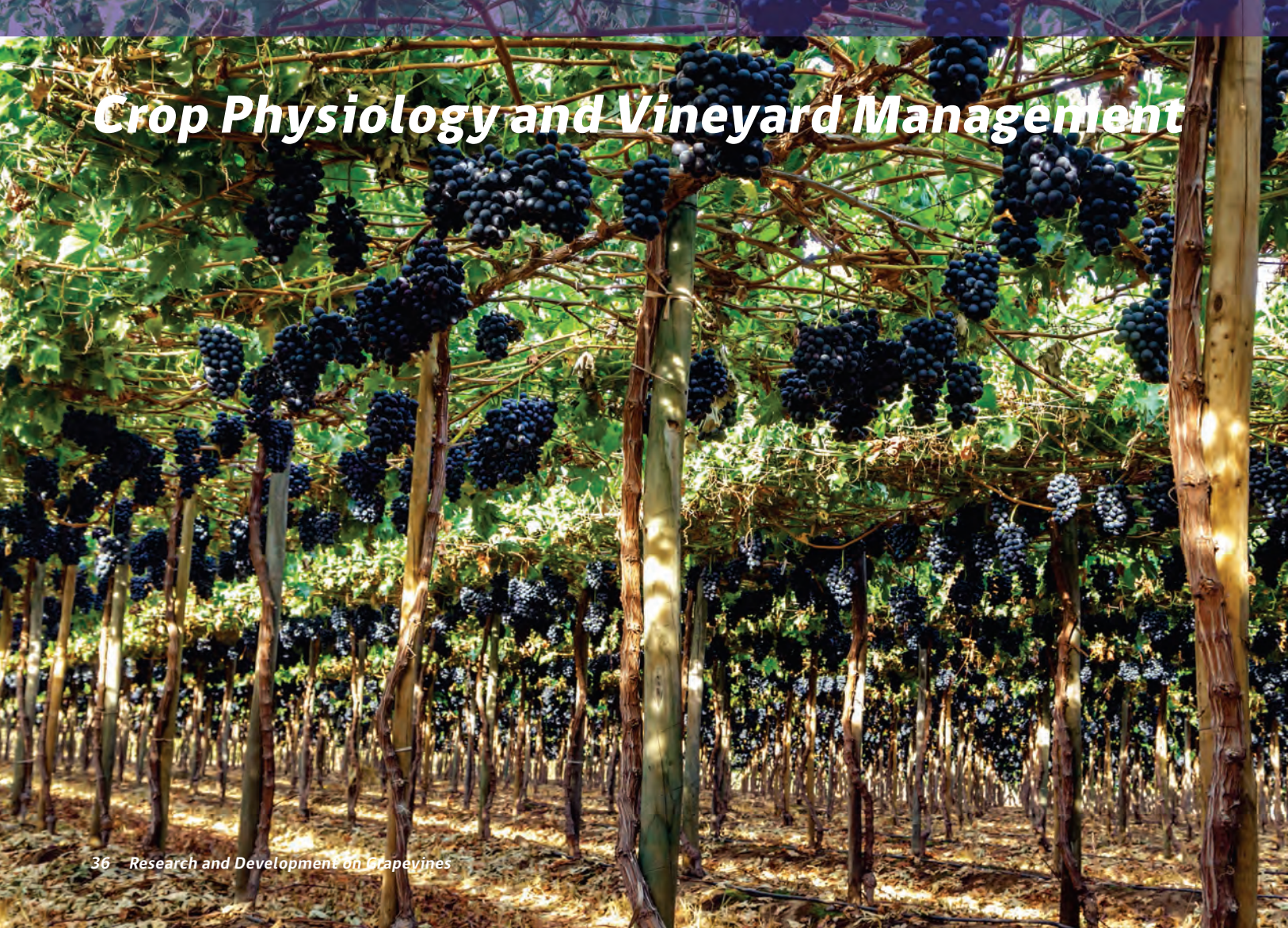
With the objective of assessing susceptibility to different fungicides, a total 12 isolates of *B. cinerea* were selected from Table Grapes in the Central Valley of Chile, which were characterized morphologically for its development to different temperatures. It was determined the EC50 of 16 a.i. for *B. cinerea*, Sensitive isolates were those with EC50 0 – 1 ppm, Resistant 1 to 5 ppm and Highly Resistant with EC50 greater than 5 ppm. Them, only the data of three a.i. With more important results. For chlorothalonil there is a low level of control of *B. cinerea*, because an inhibition greater than 80% was not achieved in any isolates. As the concentration is decreased a.i. it was possible to observe that the inhibition of *B. cinerea* was null. Based on the EC50 (range of values between 1,8 ppm – >100 ppm) it was determined that *B. cinerea* showed a high degree of resistance to chlorothalonil, because all the strains evaluated presented a level of Resistant to Highly Resistant. Because of this caution should be taken when applying this product and using a rotation of active ingredients or suitable mix to avoid control problems.

