ivia

instituto valenciano
de investigaciones agrarias

At the forefront of citrus research since 1868

From the book "Orígen y Actividades del Instituto Valenciano de Investigaciones Agrarias 1868-2000" by Salvador Zaragoza Adriaensens (2011)

JARDÍN DE ACLIMATACIÓN (1868-1887)

The origin of IVIA goes back to 1868, when the Government transferred a two-hectare plot to the Agricultural Society of Valencia to establish a crop acclimation garden (Fig. 1). The plot was located near to what is now downtown Valencia, and it was aimed to introduce new crops and to evaluate novel production techniques. The earliest field experiments recorded in official documents consisted in the evaluation of wheat cultivars using different organic fertilizers. Later, several grape cultivars were planted in the experimental farm, together with olive trees, pine nurseries, and field crops such as barley, oat, corn, tobacco, grasses, and row crops as pepper and cantaloupe melons. Some demonstrations of plowers and farm machinery were also recorded in the archives. The results of the experimental farm were periodically published in a magazine, which represented one of the oldest agricultural extension publications in Spain. Although citrus were well established in the region, no references to this crop were found in the early archives of the institution.

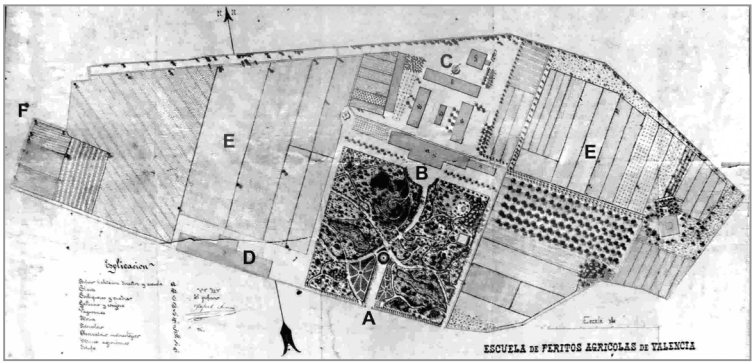

Figure 1: Site location plan of the crop acclimation garden in Valencia.

Between 1870 and 1887 the name of the institution changed several times: "Escuela de Agricultura" (1870-1878), "Estación Agronómica" (1878-1882) and "Granja Escuela Práctica de Agricultura" (1881-1887). During this periods, research efforts were focused strongly on sugarcane production and on the control of grape phylloxera (*Daktulosphaira vitifoliae*), a root feeder insect which had devastated French vineyards and was approaching Spain those days. One of the biggest issues that the institution faced was a citrus disease known as "enfermedad del naranjo", which was in fact Phytophthora gummosis. The pathogen was introduced in Spain thorough overseas planting material, and caused destructive epidemics in citrus-growing areas of Castellón and Valencia provinces. Although researchers were not able to identity the causal organism, they were successful in devising effective control measures, mainly by replacing sweet orange (*Citrus sinensis*) and citron (*C. medica*) rootstocks, widely used those days, by sour orange (*C. aurantium*). The report published in 1978 by the Director of the institution, Otto Wolffenstein, represented a pioneering phytopathological work in Spain.

GRANJAS EXPERIMENTALES (1887-1924)

From 1887 to 1903 the institution was known as "Granja Escuela Experimental". A formal education program was established, both for growers and technical crop advisors. With regard to research activities, a continuous recording of meteorological data was initiated and significant works on grape pests, such as the leaf moth (*Sparganothis pilleriana*) and downy mildew (*Plasmopara viticola*), were conducted. In 1892 the institution moved to Burjassot, a town near Valencia, where a six-hectare plot and a four-floor building were allocated by the government (Fig. 2). Field experiments were focused mainly on new emerging field crops, such as early harvesting potatoes,

cotton, and sugar beet. Somewhat exotic crops, such as opium poppy for morphine extraction and pyrethrum for insecticide production, were also evaluated in the experimental farm.

Figure 2: Chemistry laboratory of the "Granja Escuela Experimental" in Burjassot, Valencia.

The institution was renamed in 1903 as “Granja Instituto de Agricultura de Valencia” and later in 1924 as "Granja Escuela Práctica de Agricultura Regional". As a response to the introduction of the grape phylloxera in Spain, several field trials were established to evaluate a selection of American grapevine rootstocks planted in soils with different calcium content. Pest control programs were initiated by the fumigation of citrus trees with hydrogen cyanide (Fig. 3), mainly against red scale (*Chrysomphalus dictyospermi*) and mussel scale (*Lepidosaphes beckii*). This was the only method for citrus pest control during many decades. A Plant Pathology Section was created in 1909, and training courses for hydrogen cyanide applicators were initiated in 1914, in order to reduce the rather high number of accidents with this chemical.

