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## **DIRECTOR'S REPORT**

### **“In Search of Excellence”**

Since its establishment, the Agricultural Research Institute (ARI) has been actively cooperating with national, regional and international organizations and research networks, including the Food and Agriculture Organization of the United Nations, the International Atomic Energy Agency, the International Centre for Agricultural Research in Dry Areas (ICARDA), the International Potato Centre, the International Centre for Advanced Agronomic Mediterranean Studies (CIHEAM), and numerous academic institutions, including the newly established Cyprus University of Technology. A substantial number of research programmes, supported by the European Union (EU) and the Cyprus Research Promotion Foundation, are in progress. Ongoing research programmes in the various Sections of the Institute are outlined below.

In Plant breeding, efforts have been oriented towards the introduction, development and distribution of new varieties carrying the genetic potential for higher production, improved quality characteristics, resistance to pests and diseases and tolerance to abiotic stress, including drought. Particular emphasis has been given to the improvement of cereals, food legumes and fodders, utilizing both field methods and molecular genetic approaches.

In the Plant Protection Section, methods for the viral-disease-free production of citrus, grapevine and stone fruit stocks have been developed, including clonal and sanitary selection, thermotherapy, tissue culture and virus indexing techniques. The control of insect pests and soil-borne diseases has also been studied using conventional and advanced integrated methods in vegetables, grapevines, citrus and other fruit crops. Within the context of integrated crop management (ICM), sustainable approaches for the control of pests and diseases in agricultural production have been tested, aiming at the production of agricultural commodities with minimal use of pesticides and other chemicals.

Horticultural research programmes aim at improving cultural practices and at evaluating new varieties and species. New growing media and methods of flower production have been investigated. Emphasis has been given to the utilization of endemic plants for floricultural purposes. Aspects of post-harvest physiology and technology of potatoes are examined, including screening for cold chipping varieties. Watermelon rootstock-scion effects with respect to yield, quality and shelf-life are currently assessed. New rootstocks and varieties of fruit trees, table and wine grapes are currently evaluated.

The main activities of the Soil Science Section concern the design and application of closed hydroponic systems adapted to Cyprus conditions. Increasing water use efficiency, preventing pollution and using environmentally friendly local substrates have been among the main objectives. The potential for using biomass for biofuel and energy production in Cyprus and the use of agricultural waste products and by-products have been examined.

Research in Animal Production aims at enhancing productivity through improved breeding methods, management techniques and feeding practices. The effects of artificial rearing practices on lamb and kid growth and on dam milk performance are investigated. The genetic improvement of economically important characters, such as milk, meat, and fecundity, is pursued by methods of selection. A project for combating the scrapie disease in sheep, using

molecular genetic methods, is successfully implemented. The Chios sheep unit of ARI at Athalassa has been transformed into a nucleus herd of about 500 disease-resistant animals, which provides farmers with scrapie-resistant stock of high genetic value. Additional studies have been initiated to combat the scrapie disease in goats, by characterizing further the various scrapie genotypes in the ARI Damascus goat unit.

Agro-economic studies are an integral part of the research programmes of the Institute. Time-series data and market prices are utilized for the prediction of market trends for crop and animal products. Following the membership of Cyprus to the EU, the Institute has been assigned the task of maintaining the Farm Accountancy Data Network in Cyprus.

The contribution of ARI to agriculture in general has been valuable and substantial. It has, since its establishment, contributed through concerted actions to the improvement of agricultural production in Cyprus by providing solutions and introducing new technology, thus promoting a better future for the Cypriot farmer. Furthermore, the Institute has incorporated in its scope of activities the training of scientists, agricultural extension officers, technicians and farmers and functions as a valuable centre for collection, evaluation and dissemination of information on agricultural matters and technology. Over the past decade, the Institute has expanded its research activities into the areas of molecular biology, molecular genetics, post-harvest physiology and technology, toxicology, environmental issues and integrated crop production methods that are financially, environmentally and socially sustainable.

The selection of ARI by the European Commission in 2000 as a Centre of Excellence in Agriculture and Environment has constituted a landmark recognition reflecting on the high standard of scientific research conducted, and on its contribution to agricultural development and the protection of the environment. The Institute continues its valuable contribution towards the advancement of agricultural research by extending its scope of research and other activities in order to meet the technological and scientific challenges of an increasingly antagonistic, global trading environment for agricultural products.

It is a pleasure for me to acknowledge the efforts of both the permanent and the seasonal staff of ARI and their tireless commitment to quality research.



**Dora Chimonidou**  
**Director**

## PLANT IMPROVEMENT

The main activities of the Plant Improvement Section concern the improvement through breeding of barley, forage plants, seed and food legumes, durum and bread wheat, as well as studies of genetic and environmental factors affecting their productivity, quality, and resistance to diseases. Work also involves methods of improving cultural practices of forage plants, grain cereals, legumes, potatoes, aromatic plants and truffles. The Section is also responsible for the National Genebank and Herbarium.

Barley is the cereal most adapted to the often harsh Cyprus agroclimatic conditions. Spring barley is grown during winter in Cyprus as the main rainfed crop for livestock feed (hay or grain). The barley breeding programme aims at the development of new, well adapted and drought tolerant cultivars with improved quality characteristics, and of naked barley cultivars for human consumption and as feed for monogastric animals. Wild species (*Hordeum vulgare* spp. agriocrithon Aberg) and landraces are used in crosses to improve biotic and abiotic stress resistance.

The durum wheat improvement programme aims to enhance the productivity and economic value of grain and straw through hybridization and selection for agronomic performance and quality. Environmental and genetic factors affecting grain yield, water use efficiency and quality of durum wheat are within the scope of the current research work. The cereal technology programme is complementary to the improvement programme and aims at identifying varieties with suitable quality for the local farmer. Cultural practices are also examined for improved production. Factors that could enhance the quality of industrially made local bread are also evaluated.

Forage production has increased both quantitatively and qualitatively through the introduction of new species/varieties, selection of local material and improved management practices. Crops under investigation include barley, oats, bread wheat, vetch, alfalfa, triticale, and



peas. Triticale is a fast developing crop introduced mainly by cattle growers in the last few years. In the absence of a locally originated variety, all triticale seeds are currently imported or produced locally by imported varieties. The research program for the development of a new triticale variety is currently close to submitting at least one promising line for examination at the Cultivar Examination Center.

A new project has been initiated for the genetic improvement of local cowpea landraces, with respect to the changing climate conditions, and the introduction of remote sensing technology in the irrigation management of this important crop. Further work on potato crop has continued with the evaluation of new varieties and clones, and potato material with coloured flesh.

National Genebank efforts have concentrated on the collection of new genetic material and on the conservation, regeneration, evaluation and documentation of the existing germplasm. Work in the National Herbarium concerned the maintenance and documentation of the existing specimens and further research of the flora of Cyprus.

Finally, a new scientist responsible for aromatic and medicinal plants has joined the Plant Improvement Section. Research will focus on cultural techniques required for the main aromatic and medicinal plants grown in Cyprus, with emphasis placed on essential oils and their properties. Work has commenced regarding the impact of deficit irrigation on spearmint (*Mentha spicata* L.) biomass production, oil yield, and oil quality. New species of medicinal and aromatic plants, such as stevia (*Stevia rebaudiana* Bertoni), with multiple benefits to consumer health, will be studied as potential alternative crops for the Cypriot farmer.

## CROP IMPROVEMENT

### Breeding barley for grain and hay

Specific aims of the barley breeding program include the development of cultivars with improved adaptation, particularly in view of the documented climate change, improved drought resistance and improved quality traits, such as threshability, high hectoliter weight, uniform grains and high protein content. In addition, the development of dual-purpose cultivars (grain and hay) has been a priority. Trials were performed in five different locations across the island. Three new feed barley cultivars named Trikomo, Morfo, and Lefka have been introduced to the farmers. A series of crosses were performed between locally adapted material and



promising imported germplasm. Trials using internationally available germplasm, in collaboration with CIMMYT and ICARDA, continued. Following the global trends and concerns about a healthy and well balanced human diet, the barley breeding program has also focused on the development of appropriate naked barley cultivars to enhance human nutrition. (D.A. Fasoula).

Barley breeding for organic conditions is a new program aiming to cover the dietary needs of organic livestock production. The challenges associated with breeding for low-input and organic agriculture are shared among many EU countries, through formation of a scientific network. Exploitation of the capabilities of honeycomb breeding is used to face the disturbing effects of GxE interactions and incorporate stability and responsiveness to inputs. (D.A. Fasoula).



### **Whole-plant field phenotyping - molecular breeding**

An important component of the barley breeding program is the development of novel approaches to address the well known challenge of bridging the gap between genotype and phenotype. Accordingly, participation in the COST program TRITIGEN and links with the wider EU scientific communities have been established. In recognition of the importance of barley and all the related breeding work in Cyprus, the 7<sup>th</sup> Barley Meeting of the European Cooperative Program for Plant Genetic Resources (ECPGR) was successfully organized in Lefkosia by ARI and the ECPGR secretariat in May 2011. (D.A. Fasoula).

### **Breeding durum wheat, bread wheat and triticale**

The aim of the program is to develop cultivars of high and stable grain yield under rainfed and supplementary irrigation conditions. Work is based mainly on two approaches. The first is by crosses of selected cultivars possessing desirable agronomic and quality characteristics until a desired line is developed and checked in the field. A second and faster approach is the introduction of genetic material under development by CIMMYT and ICARDA, which is checked and selected under the climatic conditions of Cyprus. Sometimes a combination of these approaches is necessary for the achievement of a very good line. The practiced breeding method is a modification of the pedigree method, which retains for subsequent exploration F3 lines with a higher frequency of promising genes for high quality and agronomic characteristics positively associated with grain yield early in the program. Outstanding F5 lines enter the preliminary yield trials and the best proceed to the VCU tests for registration. The two durum wheat cultivars that are currently most cultivated are the ARI varieties Ourania and Hekabe. The two varieties were recently grown under organic farming conditions, exhibiting promis-



ing performance. (**A. Pallides**).

Forage production could be improved both quantitatively and qualitatively through crossing and selection. Thus, the program aims at identifying new varieties with high forage production and high nutritional value. The most promising lines are tested at several sites in order to assess dry yield potential,

nutritional value, disease and lodging resistance. New bread wheat lines having tall, leafy and strong stem, selected from the bread wheat improvement program, were further tested for their forage mass production and have been sent for registration in the National Catalogue. These lines proved to be tolerant to dry conditions and yield much better than durum wheat. In addition, the most promising triticale lines in terms of quality and yield from the ARI development program were promoted for advanced trials and soon at least one of them will be sent for VCU and DUS tests for registration. (**A. Pallides**).