Based on the results obtained for fluazinam high inhibition was observed *B. cinerea*, with a level higher than 93% at the maximum concentration used (7 ppm) and superior to 90% in concentrations of 5 and 0,5 ppm in most isolates. The EC50 obtained (range of values between <0.001ppm - 0.002 ppm) They showed that this a.i. could be an alternative to control for *B. cinerea*, because all the isolates studied presented Sensitivity to the molecule.

The results for fludioxonil determined that there is good control of *B. cinerea*, because in many isolates an inhibition of the 100% in the highest doses (7 and 5 ppm), with a very low dispersion of the data in these concentrations. The EC50 (range of values between <0.001ppm - 1.28 ppm) showed that fludioxonil it was a good alternative to control *B. cinerea*, because it is not yet able to generate resistance mechanisms in the studied isolates.

It is important to constantly carry out this type of study, covering a greater number of isolates and fungicides. In order to be able to be alert to resistance mechanisms, in addition to being able to recommend rotations or mixtures of suitable products, control the disease effectively

Crop Physiology and Vineyard Management



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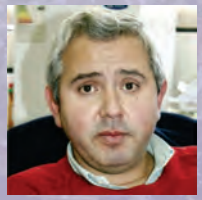

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Technical development for new table grape cvs. in Chile

María Cecilia Peppi

The project looks to accelerate the adoption of the Table Grape Breeding Program (TGBP) INIA-Biofrutales, incorporating agronomical practices to optimize yield and fruit quality. Observations and trials are held in four regions (Coquimbo, Valparaíso, Metropolitana and O'Higgins), which represent a huge portion of the country's table grape production.

There are test vineyards to show advanced selections of the TGBP and trials are established under diverse conditions, including vineyard covers (plastic and/or mesh) and a different trellis system than the usual one (Gable instead of Spanish overhead). In test vineyards we evaluate agronomical practices such as pruning type, fruit load, cluster tipping, use of plant growth regulators, etc. that help optimizing productivity and fruit quality at harvest and postharvest.

In parallel to trials there are outreach activities like field days and workshops, with the presence of growers, export managers and/or consultants, in order to determine possible markets and/or commercial windows for each advanced selection.

At the end of this project we hope to get technical guides for each selection, in order to grow new table grape cvs. with high standards in yield, quality and postharvest life. Additionally, we hope cultural practices done under covers and/or on an alternative trellis system will reduce the breach related to the incorporation of new cvs. and technologies, helping the grower to manage commercial windows, decrease costs and successfully cope with climatic events

Use of plastic covers on table grapes

Carolina Salazar y Gabriel Sellés

From 2015 a research line to evaluate the use of plastic covers on table grapes has been developed, jointly with a private company and CORFO support. The use of plastic covers in the table grape industry in Chile aimed to: i) protect against extreme climatic phenomena (frost, hail, rains at harvest, among others), ii) modify the phenology achieving to advance or delay the phenological states, and consequently the fruit maturity.

The project was developed with the purpose of evaluating the physiology, grape quality, efficient use of water, and postharvest of two varieties (red and white) of table grapes from O'Higgins Region. The results obtained had evidenced a change in the microclimate on the culture under the covers, producing an increment in the degree days, which induce a phenological shortening, driving to an ahead maturation (6 to 8 days). Likewise, the microclimatic modification induces a decrease of over 20% in reference evapotranspiration (ETo), related to free air conditions.