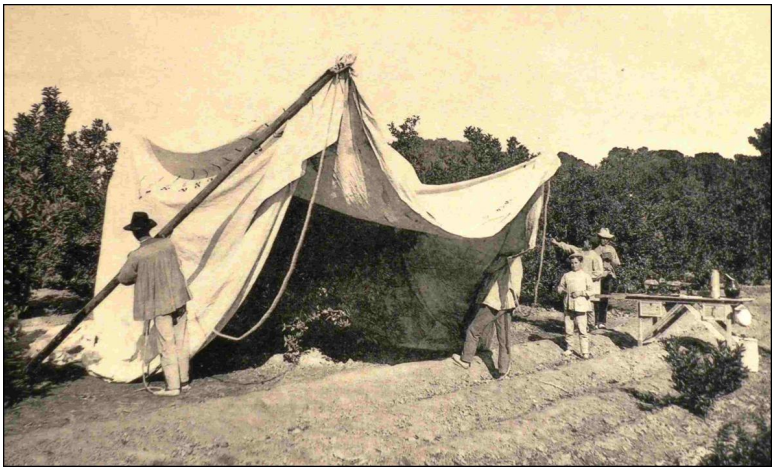

Figure 3: Application of hydrogen cyanide in a citrus orchard.

Since 1920, the number of citrus pests increased significantly with the appearance of the black scale (*Parlatoria zizyphi*), white scale (*Aspidiotus nerii*), mealybug (*Planococcus citri*), black olive scale (*Saissetia oleae*). Biological pest control programs were imitated just after the emergence of the cottony cushion scale (*Icerya purchasi*) with the introduction and multiplication of vedalia beetle (*Rodolia cardinalis*) in 1922.

One of the most relevant achievements of the institution was the introduction of the citrus cultivars 'Washington Navel' and 'Thomson' in 1910. These varieties were brought by Manuel Herrero de Egaña, who was further Director of the "Estación Naranjera de Levante". After completing field trials to confirm their agronomic characteristics, both citrus varieties were propagated and distributed among growers (Fig. 4). Specific fertilization programs were designed to improve fruit production.

Figure 4: Mechanical grading in a 'Navel' sweet orange orchard in 1920.

Silk production was an important industry in Valencia in early sXIX, and the institution was in charge of obtaining nursery trees of white mulberry (*Morus alba*). Due to the increasing importance of rice cultivation in the region, an experimental station devoted to this crop was established in Sueca in 1911. Between 1913 and 1923 the station imported a total of 75 rice cultivars from Japan, Philippines, Italy and Brazil.

The number of rice varieties increased to over 250 between 1940 and 1952, looking for semi-dwarf cultivars more adapted to mechanical harvesting. A vast collection of local cultivars were also obtained, and were used in the breeding programs together with the imported varieties. The station developed pest control programs, mainly for the Asiatic rice borer (*Chilo suppressalis*).

ESTACIÓN DE FITOPATOLOGÍA AGRÍCOLA (1924-1940)

The Plant Pathology Section became a separate institution in 1924, with the names of "Estación de Patología Vegetal de Valencia" and "Estación de Fitopatología Agrícola de Valencia" in 1927. All other sections were grouped into "Estación de Horticultura" and "Estación Naranjera de Levante" (Fig. 5).

Figure 5: Main entrance of the "Estación de Fitopatología Agrícola" (righ side of the building) and "Estación Naranjera de Levante" (left side of the building) in 1934.

The Plant Pathology Station was divided in three sections: agricultural entomology, mycology and bacteriology, and plant protection. The institution put emphasis in the biological pest control programs initiated some years before. In 1926 the station distributed by the first time beneficial insects to growers, and in 1928 the mealybug ladybird (*Cryptolaemus montrouzieri*) was imported from California and France for the control of the citrus mealybug (*Planococcus citri*). Other parasitoids, such as *Aphelinus mali*, *Opius humilis*, and *Aphitis*

crysomphali, were also successfully introduced (Fig. 6). The cycles of scale insect pests were determined experimentally and alternatives to hydrogen cyanide, such as nicotinoids and mineral oils, were evaluated. In 1928, the Mediterranean fruit fly (*Ceratitis capitata*) became a serious problem; so many studies about this insect were initiated including trapping with different baits and pupae control in soil.

Figure 6: Building for the acclimatation and multiplication of beneficial insects around 1930.