## FODDERS AND PASTURES

### Grain and forage legumes

In recent years, rainfed legumes have become increasingly popular, because of their efficient use in rotation systems with cereals and their higher feeding value than cereals, either as grain or as dry forage mass. Thus, special emphasis in current research projects has been put on the evaluation, among others, of common vetch, field peas, and alfalfa for forage production.

One of the sector's most crucial duties is the maintenance of breeder's seed for all the varieties produced in the ARI. This is also the case for legumes where the sector preserves the purity of many varieties of common vetch, field pea, fava beans, lentils, chickpea, bitter vetch, ground nut and other. Two new varieties of common vetch (*Vicia sativa*), Kimon and Zinon, were registered in the National Catalogue and have become available through seed companies for cultivation. Groundnut (*Arachis hypogaea*) varieties are on the last stage of examination and the first results are expected in 2012. (**A. Pallides**).

Alfalfa (*Medicago sativa*) is a high protein feeding stuff of great importance. Four populations have been stabilized and are currently evaluated for their yield and quality potential. One variety is in the final stage for registration in the National Catalogue. (**D.A. Fasoula and A. Pallides**).

## POTATOES

### Evaluation of potato clones

Since 2005, the ARI offers its services to breeding stations and companies for the evaluation of potato clones and varieties on a subsidy basis. Potato clones are assessed in co-operation with potato breeding stations in Europe. The objective is to select clones suitable for the local climatic conditions from the early stages of the screening procedure. The clonal material was received from Germicopa SA, France. Fourteen clones were tested in 2010 and in 2011. (**S. Gregoriou**).

### Multiplication and evaluation of potatoes genetic material

Thirteen old German varieties with coloured flesh were imported from the Genebank Gatersleben of the Leibniz Institute of Plant Genetics and Crop Plant Research (IPK) for evaluation and multiplication. The plants were planted in December 2011 in a net house at Athalassa. The plants were set in rows 60 cm apart and 100 cm in the row. Drippers of 4 l/h capacity on 16 mm diameter polyethylene line were used for irrigation and fertigation. The varieties will be evaluated for their yield and tuber quality. (**S. Gregoriou**).



### Evaluation of the coloured-flesh variety Blaue St. Galler

The variety Blaue St. Galler with blue-violet flesh imported from Germany was planted at the Xylotymbou Experimental Station. The planting was done on 21 of December, 2011. The planting distance was 65 cm between rows and 20 cm within rows. Irrigation was applied



by mini sprinklers. The main varieties Spunta, Nicola, and Cara were used as control. A randomized complete block design with four replications was used. The plot size was 0.65 m x 5.0 m. Each row consisted of 25 plants. Records have been kept on emergence, yield, tuber shape, colour of flesh and skin, and the quality of the tubers after cooking. (**S. Gregoriou**).

### **Cultivation of summer truffle**

Olive trees inoculated with summer truffles (*Tuber aestivum*) were planted at the Zygi and Acheleia Experimental Stations of the ARI, and at the Orites area in the Paphos district. The Planting was performed in the beginning of 2006. Two root-samples from each area were tested for the presence of summer truffles (*Tuber aestivum*) by PCR analysis in the UK and all samples have tested positive. No truffles have yet been harvested. (**S. Gregoriou**).

### **COWPEA**

Cowpea is a subtropical legume with substantial tolerance to the drier conditions experienced in Cyprus, and a favorite traditional food among the local population. A new project aims at the development of improved cowpea varieties, well adapted to the changing climate conditions of south-east Mediterranean. The project also involves study of the microbial environment of local cowpea landraces as well as the use of remote sensing technology to facilitate informed irrigation decisions for the farmers. (**D. Fasoula**).

## **CONSERVATION OF PLANT GENETIC RESOURCES**

### **National coordination**

Cooperation with Biodiversity International, mainly through participation in the European Cooperative Program for Plant Genetic Resources (ECPGR), as well as with ICARDA and other international and national organizations continued. ARI is the National Focal Point in the European Internet Search Catalogue (EURISCO), the national correspondent for the FAO-World Information and Early Warning System on Plant Genetic Resources and the national representative to the Committee established by the Council Regulation 870/2004. It is also involved in the implementation at national level of the International Treaty on Plant Genetic Resources for Food and Agriculture. (**A. Kyratzis**).





### National Genebank (CYPARI)

Seed collecting has been focused on native plant genetic resources threatened by genetic erosion or extinction and on useful plants such as rare species, landraces, and crop wild relatives. Around 500 new accessions have been registered during the last two years. In a collaborative joint mission with ICARDA, 443 accessions have been collected representing around 90 different taxa of native crop wild relatives. Most of the accessions collected belong to the species *Hordeum* sp., *Aegilops* sp., *Medicago* sp., *Trifolium* sp., *Vicia* sp., *Lathyrus* sp., *Lotus* sp., and *Brachypodium* sp. Duplications of these accessions have been sent to ICARDA's genebank for safety duplication. Other six accessions of rare endemic species have been donated by the Frederic University. In total, around 1,300 accessions of local landraces and wild species, including crop wild relatives and endemic species, are conserved in the Genebank under controlled conditions (0 to 4 °, and -20 °C). More than 332 germination tests have been conducted to assess the germination capacity of conserved seeds. Accessions with low germination capacity or with few seeds in stock have been or will be regenerated in the near future. During the last two years 203 accessions have been successfully regenerated.

In the framework of participation in the EU/EPGRIS project, the Cyprus National Inventory was prepared and uploaded onto EURISCO. The Genebank has become an associated member of the European Genebank Integrated System (AEGIS) and member of the European Native Seed Conservation Network (ENSCONET). (A. Kyratzis).

### National Herbarium

More than 12,000 named specimens are kept in the National Herbarium, while a number of specimens collected in recent years need documentation and naming. New software has

been developed for the computerization of the Herbarium, aiming to provide easy and quick access to specimens. More than 7,300 specimens have been recorded to the present. (A. Kyratzis).

### **Ensuring the survival of endangered plants in the Mediterranean – MAVA project**

The project started on October 2011 and it is funded by the MAVA foundation. The consortium comprises six partners from Mediterranean islands and the Kew Royal Botanic Gardens as the project coordinator. The main goal of the project is to ensure the survival of threatened plant species in the Mediterranean basin through *ex situ* conservation measures. One hundred and fifty accessions from Cyprus are expected to be collected during the next three years. (A. Kyratzis).

### **Linking on-farm and *ex situ* activities to the conservation of vegetable landraces**

The main objectives of the project are to survey and inventory vegetable landraces still in use, to collect and conserve seeds in the ARI Genebank, to create a seed exchange network and to promote on-farm conservation activities among interested farmers. In collaboration with the Department of Agriculture, 45 accessions of vegetable landraces have been collected representing 17 different species. Most of the accessions have been collected from Lemesos and Pitsilia areas. Local eggplant landraces have been chosen for field experimentation as a first case study of the genetic variation existing within local vegetable landraces and the potential for their optimized on-farm conservation. (A. Kyratzis and D.A. Fasoula).

### **European Crop Wild Relatives Red List**

This collaborative project between the European Commission and the International Union for the Conservation of Nature (IUCN) aimed at developing a European Crop Wild Relative Red List. Approximately 600 species considered as crop wild relatives of major crops worldwide have been assessed according to the IUCN criteria. The results have been published to IUCN in the context of the European Red List of Vascular Plants. (A. Kyratzis).

## **AROMATIC AND MEDICAL PLANTS**

### **Impact of deficit irrigation on spearmint**

In 2011 a spearmint (*Mentha viridis*) plantation was established at Zygi Experimental Station. The aim of the experiment is to study the impact of deficit irrigation on spearmint biomass production, oil yield, and oil quality. Furthermore, the antioxidant and antimicrobial activity of spearmint essential oil will be studied. Three levels of irrigation will be applied: 60,



80, and 100% of the estimated irrigation requirement. During the 2011 growing season all plots were irrigated adequately to establish uniform stands across all plots. Deficit irrigation management procedures will be implemented on these plots during the 2012 and 2013 growing seasons.

#### ***Stevia (Stevia rebaudiana) field trial***

A field trial of stevia (*Stevia rebaudiana*) was established at Zygi Experimental Station in 2011. The aim of the experiment is to investigate the adaptation of this plant to the climatic conditions of Cyprus and the possibility for commercial cultivation. The productivity and the steviol glycosides concentration of four varieties will be assessed. Additionally, an economic feasibility analysis will be conducted for the cultivation of this species in Cyprus.

## FRUIT TREES AND VITICULTURE

Research activity in the Fruit Trees and Viticulture Section encompasses methods of managing yield and quality of fruit trees and vines and optimising production cost. In viticulture, research work on evaluation of table grape and wine grape varieties and rootstocks, as well as ampelographic description and conservation of traditional grape varieties continues. Local clones of pomegranate and several cherry varieties are evaluated and in citrus, research work on rootstock evaluation is continued.

### VITICULTURE

#### Evaluation of table grape varieties

For the evaluation of new and traditional table grape varieties, under different environmental conditions, two experimental plots were planted at the Saittas and Acheleia Experimental Stations. At Saittas, the newly introduced table grape varieties Red Globe, Superior, Fantasy Seedless, Crimson Seedless, Autumn Royal, Sublima and the traditional varieties Verigo and Sideritis are under evaluation in terms of yield, quality and earliness. At Acheleia, in addition to the above, varieties Prima, Black Emerald, Early Superior, Summer Muscat, Ora, Victoria, Italia, Calmeria and Flame Seedless were also introduced for evaluation. (S. Savvides).