Jointly with this project, it was evaluated the potential use of polyethylene plastic covers in non-traditional areas of table grapes culture, in order to expand the frontiers towards zones with major water resources availability, to adapt against future effects of climate change. All of this, considering advantages and disadvantages of this technology, and ensuring the sustainability of the culture, keeping in mind plastic recycling, lowering its impact on the environment.

In parallel, studies have been done in the use of mesh-like covers. In these studies, it has been following the foliar cover of young plants, recently stablished on a commercial vine from Valparaiso Region. This methodology was also applied in a project in cooperation with INIFAP (Mexico), evidencing its qualities over the production of grapes grown under extreme climatic conditions, such as the ones observed in Sonora Region in Mexico

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Vineyard harvest estimation system, through artificial vision

Stanley Best

The research seeks, the generation of a system of estimation of yield in vines based on artificial vision, this will significantly reduce the costs of a spatial determination of these variables by increasing their spatial accuracy and giving way to the possibility of monitoring in critical stages of the crop.

A system of these characteristics would also form the basis of analysis for an early prediction of final yield when considering other variables associated with cultivation such as soil and vegetative expression variables. The general objective is to develop a system (hardware and software) for estimating spatial yield for crops, evaluated in vines, based on optical systems for dynamic field capture.

To the date the advances made are: segmentation of the images in the period close to harvest, deterministic model of calibration between the digital values segmented in the image and the yields obtained in the field and a segmentation software

Spectrometry-based monitoring systems (OST-SMART) for the control and management of production and quality in wine grapes

Stanley Best

The technology to be developed with this project seeks to provide vintners with a harvest optimization system that greatly exceeds current planning, in addition to improving or ensuring the quality of grapes or clusters in the production of wines or by-products.

All this entails improvements in the profitability of the producers and greater sustainability of the item, due to the improvement in the quality, timing and maturity of the fruits for the agro-industrial processes. Developing and adapting a VIS/NIR sensor to assess quality will be a great advance for Chilean agriculture, as it aims at monitoring the fruit quality variables in real time and determining the quality of its wines. The general objective is to generate an OST-SMART monitoring system to monitor the quality and development of wine grape production to enhance field management and commercialization

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New Technology for precision irrigation in vines

Claudio Balbontín

Within the framework of the efficient use of water resources in agriculture and the implementation of new technologies to address the actual and future limitations in water availability, the PLAS Satellite Agricultural Platform has been implemented. Through this platform, it is possible to carry out query satellite images (vegetation indexes) and thus monitor the state of development of the vines.

From the information of the development of the crop together with information of the environmental demand of the site, it is possible to make an accurate estimate of the water consumption of the vine and therefore define its irrigation needs. The high temporal and spatial resolution of the images allows us to accurately characterize the site-specific development of the crop, collecting variables associated with the transpiration capacity of the plants.

Additionally, satellite information allows characterizing the spatial and temporal variability of the crops, which facilitates the implementation of differentiated agronomic management in areas of the farm. The PLAS Satellite Agricultural Platform can be consulted online at the website http://maps.spiderwebgis.org/login/?custom=plas, allowing the download of crop development information on any plot located between the Coquimbo and Biobío regions.

The main lines of our work are oriented to: I) Analysis of the time series of the NDVI satellite vegetation index, monitoring of crop development and definition of net irrigation needs in vines, II) Validation of the estimation of irrigation needs of crops based on records of the internal water status of the plants, III) Agricultural regional statistics and water balances, IV) Transfer of agriculture new technologies to farmers and professionals

Vine phenology and climate change

Nicolás Verdugo

The grapevine phenology refers to the study of the stages of growth and development of the vine that occur during the growing season, mainly related to climatic variables (temperature). Examples of phenological stages are budburst, flowering, veraison and the harvest date.