ESTACIÓN NARANJERA DE LEVANTE (1931-1940)

The "Estación Naranjera de Levante" was devoted specifically to citrus research, and it was divided in five sections: citrus production, edaphology and biochemistry, physiology and morphology, cytology and genetics, and statistics and marketing. A pioneering citrus breeding program was initiated in the station. The main goal was obtaining seedless varieties

and hybrids between sweet oranges and mandarins. Relevant works on pollen morphology and germination, nutrient content of different plant organs, and fruit maturation with ethylene, were performed (Fig. 7). A precedent of the existing Citrus Germplasm Bank was officially established in 1934, which included both, commercial and ornamental citrus species imported from overseas.

Figure 7: Laboratory for industrial citrus processing.

CENTRO REGIONAL DE LAS CUENCAS DEL JÚCAR Y DEL TURIA (1940-1970)

In 1940, the Ministry of Agriculture established the "Instituto Nacional de Investigaciones Agronómicas", merging most of the agricultural research institutions present in Spain at that time. The "Estación Naranjera de Levante", "Estación de Fitopatología de Valencia", "Estación Arrocera de Sueca", and "Estación de Horticultura de Valencia" were grouped into a higher rank regional centre named "Centro Regional de las Cuencas del Júcar y del Turia".

As the citrus region expanded in Valencia, frost damage became a limiting factor in many new growing areas. The institution obtained the first agroclimatic map of the region with historical records of temperature, rainfall, and other relevant environmental variables. Field trials using fog generators, wind towers and heating systems were conducted, and different techniques to improve tree recovery were also evaluated (Fig. 8).

Figure 8: Wind tower and meteorological station in Burjassot.

In 1959, a certification program for citrus nursery plants was established in Spain just after the emergence of *Citrus tristeza virus* (CTV). The program was developed jointly by the "Estación de Fitopatología Agrícola" and "Estación Naranjera", where their respective Directors, Silverio Planes and Eusebio González-Sicilia, played a significant role. The production of tolerant rootstocks, not widely used in Spain those days, such as citranges and 'Cleopatra' mandarin, was promoted.

Extensive disease surveys conducted in commercial orchards demonstrated that the pathogen was widespread in Spain, and no healthy varieties were found. Therefore, in 1965 clean budwood of 'Owari' satsuma, 'Salustiana', 'Washington-Navel-Frost', 'Valencia-Late-Frost' sweet oranges, and 'Marsh-Frost' and 'Redblush' grapefruits were imported from California. Propagating plant material of 'SRA' clementine was also imported from Corsica. Studies on disease diagnostics, electronic microscopy, vector population dynamics and transmission, were also performed (Fig. 9).

Figure 9: Greenhouse where the diagnostic of citrus viruses was conducted.

During this period, foliar nutrient contents were studied to design new and more efficient fertilizer programs for citrus (Fig. 10). Symptoms of nutrient deficiencies were systematically characterized. In 1964, studies about the use of giberellic acid to improve fruit set in mandarin trees were initiated. Herbicide trials were also conducted and the relative susceptibility of citrus rootstocks was evaluated. A section for industrial citrus processing was established, dealing with juice

conservation, cold storage of citrus fruit, and oil extraction from citrus peel (Fig. 11). New chemicals for pest control were evaluated, drawing special attention to possible phytotoxic effects and incompatibility problems with mixtures. The first work about *Citrus psoriasis* was published in 1942.

Figure 10: Experiment with nitrogen fertilizers.

Figure 11: Fruit degreening experiment with petrol heaters.

CENTROS REGIONALES DE INVESTIGACIÓN. EL CRIDA 07. (1970-1984)

The former "Instituto Nacional de Investigaciones Agronómicas" changed to "Instituto Nacional de Investigaciones Agrarias" (INIA), and the regional centre in Valencia was renamed as "Centro Regional de Investigación y Desarrollo Agrario de la División 7ª (Levante)", with the acronym CRIDA07. Research activities were developed through four-year-projects, and all sections were reorganized in research units.

In 1971, the Spanish government signed an agreement with the World Bank, and considerable amounts of financial resources were used to develop the most ambitious agricultural research program in Spain ever. The results of this program produced major improvements in Spanish agricultural research. The number of scientists and technicians in the institution increased significantly and many of them obtained grants to complete MSc and PhD programs abroad, mainly in U.S.A., France, Belgium, UK, Italy and Australia.

Foreign researchers were also incorporated as coordination specialists, such as Walter Reuther from University of California, Riverside, Richard Albert Hensz from Texas A&I Citrus Center, Weslaco, Texas, and the citrus virologist Ralf Eduard Schwarz. The institution moved from Burjassot to Moncada, where the area of experimental fields increased to 44 ha. The new building was inaugurated in December 1976.