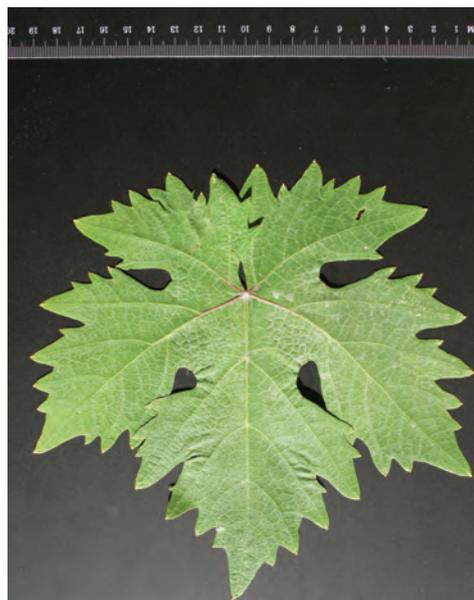


#### Performance of Superior on American rootstocks

The evaluation of variety Superior grafted on five American rootstocks resistant to phylloxera continued in collaboration with the Department of Agriculture at the Acheleia Station. Superior was grafted on 110 Richter, 3309 Couderc, 41B, 99 Richter and 420A and is evaluated in terms of yield, fruit quality and earliness. (S. Savvides).

#### Evaluation and test for distinctness, uniformity and stability of traditional wine grape varieties

Virus-free plants of traditional grape varieties from the pre-basic grapevine plantation at Zygi were planted at Saittas Experimental Station for evaluation of yield and quality in comparison



to the imported varieties Mataro, Cabernet Sauvignon, Merlot, Chardonnay and Sauvignon Blanc. The traditional varieties under evaluation are Mavro, Xynisteri, Ofthalmo, Spourtiko, Maratheftiko, Morokanella, Malaga and Lefkada. The above varieties will also be tested for distinctness, uniformity and stability in order to meet the Council Regulation 2100/94 on Community Plant Variety Rights. (S. Savvides).

#### **Collection and ampelographic description of traditional table and wine grape varieties**

The traditional table grape varieties Verigo and Sideritis and the wine grape varieties Mavro, Xynisteri, Ofthalmo, Spourtiko, Maratheftiko, Morokanella, Omio, Promara, Skouro Mavro, and Kanella have been planted at Saittas Experimental Station for the acquisition of primary and secondary descriptor data according to the International Organisation of Wine and Vine (OIV) standards. (S. Savvides).

#### **Evaluation of traditional wine grape varieties grafted on American rootstocks**

Two new experimental plots were planted for the evaluation of traditional wine grape varieties Maratheftiko and Xynisteri grafted on the American rootstocks 110 Richter, 3309 Couderc, 41B, 99 Richter, 420A, and 140 Ruggeri. Both varieties are evaluated in terms of yield, fruit quality and earliness. (S. Savvides).

#### **Management and conservation of grapevine genetic resources**

The long-term objective of this project is to increase knowledge on European grapevine genetic germplasm, to enhance its preservation and management, and to promote its future utilisation.



tion. That includes preservation and study of *in-situ* populations of wild vines as well as of old and neglected varieties. Special interest is also given to the characterisation of agronomic and technological characteristics of old autochthohous varieties under conventional conditions. Current work in progress includes the *in-situ* evaluation and morphological characterisation of all wild vine individuals. (S. Savvides).

## CITRICULTURE

### Rootstock evaluation

The aim of citrus rootstock evaluation is to identify rootstocks tolerant to the tristeza virus capable of replacing Sour Orange, the rootstock commercially used in Cyprus, which is highly susceptible to the virus. The commercial cultivars Delta, Nova, Ortanique and Lane Late are evaluated on various rootstocks.

## DECIDUOUS FRUIT TREES

### Characterization and evaluation of local pomegranate clones (*Punica granatum* L.)

An *ex-situ* clonal selection of local pomegranate was established at Zygi Experimental Station in 2010. The clones are studied regarding their morphological characteristics



and phenological stages and will be evaluated in terms of yield and quality. (S. Ioannidou).

### **Evaluation of Cherry varieties**

At the Saittas Experimental Station several cherry varieties are evaluated in terms of fruit quality, yield, and earliness. The varieties under evaluation are: Bigarreau Burlat, Black Tartarian, Utah Giant, Bigarreau Ferbolous (Verdel), Bigarreau Summit, Bigarreau Fercer (Arcina), Bigarreau Reverchon (Souche Sandar), Griotte Du Nord, Bigarreau Lapins, and Van. (S. Ioannidou).



## VEGETABLE AND ORNAMENTAL CROPS

The Vegetable and Ornamental Crops Section undertakes research on intensive vegetable production systems, on floral and landscape ornamental crop production, and on the postharvest technology of horticultural commodities. Current research work on vegetable crops focuses on rootstock-scion relations with respect to productivity, disease-resistance, stress response, quality and postharvest performance. Work on leafy salad crops examines the effect of planting pattern, nitrogen administration schemes, shading, seasonal adaptation and harvest age on yield, quality, shelf-life, and consumer safety. Work on ornamental crops examines the effect of salinity, with respect to substrate, development stage, and seasonality, on the hydroponic production of cut flowers. The evaluation of endemic species of Cyprus flora for potential use in commercial floriculture constitutes a perennial theme in floricultural research. Work on postharvest technology further engages on the non-chemical control of potato tuber dormancy with respect to carbohydrate metabolism and processing quality, on quality assessment and minimal processing of fresh fruit and vegetables, and on alternative postharvest treatments for controlling loss of quality to pathological and physiological causes.

### VEGETABLE CROPS

#### **Impact of three hybrid rootstocks on yield, quality and nutritive value of five watermelon [*Citrullus lanatus* (Thunb) Matsum & Nakai] cultivars**

The objectives of this study were to evaluate the possible effects of rootstock on yield and quality of watermelon cultivars in Cyprus. Scions of five cultivars (Celebration, Gallery, Pegasus, Extazy and Torpilla) were grafted onto three *C. maxima* x *C. moschata* hybrid rootstocks, in a split-plot design with non-grafted plants as the control. Significant interactions observed between variety x rootstock were eliminated by excluding outlier cv. Extazy and subjecting it separately to further analysis. The total, tradeable weight and flesh firmness at harvest were significantly increased in all large-fruited cultivars by grafting but significant differences were not observed between the different rootstocks used (Table 1). No effect of grafting was observed on lycopene concentration and flesh colour. Grafting also did not affect TSS content of the four large fruited cultivars, however one rootstock decreased TSS content of cv. Extazy in comparison to the control. Cultivar differentiation was obtained only in relation to lycopene concentration and flesh firmness. It appears that grafting on hybrid rootstocks does not generally impact adversely any of the critical quality characteristics of watermelon cultivars while on the contrary, it increases flesh firmness. Nevertheless, the choice of rootstock can be of concern with certain cultivars, as exemplified in the case of cv. Extazy. (G.A. Soteriou and M.C. Kyriacou).

**Table 1.** Mean comparison for yield and quality components of watermelon cultivars Celebration, Gallery, Pegasus, Extazy, and Torpila grown self-rooted or grafted on rootstocks TZ148, Bombo, and N101

	Tradeable yield (tons ha <sup>-1</sup> )	Number of fruit (per ha)	Mean fruit weight (kg)	TSS content (%)	Flesh firmness (kg)	Flesh lycopene content (µg g <sup>-1</sup> FW)
<b>Cultivar</b>						
Celebration	54.8	5630	9.75	11.4	3.0B <sup>X</sup>	75.3
Gallery	55.5	6500	8.62	12.0	3.2AB	60.1
Pegasus	53.6	6080	8.82	12.0	3.5A	63.5
Torpilla	57.1	6370	8.92	11.9	3.6A	71.8
<b>Rootstock</b>						
TZ148	62.2a <sup>Y</sup>	6560	9.51a	11.7	3.5a	67.32
Bombo	55.2a	6080	9.17a	11.8	3.6a	66.75
N101	60.3a	6330	9.53a	11.9	3.6a	69.33
Self-rooted	43.3b	5600	7.90b	11.9	2.6b	67.41
<sup>Z</sup> <b>Cultivar Extazy</b>						
TZ148	67.3a	20610a	3.28	10.9ab	9.9a	98.5
Bombo	56.5ab	17410a	3.20	10.0b	10.5a	88.9
N101	59.5a	17410a	3.40	10.5ab	11.2a	90.9
Self-rooted	41.2b	11710b	3.50	11.6a	6.3b	90.0

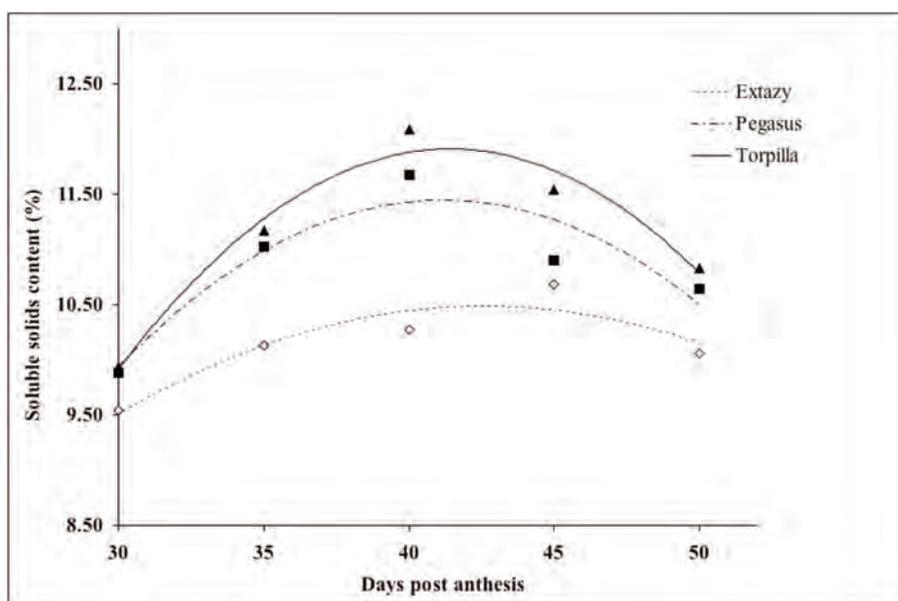
<sup>X</sup>Capital letters indicate mean separation within column among cultivars according to Tuckey-Kramer HSD Test (P<0.05).

<sup>Y</sup>Lower case letters indicate mean separation within column among rootstocks according to Tuckey-Kramer HSD Test (P<0.05).