This line of research considers the calibration and validation of predictive models of key phenological stages (budburst, flowering, veraison and harvest), using climatic information, with the aim of generating management tools at different levels: (i) productive level, for planning agricultural activities in the vineyards, (ii) regional level, for the selection of grapevine varieties best adapted to each region (agroclimatic zone) and (iii) simulate the behavior of the phenology under future climate conditions (climate change).

On the other hand, this line of research considers studying how the phenological stages are affected by some productive management, such as the use of rootstocks, covering (nets, plastic film), trellis system, pruning, among others. This information will allow viticultural management to be adapted to future climate change scenarios

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Table grape rootstocks: Aconcagua Valley experiences

Gabriel Sellés y Carlos Zúñiga

In Chile, there is little information regarding the response of rootstocks in table grapes under limiting physical and chemical soil conditions, as well as their effects on the quality and productivity of the plants. During 5 seasons (2007-2012), the Agricultural Research Institute (INIA) conducted a research in the Aconcagua Valley to answer these questions.

Two experiments were conducted, on one hand, to measure the response of grafted plants to low air conditions, a potting test was carried out where grafted and ungrafted plants were tested on different soil textures (silty loam, sandy, sandy loam, clay loam) with different macroporosity (9.5-22%). Different rootstocks (Freedom, Harmony, Richter 110, Salt Creek, 1616) were used on grafted plants. On the other hand, in field conditions, ungrafted and grafted plants were tested in low soil aeration conditions caused by frequent watering.

The conclusions indicate that by decreasing the air content of the soil under 16% stomatal conductance, chlorophyll content, leaf area index, and canopy development are also reduced, and this decrease affects the ungrafted plants more than the grafted ones. Richter 110, Freedom, Harmony and SaltCreek rootstocks performed better in low soil aeration conditions and controlled conditions.

Similar performance with higher macroporosity values detected in grafted and ungrafted plants. Grafted plants showed a later budburst than the ungrafted plants, however, the plant vigor of the grafted plants was higher.

A shorter period was also detected between budburst and harvesting in grafted plants associated with a faster sugar accumulation in the fruit. Grafted plants had higher incidence of physiological disorders probably associated to hormonal imbalances caused by their greater vigor. The use of rootstocks caused greater absorption of potassium in plants and greater accumulation of nitrogen. Similarly, decreased absorption of magnesium was observed.

The grafted plants showed less absorption of microelements, especially when using Harmony rootstock. Under high soil calcium content, grafted plants showed different behaviors depending on the rootstock, however, Salt Creek and Freedom showed a better performance

Table grapes irrigation requirements: Aconcagua Valley experiences

Carlos Zúñiga y Gabriel Sellés

The Agricultural Research Institute (INIA) carried out a thorough study of the table grapes water requirements from 2007 to 2012 in the Aconcagua Valley. In this study, through different methodologies the crop coefficients, irrigation thresholds, crop response to different irrigation volumes, and production functions were determined. Through lysimeters and Eddy Covariance weather stations, water requirements were obtained for table grapes growing under overhead trellis system.

Obtained results indicated that under the Aconcagua Valley conditions the crop water requirements exceeded those of the potential evapotranspiration between fruit set and veraison periods. In addition, the amount of water needed for the cultivation of table grapes obtained using lysimeters and Eddy covariance were similar and reached values close to 8000 m^3/ha in the season.

From the quantities of water needed for the table grape, their crop coefficients (Kc) were obtained, which reached maximum values of 1.2 during veraison. Parallelly, a correlation was obtained between the crop coefficients and the shade percentage under the trellis system, finding a positive and significant correlation between the two parameters ($Kc = 0.012 \times S\% + 0.072$, $R2 = 0.75$, $p < 0.01$).

Additionally, given the great development of table grape roots, the irrigation threshold that does not depress the production and quality of the fruit was estimated. This value was obtained by monitoring the soil water content continuously with capacitance probes placed on the row and between rows, in addition to stem water potential periodic monitoring. Obtained results indicate that the irrigation threshold in the crop rows was 30% of the available water

Postharvest Technology and Fruit Quality

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Postharvest

Bruno Defilippi

The Postharvest Unit at INIA focuses on studying the causes affecting quality attributes during long term storage of table grapes, providing the bases for the development of technological approaches applied in the different productive stages, integrating both pre and postharvest managements and technologies in order to ensure an integral view to quality improvement.