The National Department of Citrus was created under the auspices of the World Bank program to coordinate all research activities. In 1973, a five-year National Plan for Citrus was initiated, covering five research areas: fertilization and crop

production, rootstocks, varieties, clean stock program, and the control of the woolly whitefly (*Aleurothrixus floccossus*) (Fig. 12).

Figure 12: Woolly whitefly on a citrus leaf.

The Phytosanitary Improvement Program for Citrus Varieties was initiated 1975, to obtain virus-free plant propagating material using the recently developed shoot-tip-grafting technique. In 1981, a research unit was created to deal specifically with this subject.

A protected Citrus Germplasm Bank, known as International Board of Plant Genetic Resources, was established in Moncada and healthy propagating material was multiplied and released to growers through commercial nurseries (Fig. 13). The first trees were planted in 1981, and all citrus orchards in Spain were progressively replaced by virus-free plants grafted on tolerant rootstocks.

Viral diseases were eradicated from the Spanish citrus industry and currently more than 600 virus-free accessions are available in the Citrus Germplasm Bank. The Quarantine Citrus Station was created in 1982, including biosecurity greenhouses to allow

the safe importation of overseas plant propagating material (Fig. 14). To date, 140 million healthy plants have been originated in the quarantine, sanitation and certification programs.

Figure 13: Official release of virus-free propagating material to Spanish citrus nurseries in 1979.

Figure 14: Quarantine Citrus Station in Moncada.

INSTITUTO VALENCIANO DE INVESTIGACIONES AGRARIAS (IVIA) (1984- present)

The current "Instituto Valenciano de Investigaciones Agrarias" (IVIA) was established in 1984, incorporating all the sections and units of the former CRIDA 07 of INIA located in Valencia. The institution was transferred to the regional government (Generalitat Valenciana) and was formally recognised by a law act in 1991. Currently, the institution has seven research centres in Moncada: Plant Protection and Biotechnology, Genomics, Citriculture and Crop Production, Sustainable Agriculture, Postharvest Technology, Agroengineering, and Livestock Technology, together with two extension services: Irrigation Technology Service and Technological Development Service (Fig. 15).

Figure 15: Aerial view of IVIA facilities nowadays.

Recent citrus pathology research topics in the Plant Protection and Biotechnology Centre include: development of detection and diagnostic methods for CTV and other citrus viruses and viroids, epidemiology and transmission efficiency of CTV by different aphid vector species, epidemiology and control of diseases caused by fungi and oomycetes such as *Phytophthora* spp., Alternaria brown spot of mandarins, and fruit rots, and development of diagnostic methods and risk analysis for quarantine diseases of citrus, such as citrus canker and huanlongbing. Entomology research is aimed to develop biorational pest control methods, design and update of citrus integrated pest management programs, and application of molecular tools for proper identification of pests and natural enemies.

The citrus breeding and genetics programs of the Plant Protection and Biotechnology Centre comprise several research groups working on reproductive biology, genetic control traits; quantitative trait locus, candidate gene analyses, and marker-assisted selection. A triploid breeding program is also in progress to produce new seedless mandarin cultivars. The genetic transformation program is aimed to introduce resistance to pests and pathogens, as well as modulation of development and improvement of fruit quality.

The Citrus Genomics Centre develops and apply genomic tools for citrus variety improvement, with special emphasis on the development of new genomic resources to characterize natural and induced diversity, dissect agronomical traits and provide commercial varieties. Citrus growth and development related to productivity and fruit quality are also studied at the molecular and physiological level.

The Citriculture and Crop Production Centre works in the improvement of crop production techniques, nutrient dynamics and crop physiology. Breeding programs to obtain semi-dwarf rootstocks and seedless late-maturing mandarins are also in progress. Currently, the IVIA hosts the European Community Plant Variety Office (CPVO), which deals with registration and characterization of new citrus varieties.

The research conducted at the Sustainable Agriculture Centre mainly covers aspects of citrus production related with organic nutrition, soil biology, nitrate leaching and soil and water pollution, GIS and modelling of soil salinity. The irrigation management program deals mainly with the establishment of citrus water needs and seasonal crop coefficients.

The Postharvest Technology Centre develops programs to improve degreening of early-maturing varieties, evaluate the effect of different rootstocks in fruit quality, develop controlled atmosphere storage systems, reduce citrus peel disorders by hormonal treatments, and control of fruit rots using low-toxicity compounds.

The Agroengineering Centre has several research programs including the design of new harvesting machinery, precision agriculture, spray drift reduction, ergonomics and improvement of worker welfare, development of new sensors for seed detection, recognition of physiological disorders, and internal fruit quality assessment in packing-lines.