<sup>Z</sup>Rootstock mean separation for outlier cv. Extazy

### Quality profile of late-season open-cultivated watermelon fruit [*Citrulus lanatus*] with respect to age at harvest

The impact of harvest date, defined as days from anthesis (fruit-setting), was assessed on important quality aspects of watermelon fruit. Three cultivars (Pegasus, Extazy and Torpila) grafted onto *C. maxima* x *C. moschata* hybrid rootstock TZ148 were harvested 30, 35, 40, 45 and 50 days from anthesis. A CRD-split plot design was used with variety as the main plot and harvest date as the sub-plot. Development of fruit quality characteristics (total soluble solids, flesh firmness, soluble carbohydrates, lycopene content) was best fitted to a second order polynomial equation using least squares regression. The total soluble solids content (TSS) of all cultivars tended to maximisation between days 40 and 45 post anthesis (Fig. 1). The TSS of cv. Extazy tended to be lower than the other two cultivars throughout the growing period. Flesh firmness of Pegasus and Torpilla declined between days 30 and 45, and incurred a minor increase thereafter. Cultivar Extazy differentiated from the other two cultivars in respect to its firmness, which did not show decrease until 40 days post anthesis, and tended to be higher than the other two cultivars throughout the growing period. (G.A. Soteriou and M.C. Kyriacou).



**Figure 1.** Change in total soluble solids content (TSS) of cultivars Pegasus, Extazy, and Torpilla with age of fruit at harvest determined as days post anthesis.

#### **Yield and quality of four mini watermelon [*Citrullus lanatus* (Thunb) Matsum & Nakai] cultivars grafted on *C. maxima* x *C. moschata* and *Lagenaria siceraria* rootstocks**

Over the last years, the market share commanded by mini (3-5 kg) watermelon cultivars has been growing across watermelon producing countries. In Cyprus this type of watermelon has not been adopted yet by local producers, mainly because of the unfamiliarity of the local market with the product. The objectives of this study were to evaluate the performance of mini watermelon cultivars vis-à-vis common large fruited cultivars, as well as their response to grafting on different rootstocks. Accordingly, scions of four small-fruited cultivars (Petite, Vivlos, Extazy, and Esmeralda) were grafted on two rootstocks (*C. maxima* x *C. moschata* ‘TZ148’, and *Lagenaria siceraria* ‘Festival’), in a completely randomised design with four replications. Large-fruited cultivar Pegasus grafted on the same two rootstocks was used as control. Yield in all cultivars was above the regional average (52 t ha<sup>-1</sup>) except for cultivar Vivlos (Table 2). Cultivars Petite and Extazy tradeable yield did not differ significantly from Pegasus although the large fruited variety produced fewer tradeable fruits. Esmeralda and Vivlos tradeable yield was lower than Pegasus. No significant differences regarding fruit dimensions were observed among the small fruited cultivars although Extazy produced lighter fruits than the others. No cultivar differentiation was observed in TSS content. Cultivars Extazy and Petite produced firmer fruits than Pegasus. Tradeable yield, number of fruit and mean fruit weight was higher on rootstock TZ148 than on Festival, although both rootstocks produced fruit of similar size. The TSS content was the same on both rootstocks but fruit produced on TZ148 had firmer flesh and thicker rind than fruit produced on Festival. (G.A. Soteriou and M.C. Kyriacou).

**Table 2.** Mean comparison for yield and quality components of watermelon cultivars Petite, Vivlos, Pegasus, Extazy, and Esmeralda grafted on rootstocks TZ148, and Festival

	Tradeable yield (tons ha <sup>-1</sup> )	Number of fruit (per ha)	Mean fruit weight (kg)	Rind thickness (mm)	Fruit shape (length/width)	TSS content (%)	Flesh firmness (kg)
<b>Cultivar</b>							
Petite	73.5A <sup>x</sup>	16704B	4.4B	14.4A	1.0B	11.2	5.6B
Vivlos	45.2C	10752CD	4.2B	8.8C	1.0B	11.4	4.1BC
Pegasus	78.6A	9984D	7.9A	13.3A	1.2A	11.3	3.1C
Extazy	69.2AB	21632A	3.2C	14.3A	1.0B	10.8	10.3A
Esmeralda	59.7B	13504BC	4.4B	10.9B	1.1B	11.0	3.7C
<b>Rootstock</b>							
TZ148	74.3a <sup>y</sup>	15386a	5.2a	13.0a	1.1	11.2	5.9a
Festival	56.2b	13645b	4.5b	11.7b	1.1	11.1	4.8b

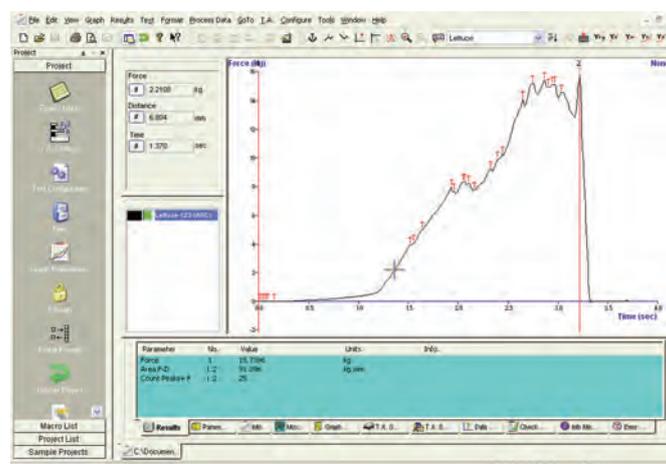
<sup>x</sup>Capital letters indicate mean separation within column among cultivars according to Tuckey-Kramer HSD Test (P<0.05).

<sup>y</sup>Lower case letters indicate mean separation within column among rootstocks according to Tuckey-Kramer HSD Test (P<0.05).

### Impact of nitrogen fertilisation strategies in soil and soilless cropping systems on quality, safety and postharvest behaviour of salad crops

A number of individual experiments for each of four salad crops (lettuce, spinach, rocket, and coriander) are conducted in order to examine the effects of nitrogen (N) application methods and cultivation period on pre- and post-harvest residual nitrate/nitrite concentrations and other important biochemical and physical indices of quality. Sampling and sample preparation for nitrate and nitrite analysis are performed according to EU Commission Regulation 1882/2006 directives. Analysis is performed by high performance liquid chromatography (HPLC) using a mobile phase of 0.01M methanolic solution of octyl-ammonium phosphate (pH 6.5), a C18 4.6x250 mm 5 µm column for separation, and UV detection at λ= 220. Quantification is performed by use of external standards of sodium nitrate/nitrite with a linearity of calibration ≥ 0.9999. Retention times are 7.8 and 10.0 min for nitrite and nitrate ions, respectively. Analysis of crispiness is performed at the basal section of the leaf midrib on a Texture Analyser equipped with 5-blade Kramer cell and a 50 kg work load.

The objectives of the first year experiments were to evaluate the effects of basal and top dressing N applications on lettuce yield, quality, and safety, with respect to nitrate/nitrite residual content, during the summer season. A multi-factorial CRD design was deployed, with combined basal (0, 100, 150 and 200 kg N ha<sup>-1</sup>) and top dressing (0, 50, 100 and 150 kg N ha<sup>-1</sup>) N applications in four replications. Preliminary results showed that plant weight and nitrate content were influenced by basal N application only, whereas total N content and leaf CIELAB



colour components were also influenced by top dressing. Leaf crispiness was not affected by either of the two application methods examined.

Postharvest behaviour of lettuce summer crop was assessed in a multi-factorial CRD design with three factors: a) nitrogen application rate (0, 100, 200, 250 and 300 kg N ha<sup>-1</sup>) in combined base and top dressing, b) storage temperature (5 and 22 °C), and c) storage period (0, 2, 3 and 4 days). Storage at 5 °C showed that a period of up to 4 days did not affect the quality characteristics examined. Storage at 22 °C for 0-4 days (Table 3) deteriorated leaf blade colour, which showed transition toward yellow (increase in L\* and b\*, decrease in h<sup>0</sup> after the 3<sup>rd</sup> day of storage. Decrease in chlorophyll a appeared on the 2<sup>nd</sup> day but became significant on the 4<sup>th</sup>. Crispiness was reduced significantly on the 3<sup>rd</sup> day of storage. Storage at 22 °C did not influence nitrate levels and total chlorophyll (a and b) and carotenoid content. Nitrite ions were not detected in any sample. Nitrogen application rate influenced leaf nitrate content, which increased up to the rate of 200 kg/ha and then remained unaltered up to 300 kg/ha. A trend for improvement of leaf blade colour (lower b\*, higher h<sup>0</sup> was observed with increasing N. However, differences were visually discernible only against the control. A significant observation was the improvement of crispiness at N application rates above 200 kg/ha. (**G.A. Soteriou and M.C. Kyriacou**).



**Table 3.** Mean comparisons for postharvest chlorophyll a, total chlorophyll (a and b), and carotenoid concentrations, leaf coloration, and crispiness in Romaine type lettuce (cv. Paris Island) summer crop with N application rates of 0, 100, 200, 250, and 300 kg N/ha and storage at 22 °C for 0, 2, 3, 4 days

	NO <sub>3</sub> (µg g <sup>-1</sup> FW)	L	C*	h <sup>o</sup>	a*	b*	Crispiness (No. peaks)	Chlorophyll A (mg g <sup>-1</sup> FW)	Chlorophyll AB (mg g <sup>-1</sup> FW)	Carotenoids (µg g <sup>-1</sup> FW)
Storage (22C)										
0	1263	35.16b	10.31ab	122.20a	-5.49b	8.71b	25.1a	0.25a	0.37809	0.073
2	1129	35.35b	10.02ab	121.24a	-5.19ab	8.56b	21.5ab	0.24ab	0.36207	0.072
3	1321	35.43b	9.80b	119.49b	-4.83a	8.52b	19.3b	0.25ab	0.37827	0.074
4	1269	36.58a	11.25a	117.30c	-5.12ab	10.01a	13.9c	0.22b	0.35274	0.069
N FERT (kg ha <sup>-1</sup> )										
0	392c	35.33	9.39b	116.67c	-4.22a	8.38ab	16.083b	0.25ab	0.38424	0.075ab
100	991b	36.00	11.12a	119.79b	-5.51b	9.65ab	20.344ab	0.23b	0.35359	0.068b
200	1469ab	35.89	10.83ab	120.87ab	-5.52b	9.31ab	20.767ab	0.22b	0.33478	0.068b
250	1611a	35.90	10.74ab	120.41ab	-5.40b	9.27ab	20.906a	0.23b	0.35488	0.070b
300	1558a	34.96	9.41b	121.72a	-4.92a	8.01b	21.233a	0.27a	0.41002	0.080a