Research performed in this Unit has the objectives of responding to both commercial situations by the use of technology in the export industry, and scientific development made by fundamental science.

The main research areas include:

- Understanding textural changes (firmness) during storage.
- Development of strategies for improving berry size, color and reducing berry shattering.
- Development of controlled atmosphere and modified atmosphere for controlling *Botrytis* and stem water loss.
- Evaluation and management of new table grape genotypes.
- Evaluation of GRAS compounds for controlling decay.
- Understanding changes in flavor metabolism and mechanisms of regulation during fruit development and postharvest life.

The research projects developed on table grapes by INIA's Postharvest Unit, and in close collaboration with several academic institutions, include:

1. Understanding changes in flavor metabolism and mechanisms of regulation during fruit development and postharvest life of table grapes.
2. Study on rachis physiology changes of table grapes by different postharvest treatment modifications.
3. Effect of luminosity on pigment metabolism involved in the development of color in table grapes.
4. High-CO_2 controlled atmospheres reduce decay incidence in Thompson Seedless and Red Globe table grapes.
5. Molecular and physiological study of postharvest rachis browning of table grape.
6. Characterization of sugars and organic acids in commercial varieties of table grapes

Oenology and viticulture

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Support to the small viticulture of the rainfed

Marisol Reyes

This project seeks to establish analytical support services through the establishment of an Oenology Laboratory that supports the process of production and storage of wines from small and medium-sized wine growers. There is also a complementary service that allows filtering, mixing and bottling wines, counting on the entire production process with specialized assistance.

At the same time, the vineyard management processes have been strengthened and permanent assistance has been made in the elaboration and aging of wines, which has allowed improving and maintaining the quality of wines from production to the sales process

Determination of the effect of thermal stress on vines

Marisol Reyes

The general objective of this project is to quantify the effect of thermal stress on the physiology, development and quality of vines and wines, under the conditions of the interior dry land. A passive methodology was validated to increase the ambient temperature in the vineyard, whose increase is recorded together with the ambient and soil humidity.

The effects of thermal stress on the Cabernet sauvignon, Syrah, Carmenere and País varieties in the Tutuven and Maule valleys are being quantified. The observations indicate that there is a detrimental effect of the average increase of 2 ° C, on the growth of shoots and yield, increase in the level of sugar and alcohol and decrease in acidity, in addition to various effects on physiological variables

Re-evaluation of heritage wine viticulture through scientific and technological innovation

Irina Díaz

We develop work in rainfed wine viticulture in order to value vines grown by small and medium-sized one's farmers. This is how we have studied varieties denominated in Chile as patrimonial (minority), such as País, Muscat of Alexandria, Carignan, Cinsault, White Ovoid among others, to elaborate with them different types of wines, from those whose form of elaboration is based on ancestral techniques or using modern manufacturing techniques incorporating technology and control in the production and with quality.

The production of ancestral wines such as sunny wines (grapes dehydrated in the sun) and mistelas (sweet wine headed with ethyl alcohol) are alternatives for the development of local and national wine market. In the field of innovation, these grapes have been used to make dehydrated wine, sweet wines, chichas (d.o. chilena), sparkling wines and an-alcoholic wines.

The purpose is to generate wines with added value that are demanded by specific markets that value the wine heritage and that demand little sold varieties in the global market. We have investigated ancestral varieties for Pisco elaboration and their behavior on abiotic stress scenarios. All the work includes studies between the regions of Atacama and Biobío, covering various disciplines such as ecophysiology, viticulture, oenology and genetics. In parallel, different monitoring strategies were developed for the early detection of problems in alcoholic fermentation in order to have a tool for decision-making

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Viticulture and climate change: effects of temperature increase

Carolina Salazar

Five years ago, a multidisciplinary group of INIA, distributed across Chile, started to look for answers to the main climate questions that has been rising at field level in the wine industry. To evidence the effect of the climate change, it was evaluated historical climatic data from wine valleys and sub-valleys of Chile, observing that temperature is one of the main determinant factors for grape production in our country.