## POSTHARVEST TECHNOLOGY

### Postharvest physicochemical quality characteristics of watermelon [*Citrullus lanatus* (Thunb) Matsum & Nakai] cultivars in response to the use of inter-specific rootstocks

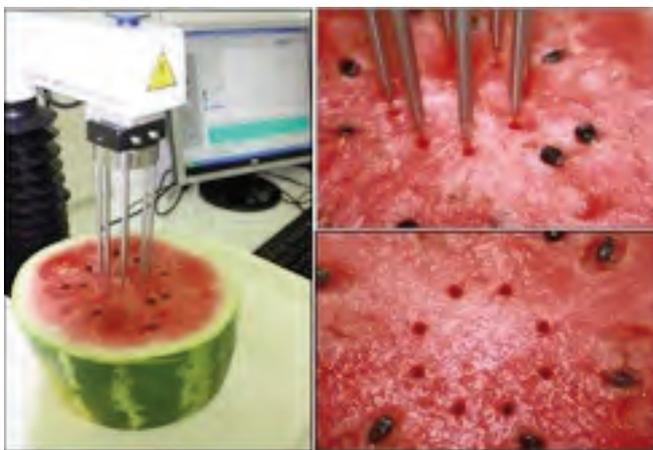
Change in physical and compositional fruit quality attributes during storage at 25 °C was evaluated in four large-fruited, seeded watermelon cultivars (Celebration, Gallery, Pegasus, Torpilla) grafted onto three inter-specific (*Cucurbita maxima* x *C. moschata*) hybrid rootstocks (TZ148, Bombo and N103) or grown self-rooted. Experiments were ran in 2009 and repeated in 2010.

First year mean comparisons between rootstocks showed no differentiation in rind thickness, while all rootstocks resulted in thicker rind than self-rooted control. In both years rind thickness reduced significantly after 7 and 14 d storage at 25 °C. Cultivar ranking remained unaltered in both years; Celebration and Torpilla developed thicker rind than Gallery and Pegasus. The effect of rootstock on flesh firmness was pronounced, accounting for 59.9 and 47.5% of the total variance in year 1 and year 2, respectively (Table 3). All rootstocks resulted in higher firmness than the self-rooted controls. Firmness improved by 35.9 to 39.9% in year 1, and by 51.6 to 59.7% in year 2. Differentiation of rootstocks was insignificant in year 1 whereas in year 2 cv. Bombo resulted in lower firmness than cv. N101 by 5.1%. Torpilla and Pegasus were the cultivars of highest flesh firmness; Gallery was of intermediate firmness and Celebration the least firm. Mean comparisons indicated a significant decrease in firmness after 14 and 7 d storage at 25 °C in year 1 and year 2, respectively.

The soluble solids content (SSC) in year 1, remained unchanged until 7 d storage and decreased only after 14 d. In year 2, the SSC decreased after both 7 d and 14 d storage. In both years the SSC remained above 10% throughout storage, rendering the fruit acceptable in terms

of perceived sweetness. Cultivar Pegasus maintained the highest SSC in both years. The effect of rootstock on SSC was not significant in year 1, while in year 2 it was highly significant as the means of the three hybrid rootstocks ranged 10.5-10.7% and were significantly lower than the mean (11.5%) of the self-rooted control. Fructose and glucose concentrations in the fruit juice were almost solely affected by storage (Table 4). Both concentrations decreased after 7 and 14 d storage. Sucrose concentration was affected by rootstock and storage, the respective effects of which accounted for 11.7 and 80.6% of its total variance. Mean sucrose concentration for the three hybrid rootstocks was undifferentiated (4.3 to 4.5%). However, the mean sucrose concentration in the self-rooted control (5.2%) was significantly higher. Mean sucrose concentration over all rootstocks increased significantly (by 40.5%) after 7 d storage and remained unchanged up to 14 d. Finally, the mean total concentration of the three soluble sugars presented no differences between the three hybrid rootstocks as it ranged 9.7-9.8%, whereas a significantly higher concentration of 10.4% was observed in the self-rooted control. The mean total sugar concentration incurred a significant decrease after 14 d storage. Mean lycopene content presented no differences between the three hybrid rootstocks examined but it was significantly higher than the content found in the self-rooted control (Table 4). Mean lycopene content in fruit derived from plants grafted on hybrid rootstocks ranged 71.7-72.5 mg kg<sup>-1</sup> f.w. and was significantly higher than the mean content in fruit from self-rooted controls which was 66.8 mg kg<sup>-1</sup> f.w. Lycopene content increased after 7 d storage at 25 °C in both years of experiments; however, it declined after 14 d in year 1 whereas it remained unchanged between 7-14 d in year 2. Among the cultivars evaluated, 'Celebration' and 'Torpilla' had the highest lycopene content.

Correlation analysis on two-year data was performed for lycopene content, soluble solids content, flesh firmness, and total soluble sugar content with chromatic components L\*, C\*, h<sup>o</sup>, and a\* (Table 4). The highest linear correlation coefficients for lycopene content were 0.50 and 0.53 obtained respectively with chroma (C\*) and colour component a\*.



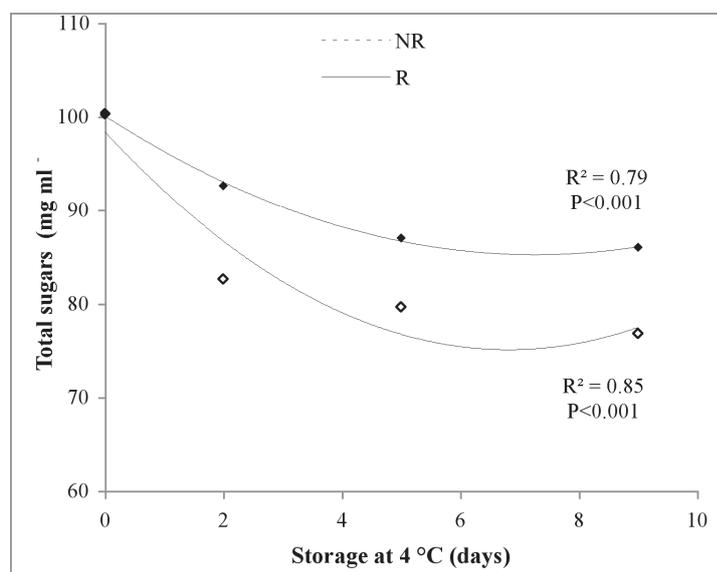
SSC with C\* and a\* were significant but the correlation coefficient in both cases was low ( $r = 0.26$ ). None of the chromatic components correlated significantly with the soluble sugar content. Flesh firmness correlated significantly with C\*, h<sup>o</sup> and a\*; however only the negative coefficient of correlation with h<sup>o</sup> was notably high ( $r = -0.35$ ). (M.C. Kyriacou and G.A. Soteriou).

**Table 4.** Fruit rind thickness, flesh firmness, total soluble solids, sugar content, and lycopene content of four watermelon cultivars (Celebration, Gallery, Pegasus, Torpilla) grown self-rooted or grafted on three hybrid rootstocks (TZ148, Bombo, N101) and stored postharvest for 0, 7, or 14 days at 25 °C and 90% relative humidity

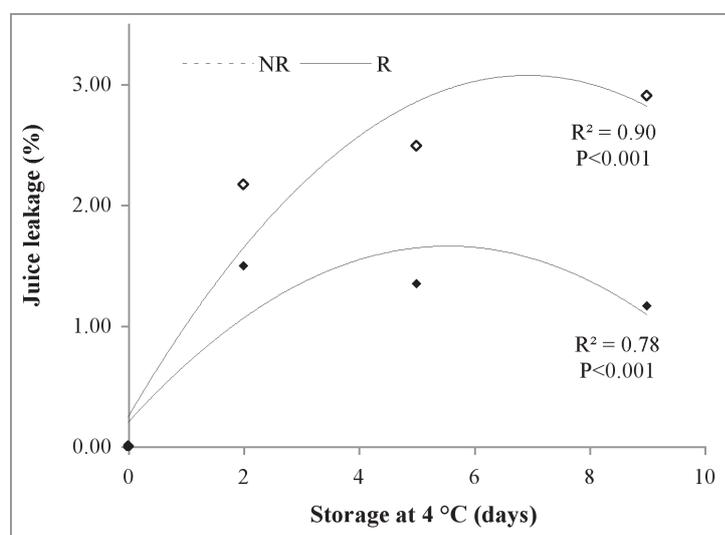
	Rind thickness (mm)		Firmness (kg)		Soluble solids (%)		Fructose (g/100 ml)		Glucose (g/100 ml)		Sucrose (g/100 ml)		Total sugars (g/100 ml)		Lycopene (µg/ g f.w.)		
	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	Year 1	Year 2	
<b>Storage</b> (days at 25 °C)																	
0	12.4 a	11.4 a	3.31 a	3.84 a	11.8 a	11.2 a	3.94 a	2.45 a	3.70 b	10.08 c	67.7 b	65.9 b					
7	11.3 b	10.4 b	3.15 ab	3.23 c	11.8 a	10.9 b	3.27 b	1.60 b	5.17 a	10.04 a	80.1 a	72.0 a					
14	9.3 c	10.0 c	3.01 b	3.59 b	10.7 b	10.3 c	2.88 c	1.29 c	5.28 a	9.46 b	65.3 b	72.2 a					
<b>Cultivar</b>																	
Celebration	11.6 a	—	2.77 c	—	11.2 b	—	—	—	—	—	77.4 a	—					
Gallery	10.7 b	10.3 b	3.10 b	3.30 c	11.8 a	10.8 ab	3.41	1.86 a	4.78	10.04	64.3 b	66.0 b					
Pegasus	10.9 b	10.6 b	3.42 a	3.51 b	11.7 a	11.1 a	3.39	1.92 a	4.59	9.89	67.9 b	67.0 b					
Torpilla	11.6 a	11.2 a	3.38 a	3.94 a	11.3 b	10.7 b	3.46	1.77 b	4.48	9.71	74.6 a	75.9 a					
<b>Rootstock</b>																	
TZ148	11.4 a	10.9	3.47 a	3.81 ab	11.5	10.7 b	3.47	1.88	4.46 b	9.82 b	72.4 a	73.4 a					
Bombo	11.5 a	10.6	3.37 a	3.76 b	11.6	10.5 b	3.48	1.85	4.33 b	9.66 b	71.7 a	70.5 a					
N101	11.2 a	10.7	3.38 a	3.96 a	11.5	10.7 b	3.39	1.83	4.46 b	9.67 b	72.5 a	71.6 a					
Self-rooted	10.7 b	10.7	2.48 b	2.80 c	11.5	11.5 a	3.34	1.83	5.22 a	10.39 a	66.8 b	62.7 b					

### Effect of rind processing and cold storage on the quality of fresh-cut watermelon

Although fresh-cut watermelon is marketed, among other forms, in slices with or without rind, the removal of the epidermal rind during processing constitutes a factor for the storage stability of this product not previously studied. The purpose of this work was to assess the impact of removing the rind from fresh-cut watermelon slices on the quality of the packaged product stored at 4 °C for up to 9 days. Storage at 4 °C, regardless of the presence or absence of rind, decreased lycopene concentration. Storage increased marginally the lightness of flesh colour, which remained otherwise unaffected by both storage and rind processing. Heart and placental flesh firmness increased with storage, likely as a result of the leakage of juice and the lignification of fiber strands, but were unaffected by rind processing. The integrity of placental cell membranes, expressed as electrolyte leakage from placental tissue plugs, was not affected by either storage or rind processing. Retaining the rind on watermelon slices limited



**Figure 2.** Total concentration of soluble sugars (fructose, glucose, and sucrose) and juice leakage of rind-bearing (R) and rind-less (NR) fresh-cut watermelon slices stored at 4 °C for 0, 2, 5 and 9 days.



the leakage of juice and the loss in fresh weight during storage (Fig. 2). The presence of rind also retarded the decline in the soluble solids content of the juice, particularly the content of soluble sucrose (Fig. 2). Transition in quality parameters was most pronounced during the first two days of storage. Removing the rind from fresh-cut slices accelerated senescence and off-flavor production, while the presence of rind improved the overall storage stability of fresh-cut watermelon slices. (M.C. Kyriacou, P. Petrou, G.A. Soteriou).

### Postharvest performance of table grape varieties packaged with polymeric sodium metabisulfite sheets

Local table grape varieties Mavro and Sideritis, and introduced varieties Superior, Calmeria, and Crimson were evaluated as per their storage performance under standard postharvest handling and storage practices. Packaging was performed in perforated, corrugated carton boxes with porous polyethylene liners. Gray mould was controlled by means of slow-release polymeric sodium metabisulfite sheets (Vanguard®). Storage conditions were 0.5 °C and 90-95% relative humidity. Decay incidence, berry shattering, stem browning and multiple fruit and juice quality parameters were evaluated in order to define the potential marketable life of table grape varieties grown under Cyprus conditions. Polymeric sodium metabisulfite sheets suppressed development of grey mould (*Botrytis cinerea* Pers.) for 8-10 weeks in early cv. Superior, for 6-8 weeks in late cv. Mavro, for 14-16 weeks in late cv. Sideritis and cv. Calmeria, and for 16-18 weeks in late cv. Crimson (Table 5). However, a significant effect of crop year was observed on the storability of all varieties. Discoloration of the rachis was limiting on the storability of all varieties, as was shattering particularly in Crimson, Sideritis, and Mavro. Storability was most limited in the local varieties Mavro and Sideritis, while the longest storability was observed in cv. Crimson. At maximum storage life the relative loss in fresh weight was

	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY
SUPERIOR	Dark Grey						
CRIMSON	Light Grey						
CALMERIA	Light Grey						
SIDERITIS	Light Grey						
MAVRO	Light Grey						

**Table 5.** Storability of table grape varieties Superior, Crimson, Calmeria, Sideritis, and Mavro stored at 0.5 °C and 90-95% relative humidity under slow-release polymeric sodium metabisulfite sheets. Dark grey color denotes the safety span for storability; light grey colour denotes storability span subject to annual variation.

<3% and did not affect berry firmness significantly; no significant alteration in organoleptic characteristics was observed during the same period. The juice content of soluble solids and the titratable acidity did not significantly change with storage. Among the varieties examined, Crimson presents the greatest storage potential allowing extension of its marketing through Christmas season. (M.C. Kyriacou and S. Savvides).

### **Evaluation of an *ex situ* collection of local pomegranate (*Punica granatum* L.) accessions as per their qualitative and technological traits, their antioxidant value and storage performance**

An *ex situ* collection of local pomegranate accessions collected over a wide range of localities on the island has been established at the Zygi Experimental Station for purposes of characterization. The collection is anticipated to reach fruiting age in 2013, wherein fruit characteriza-



tion will commence. This will include seed, fruit and juice characterization, assessment of juice antioxidant value and fruit storage behaviour. Preparatory analytical work has included validation of chromatographic methods for separation and quantification of soluble carbohydrates, organic acids, and anthocyanin compounds in the pomegranate juice; characterization of free radical scavenging potential of pomegranate juice; texture and fibre analysis for assessment of seed hardness. (M.C. Kyriacou).

## **FLORICULTURE**

The European Programme “GEWAMED” (Mainstreaming Gender Dimensions into Water Resources Development and Management) aiming at exchanging information and experience on water saving in the Mediterranean region was completed and the final reports were sent to the European Union for evaluation.

### **Cultivation of lisianthus (*Eustoma grandiflorum*)**

The effect of salinity is examined on hydroponic production of lisianthus (*Eustoma grandiflorum*). The main objectives of the project are: (a) to evaluate the effect of salinity on productive, morphological, qualitative, and physiological characteristics of lisianthus flowers



grown on 2 different substrates, and (b) to evaluate the effects of salinity and substrate type on the postharvest vase-life and physiology of lisianthus cut flowers.

Lisianthus cv. Echo Blue is grown on coco soil and rock-wool substrates in a controlled greenhouse environment at the Zygi Experimental Station using an open hydroponic system. Nutrient solution of four different levels of salinity (expressed as electrical conductivity, EC) is used: 2 (control), 4, 6, and 8  $\text{dS m}^{-1}$ . The different levels of salinity are attained by adding sodium chloride in the nutrient solution (control). Irrigation is performed using self-compensating drippers of 4 l/h discharge while drainage will be kept constant 20-30% throughout the experiment. (L. Vassiliou and M.C. Kyriacou).

## **ANIMAL PRODUCTION**

The research activities of the Animal Production Section involve work on nutrition, management, animal breeding and physiology of reproduction. Research is generally directed towards increasing milk and meat yields under semi-intensive or intensive systems of management in sheep, goats and dairy cattle. In addition, genetic methods and animal husbandry practices are employed, aiming at controlling and preventing animal diseases.

In animal breeding, the research work aims at improving the genetic stock with respect to important economic traits in livestock using within-breed selection methods. Genetic evaluations are based on selection indices that combine individual capacity of young animals for growth, and milk production of female ancestors. This method is routinely used at all government breeding units for the evaluation and selection of superior breeding stock in sheep and goats. Further research in genetic improvement at ARI is directed toward dissecting the genetic aspects underlying milk production, and further characterising scrapie genotypes in goats.

Research programmes in the area of reproductive physiology of farm animals aim at improving reproductive performance. In this regard, genetic and environmental factors that influence seasonal reproduction, reproductive development and puberty in sheep and goat breeds under local conditions are examined. In farm management, artificial rearing systems using automated feeders and milk substitute for lambs and kids are evaluated.

A research project in which genetic methods are employed to combat the scrapie disease in Chios sheep has been successfully implemented by ARI in cooperation with the Veterinary Services. The Chios sheep unit of ARI at Athalassa has been transformed into a nucleus herd of scrapie-resistant genotypes. The number of productive animals at the nucleus has been kept around 500 breeding females.

A programme commenced in 2008 to transform the Damascus goat herd at ARI into a nucleus of scrapie-resistant genotypes has continued through 2010/11, aiming at creating a nucleus of 300 scrapie-resistant breeding goats. This shall enable ARI to issue scrapie-resistant animals to farmers in order to contribute significantly in eradicating the disease from the Cyprus goat population.

### **The ARI dairy cattle unit**

The Friesian/Holstein dairy cattle unit of ARI is situated at Athalassa. The performance of

**Table 1.** Performance of dairy cattle at the ARI unit, Athalassa

Variable	Year	
	2010	2011
Cows calved	32	29
Heifers calved	17	21
Abortions	1	-
Calves born alive	50	42
Calves born dead	2	8
Calves died	1 (2.0%)	3 (7.1%)
Calving interval (days)	410	441
Days open	133	159.9
Duration of pregnancy (days)	277	278
Services/conception	2.3	2.3
Annual cows	46.1	45.5
Milk produced (l)	395,861	385,059
Milk/annual cow (l)	8,582	8,463
Milk fat %	3.54	3.35
Milk protein %	3.35	3.38

cows during the years 2010 and 2011 is shown in Table 1. The overall performance of the herd has been very satisfactory. Milk yield and milk quality were very good. Milk produced was 395,861 l in 2010, and 385,059 l in 2011. Some differences observed in total milk production in 2010/11 are a consequence of the decrease of annual cows from 50.0 in 2009 to 46.1 in 2010 and to 45.5 in 2011. Even so, in 2010 and 2011 milk yield per annual cow was higher than that of 2009, indicating increased productivity per animal. Finally, cows that suffered from mastitis were removed from the herd. (**G. Hadjipavlou and D. Sparaggis**).

### **Performance of Chios sheep and Damascus goat nucleus herds at ARI**

The ARI small ruminant herds consist of 500 Chios sheep and 275 Damascus goats. Male and female replacement stock is selected on the basis of an index combining 60-day milk yield of dam and grand dam and individual body weight at 98 days of age for lambs and at 105 days for kids. Production and reproduction characteristics for the two herds during the periods 2010/11 are shown in Tables 2 and 3. (**G. Hadjipavlou**).