Since 2015, the group of Viticulture and Climate Change had developed assays in commercial conditions, achieving to identify that the sustained rice in temperatures had been rising the sugar in grapes, decreasing anthocyanins, generating grapes of lower quality with diminished yield, thus, a low-quality wine.

These trials aim to measure the increment of temperature in field, keeping the natural variability set, through a polycarbonate panel system, funnel inverted-shaped, named open top chamber (OTC). This system was replicated from Australian previous works and modified according to our local conditions. With this OTC, temperatures were incremented, at bunch level, about 1ºC during the growth season, evidencing an decoupling between sugar and wine color, in two red varieties of major relevance on Chile: Cabernet Sauvignon and Syrah.

Taking all the above into account, the next step in this research line are framed in the search of novel adaptation strategies based on agronomic handling observed on international and national previous experiences, applicable on Chile, that allow, at short-term and costs, to mitigate the effects of the temperature increase in commercial vineyards. Hence, it will begin to be evaluated alternatives of ensure the sustainability of the culture. Between these new agronomic handling alternatives to adapt the fruit maturity with the new climatic conditions, will be included new pruning techniques and water settings

Productive improvement of wines and traditional vineyards in the Biobío Valley using technological transfer group (GTT) methodology

Carlos Ruiz

The objective of the project was to train viticulture producers in improving the production and quality of grapes and wines from traditional vineyards in the Biobío Valley using technological transfer groups (GTT). An initial diagnosis determined that vineyard management was deficient with a head-training or goblet pruning system very close to the ground and a high incidence of fungal diseases, particularly oidium and anthracnose. In addition, there was deficient soil management and weed control.

Furthermore, vineyards are quite often affected in varying degrees, depending on the season, by low temperatures at the beginning of sprouting. The wines, mostly of the País variety, usually have problems of volatile acidity after 4 to 5 months of aging. There are two groups of growers in the Biobío Valley, the GTT-Vides from Yumbel, 12 producers (10 men and 2 women) who own 24 ha of vineyards and the GTT-Vides from Nacimiento, 15 growers (all men) who own 29 ha of vineyards. An agronomic management program was developed, which included recommendations for pruning, fertilization, disease control, weed control, and timely harvest time based on grape maturity.

The recommended technologies have been adopted by 50% of the vitivinicultural producers of the GTT-Vides Nacimiento and 55% of the GTT-Vides Yumbel, and these have generated a positive impact on grape yields and quality. As for wine quality, a sensory evaluation based on a qualitative scale of 1 to 10 determined that the wines from GTT-Vides Nacimiento, derived from País grapes, reached 8.3 points for clarity, 6.4 for first nose, 7.0 for second nose, and 7.0 for mouthfeel. Likewise, GTT-Vides Yumbel, also with wines from País grapes, reached 6.6 points for clarity, 5.0 for first nose, 5.6 for second nose, and 6.8 for mouthfeel after the first year. GTT-Vides Yumbel also produced wines with a blending of varieties, 75% País and 25% Malbec or Cabernet, which had scores 15% higher than wines made with only País grapes

Viticulture in the southernmost part of the world

Diego Arribillaga

Chile chico is a town in chile located beside of General Carrera lake, in the Aysen region (46° 32′ Lat Sur; 71° 43′ Long O). The research line of the vines for this area oriented to the introduction of varieties and rootstocks that adapt to the climatic conditions of the sector, among those found Pinot Noir, Sauvignon Blanc, Chardonay, among others. In this way, we want to expand the national winemaking boundaries, towards more southern areas as a result of climate change, can become an opportunity for differentiation and diversification of wine production, so it is necessary to adapt management techniques and develop technological production packages, which they allow to elaborate wines and other quality wine products that express their origin in the Province of General Carrera. They are already promising results that have given rise to the world's first southernmost wine, developed by INIA: Keóken (Dawn in Tehuelche language)