### **Effect of artificial rearing on kid growth and milk production of Damascus goats**

Research on zero suckling systems in Chios ewes and Damascus goats continued in 2010/11. Lambs and kids on zero suckling were reared artificially on milk substitute using four automatic milk feeding machines. Yearling Damascus goats were allocated as they kidded to either natural suckling (NS, 22 goats) or were separated from their kids immediately after birth

**Table 2.** Production characteristics of Chios ewes at ARI (2010/11)

Trait	Yearlings	Adults
No. of ewes lambing	231	550
Lambs born/ewe	1.78	2.21
Lambs born live/ewe	1.51	1.89
Litter weight at birth (kg/ewe)	5.27	5.95
Lambs weaned/ewe	1.42	1.80
Litter weight at weaning (kg/ewe)	15.7	18.5
60-day milk (kg/ewe)	101	124
Total milk (kg/ewe)	261	329
Days in milk	197	234
Milk fat (%)	4.58	4.90
Milk protein (%)	5.18	5.51

**Table 3.** Production characteristics of Damascus goats at ARI (2010/11)

Trait	Yearlings	Adults
No. of goats kidding	132	267
Kids born/goat	1.61	2.01
Kids born live/goat	1.50	1.92
Litter weight at birth (kg/goat)	5.35	8.12
Kids weaned/goat	1.30	1.73
Litter weight at weaning (kg/goat)	20.0	24.6
60-day milk (kg/goat)	120	148
Total milk (kg/goat)	357	479
Days in milk	209	248
Milk fat (%)	3.55	4.00
Milk protein (%)	3.94	4.10

(24 goats); NS goats suckled up to two kids, while separated kids were artificially reared (AR) on milk replacer. Colostrum was given to AR kids by bottle feeding. All kids were weaned at  $49 \pm 3$  days of age. Following weaning, 15 male kids from each NS and AR groups were fattened for 70 days. AR goats were milked twice daily. NS goats were milked once daily before and twice daily after weaning. Birth weight of kids in both groups was similar (4.2 kg). NS kids had a faster ( $P < 0.01$ ) pre-weaning growth rate than AR kids (215 vs 185 g/day) and were heavier ( $P < 0.05$ ) at weaning (14.9 kg) than AR kids (13.5 kg). After weaning, males of both



groups had similar growth rates (AR:190, NS:208 g/day). Final weight at 120 days of age of AR (27.1 kg) and NS kids (29.4 kg) was similar. Milk yield of AR goats (118 l) during the pre-weaning period was higher ( $P<0.05$ ) than that of NS goats (31 l). Fat and protein content of milk was 3.69 and 3.71% for AR goats and 3.23 and 3.30% for NS goats, respectively. Post-weaning milk yield (142 days) of both groups was similar (NS: 301 l, AR: 273 l). No differences were observed in milk fat and protein content between suckling and non-suckling goats (fat: 4.02 and 4.16%, protein: 3.96 and 4.03%, respectively). Total milk yield (190 days) was 392 l for AR and 332 l for NS goats. These results indicate that artificially reared kids had satisfactory pre-weaning growth, although slightly lower than that of suckling kids; however, both groups reached the same final weight at 120 days of age. Goats on zero suckling produced more marketable milk over their whole lactation period than suckling goats. Marketable milk of mature goats was 85 kg more than that of goats that suckled their kids. Therefore, in particular to dual purpose breeds such as the Damascus one, artificial rearing may increase farmers' income, with no adverse effects on kid growth. (A. Koumas and G. Hadjipavlou).

### Genetic and molecular techniques for controlling scrapie disease in sheep

The project for combating scrapie disease in Chios sheep with the use of genetic and



molecular methods is implemented under the close cooperation of the Animal Production with the Agrobiotechnology Section of the ARI. The present population of the ARI unit consists of breeding ewes and rams of the ARR/ARR genotype, which is resistant to scrapie. For breeding purposes, the number of resistant rams and ram lambs issued to farmers in the period of 2010/11 was 60 and 347, respectively, and that of surplus female lambs was 238. In addition, 72 ewes were issued to farmers. It is anticipated that by reducing the incidence of the disease and increasing the frequency of the desirable allele, and consequently of the resistant genotypes, the disease can be controlled and, eventually, eradicated. It should be emphasized that the project for controlling scrapie in Chios sheep runs in parallel with the project aiming at the genetic improvement of economically important traits (milk yield, growth, prolificacy, etc). (A. Koumas, G. Hadjipavlou and I.M. Ioannides).

### **Genetic and molecular techniques for controlling scrapie disease in goats**

This programme runs in the framework of an ARI-funded joined research project between the Animal Production and Agrobiotechnology Sections, and in cooperation between ARI and the Veterinary Services. During 2010/11, the collection of genetic and production information for Damascus goats continued, with the aim of further studying the different *PrP* genotypes in goats and potential associations between genotype and production characteristics of the animals. For this purpose, targeted matings were designed and performed in both breeding sea-

sons of each year, in order to increase the frequency of the D and S alleles at codon 146 of the *PrP* gene, and to simultaneously decrease the N allele at the same locus. Particular emphasis was given in reducing the numbers of homozygous NN animals in the flock. In 2010 and 2011, molecular genotyping of the selected *PrP* alleles was conducted by the Molecular Biology Laboratory (Agrobiotechnology Section) for close to 500 animals. In this period, the Animal Production section provided farmers with 81 bucks, 54 goats, and 51 male and 5 female kids. All the animals had proposed scrapie-resistant genotypes, in order to decrease the frequency of the assumed scrapie-susceptible N allele in the Cyprus Damascus goat population. For all genotype classes, records on body weight at birth, at weaning, and at 120 days, dam prolificacy and milk production have been collected to examine potential associations between genotype and animal production traits. All information is recorded in an extended, continuously updated database, according to standard procedures of the Animal Production section. (**I.M. Ioannides, A. Koumas and G. Hadjipavlou**).

#### **Use of molecular and quantitative genetics for the improvement of the Chios sheep**

This project commenced in 2009 and shall be completed in May 2012. It is funded by the Research Promotion Foundation and the Cyprus University of Technology, with the latter serving as the project coordinator. Apart from ARI, the Alexander Technological Educational Institute of Thessaloniki and the Scottish Agricultural College also take part in the aforementioned study. The main aim of the research was to identify and characterize genetic regions that might be associated with milk production traits in Chios sheep, utilizing genetic information from the ARI flock. Research findings could potentially be used for genetic improvement in the Chios and in other sheep breeds. Additionally, the rate of inbreeding in the ARI flock was determined using classical and molecular genetic techniques, and was found to be very low, indicating the success of the long-term breeding scheme followed at ARI. With respect to the genetic study conducted, a total of 246 Chios sheep were genotyped for various candidate genes that might affect milk production and quality. The genetic diversity of the Chios breed was investigated regarding *β-lactoglobulin* (*β-LG*) genotypes and the existence of single nucleotide polymorphisms (SNPs) at other loci, already known to affect bovine milk traits. The study examined the presence of the most common *β-LG* variants, A and B, the growth hormone receptor (*GHR*) F279Y polymorphism and the *acylCoA:diacylglycerol acyltransferase 1* (*DGATI*) K232A SNP. Preliminary results indicate that both the A and B alleles are present at

the  $\beta$ -*LG* locus, with the AA genotype detected in 57%, the AB in 39%, and the BB genotype in 4% of the animals studied. With respect to bovine SNPs, the *GHR* F279Y and the *DGATI* K232A polymorphisms were not identified in Chios sheep. Additionally, a novel genetic polymorphism was identified in the *acetyl-CoA acyltransferase-2* (*ACAA2*) gene and its potential association with ovine milk traits has been under investigation (**G. Hadjipavlou and A. Koumas**).

## PLANT PROTECTION

Research activities in Plant Protection concern the disciplines of Plant Pathology, Entomology and Pesticide Toxicology. Under each of these disciplines, specialized studies are conducted to address major crop protection problems associated with particular pests (insects, mites) or diseases (viral, prokaryotic and fungal). In addition, joint multi-disciplinary research projects targeting all important pests and diseases of particular crops are undertaken. All studies are governed by the considerations of sustainability in crop protection and production, food quality and safety, environmental protection and the utilization of new technologies for the development of more effective crop protection practices.

In line with the above principles, one of the main activities of the Section concerns the development of integrated pest management (IPM) strategies, based on various combinations of ecosystem-oriented methods, i.e. biological control, cultural practice, natural products, resistant varieties, resistant rootstocks and minimal use of selected, mild pesticides. This approach ensures sustainability and minimizes pesticide risk to human health and the environment. It can be applied alone or in combination with other ecosystem-oriented production practices, in the context of an advanced system of sustainable agriculture, known as integrated crop management (ICM). Studies to develop IPM/ICM systems were carried out on citrus, grapevines and on vegetable and ornamental greenhouse crops, in cooperation with other Sections of the Institute.

The Section also provides advice to a number of organizations including the Medical and Public Health Services, the Department of Forests, the Department of Agriculture, private companies and farmers concerning the identification and management of pests and diseases.

### ENTOMOLOGY

#### **Development of an automated warning system for monitoring the Mediterranean fruit fly, *Ceratitis capitata* (Diptera: Tephritidae)**

The Mediterranean fruit fly is one of the world's most destructive fruit pests. Traps containing lures are commonly used to monitor *C. capitata* population size, therefore they should be inspected continuously. The ARI, in cooperation with CNE Technology LTD and NOVATEX solutions LTD, developed a novel type wireless trap to monitor Med fly populations. The trap was developed in the context of a research programme funded by the Cyprus Research Promotion Foundation. (N.A. Seraphides).



### Development of a warning system for monitoring the California red scale, *Aonidiella aurantii* (Homoptera: Diaspididae)

The California red scale, *Aonidiella aurantii* (Maskell), is a major citrus pest. In Cyprus, four generations per year have been reported, while the control of the scale has been a problem to citrus growers because of its continuous reproduction and the overlap of generations. Decision on when treatment is needed mainly depends on monitoring male scale populations



with the use of pheromone traps. The ARI, in cooperation with the Cyprus University of Technology, CNE Technology LTD and CYPROFRESH, launched a research programme funded by the Cyprus Research Promotion Foundation concerning the development of a novel, automated, and energetically autonomous trap for monitoring male red scale. The trap system records major environmental parameters that affect *Aonidiella aurantii* populations and

includes wireless networks, a GIS platform and automatic user notification services via email and SMS. (N.A. Seraphides).

### Management of insect pests in pomegranate orchards

Insect pests of pomegranates in Cyprus have not received much attention by researchers, although numerous insect pests have been reported to attack the crop. Among them, the Mediterranean fruit fly *Ceratitis capitata* Wied, the carob moth *Ectomyelois ceratoniae* Zeller, aphids, and scales are the most important. The research programme aims to identify, monitor and develop the best strategy to manage pomegranate insect pests in orchards. (N.A. Seraphides).



### Biology and management of the tomato borer, *Tuta absoluta* (Lepidoptera: Gelechiidae)

The tomato borer, *Tuta absoluta* (Lepidoptera: Gelechiidae), is a devastating pest of tomato and other solanaceous crops originated in South America. After its initial detection in Eastern Spain in 2006, it rapidly invaded various other European countries and spread throughout the Mediterranean basin. It was first reported in Cyprus on November 2009 in the Lemesos district and now it can be found in all cultivated areas of the island. Immediately after the identification of the pest, ARI in cooperation with the Department of Agriculture, issued official pest management guidelines. Insecticides were officially registered in the national catalogues exclusively for the control of *T. absoluta*, while awareness campaigns for farmers were organised.

Studies concerning the biology and management of *T. absoluta* were initiated at the main insectary of ARI. The development period of *T. absoluta* on different plant hosts (tomato, potato, egg plant, sweet pepper and bean) at constant temperature ( $26 \pm 1$  °C), relative humidity (68%) and photoperiod (16L:8D) was investigated. Results showed no differences on the development period from egg to adult on tomato and potato (21 days), a three-day increase on eggplant, while *Tuta absoluta* failed to complete its development on bean and sweet pepper. (N.A. Seraphides).



### Rearing of beneficial insect populations

Wide applications of chemicals to control insect pests generate many drawbacks concerning agriculture, environment and human health. By releasing natural enemies to control insect pests these drawbacks could be greatly reduced. For this purpose, populations of natural enemies of greenhouse pests, such as the parasitic wasp *Diglyphus isaea* against leafminers (*Liriomyza* sp.), the predatory bug *Macrolophus caliginosus* against whiteflies, thrips etc., the lacewing *Chrysoperla carnea* against aphids, whiteflies etc., and the predatory bug *Nesidiocoris tenuis* against lepidopteran eggs, aphids etc., are reared at the main insectary of the ARI. (N.A. Seraphides).



### Botanical insecticides in controlling Kelly's citrus thrips (Thysanoptera: Thripidae) on organic grapefruits

Kelly's citrus thrips (KCT), *Pezothrips kellyanus* (Bagnall) (Thysanoptera: Thripidae) was first recorded in Cyprus in 1996 and became an economic citrus pest. In Cyprus, KCT larvae cause feeding damage mainly on immature lemon and grapefruit fruits. Use of botanical insecticides is considered an alternative tool to synthetic chemicals, offering solutions for healthy and sustainable citrus production. During 2008-2010, a number of botanical insecticides (active ingredients) were evaluated in field trials against KCT larval stage I and II aiming at controlling the pest's



population and the damage to organic grapefruit. Treatment with pyrethrins and azadirachtin (Neemex 0.3%W/W) were the most effective against KCT compared to the untreated control. In these treatments, the mean percentage of fruit damage was 21.3 and 22.2, respectively, compared with 33.6 in the untreated control. The mean percentage of damaged fruits in treatment with azadirachtin (Oikos 10 EC) was 24.6 and in treatment with garlic extract was 30.6, compared with 33.6 in the control. (V.A. Vassiliou).

### Outbreak of Florida red scale *Chrysomphalus aonidum* L. (Hemiptera: Diaspididae), in Cyprus

The Florida Red Scale, *Chrysomphalus aonidum* (L.) (Hemiptera: Diaspididae) is a leaf-infesting species, but in high-density infestations it may also affect fruits, stems and trunks, and may cause premature leaf or/and fruit drop and stem dieback. The scales appear as circular dark spots. This injurious diaspidid pest attracted attention on the island of Cyprus as early as 1890. No other outbreaks have been recorded since 1959, when the pest was successfully controlled by its natural enemy, the parasitoid *Aphytis holoxanthus* that has been introduced from Israel. Periodic samplings conducted during 2008-2011 revealed high population levels of the pest on citrus and various ornamental plants in the town of Lemesos (Latitude 34° 41' N, Longitude 33° 03'E). This outbreak was observed in urban areas where host plants are not usually treated with insecticides systematically as in the nearby commercial citrus orchards of the Fassouri area. The pest was found in high numbers mainly on citrus including *Citrus aurantiifolia* (lime), *Citrus limon* (lemon), *Citrus maxima* (pummelo), *Citrus sinensis* (navel orange), and *Citrus paradisi* (grapefruit), as well as on ornamentals, including *Jasmine* spp., plants of the family Palmae, such as *Phoenix dactylifera* and *Chamaerops humilis* and other plant species which appear to serve as alternative hosts for this insect pest. Additionally, in late 2008 this diaspidid scale was found on grapefruit trees of an organic cultivation in the coastal



area of the Paphos district (Latitude, 34.740 N, Longitude, 32.480 E), at the Acheleia Experimental Station of the ARI, as well as on olive trees (*Olea europaea*). Affected plant parts included leaves, stems, fruits and pods. There was a noted preference for fruit over leaves. Heavy infestations caused yellowing of the leaves, followed by abnormal defoliation of part or all of the host plant. In

many cases damage was very severe and caused tree death. This polyphagous species with preference for citrus was mainly found at the lower and central shaded parts of the canopy of young and mature citrus trees and rarely on green wood. To the present, *C. aonidum* outbreak has been observed only in these two coastal areas indicating a preference for humid environments. Monitoring the pest during 2010/2011 in the Acheleia Experimental Station (citrus and olive trees), it was found that in the absence of conventional compounds more than 90% of the established pest population was parasitised by the parasitic wasp *Aphytis melinus* DeBach (Hymenoptera: Aphelinidae). (V.A. Vassiliou).

### **Insecticide resistance in *Bemisia tabaci* populations from Cyprus**

A comprehensive study on the *Bemisia tabaci* (biotype B) resistance to neonicotinoid insecticides imidacloprid, acetamiprid and thiamethoxam, and pyrethroid bifenthrin was conducted in Cyprus. The resistance level to eight field-collected *B. tabaci* populations was investigated. The activities of enzymes involved in metabolic detoxification and the frequencies of pyrethroid and organophosphate target site resistance mutations were determined. Moderate to high levels of resistance were detected for imidacloprid [resistance factor (RF) 77–392] and thiamethoxam (RF 50–164) while low resistance levels were observed for acetamiprid (RF 7–12). Uniform response of the Cypriot whiteflies could be observed against all neonicotinoid insecticides. No cross-resistance between the neonicotinoids was detected and no association with the activity of the P450 microsomal oxidases. Only imidacloprid resistance correlated with carboxylesterase activity. Low to extremely high resistance was observed for insecticide bifenthrin (RF 49–1243) which was associated with the frequency of the resistant allele in the sodium channel gene but not with the activity of the detoxification enzymes. Finally, the F331W mutation in the acetylcholinesterase enzyme *ace1* gene was fixed in all *B. tabaci* populations from Cyprus. (V.A. Vassiliou).



### **Effectiveness of insecticides in controlling the first and second generations of the *Lobesia botrana* (Lepidoptera: Tortricidae) in table grapes**

The moth *Lobesia botrana* (Denis&Schiff.) (Lepidoptera: Tortricidae) is a key pest of table and wine grape (*Vitis* spp.) varieties in Cyprus. Many different insecticide combinations were applied for three consecutive years (2006-2008) in a Sultana seedless table grape vineyard, aimed at controlling the first and second generations of this pest under warm and dry Mediterranean climatic conditions. In Cyprus, Sultana is the main early maturing table grape variety grown in the country. *L. botrana* has two generations and a partial third on this export



variety, of which the first two generations are the most destructive. Applications were made according to pheromone trap captures of males. One application was used against the first and two applications against the second generation of *L. botrana*. A high rate of bunch damage was observed in the untreated rows during all years, reaching 56.7, 62.5, and 69.2% in 2006, 2007, and 2008, respectively. Differences between insecticide treatments and the untreated control were significant. The treatment combination of lufenuron, spinosad,

and indoxacarb as well as the combination of chlorpyrifos, spinosad and indoxacarb, used against the first and second generations of *L. botrana*, were the most effective compared with the untreated control. Satisfactory control of the pest also was observed with other combinations such as lufenuron, cypermethrin, and *Bacillus thuringiensis*; chlorpyrifos, cypermethrin, and *B. thuringiensis*; and lufenuron, deltamethrin, and azadirachtin. (V.A. Vassiliou).

#### **First report of the nipa palm hispid *Octodonta nipae* on queen palms in Cyprus**

Numerous adults and larvae of the nipa palm hispid *Octodonta nipae* (Maulik) (Coleoptera: Chrysomelidae: Cassidinae) were found for the first time on the island of Cyprus, in unopened young leaves of *Syagrus roman-zoffiana* (Cham.) Glassman palm species. All infested palms of this species evinced serious decline with all young leaves showing signs of attack, but the beetles and larvae themselves were found only in fronds from the central shoot. (V.A. Vassiliou).



## **PLANT PATHOLOGY**

#### **Sanitation of local citrus varieties and/or clones**

The main objectives of the project were the elimination of viruses and viroids from local citrus clones and/or varieties. The micrografting in vitro technique was used to free from virus and other pathogens valuable local citrus varieties and/or clones. A survey in commercial groves was conducted for selection of elite mother plants of citrus, including Polyphori and Lapithou lemon (*Citrus limon* Burm f.), Jaffa, Siekeriko and Aematoyisiki orange (*C. sinensis* L.), Arakapas mandarin (*C. reticulata* Blanco), Frappa (*C. grandis* (L.) Osbeck), Bergamot (*C. bergamia* Risso & Poit.), Coumantantas (*C. comandatore*) and Pummelo (*C. maxima*). All mother plants were tested for viruses and viroids by biological indexing, by ELISA for *Citrus*

*tristeza virus* (CTV), and by RT-PCR for viroids. All mother trees were found free of CTV, Citrus Infection Variegation Virus (CIVV) concave gum and impietratura, but were infected by Citrus Exocortis Viroid (CEVd) and/or other viroids, including Citrus Cachexia Viroid (CcaVd) and Citrus Bent Leaf Viroid (CBLVd). Some mother trees were infected by Citrus Psorosis Virus (CPsV). The standard procedure of shoot-tip grafting technique was used for elimination of viroids



and CPsV in the selected citrus isolates. Micrografted plants, re-grafted on sour orange seedlings *in vivo*, and successfully established and transferred to the glasshouse, were tested 6-9 months later for the viruses and viroids present in meristem donor mother plants. Polyphori and Lapithou lemon, Arakapas mandarin, Jaffa and Siekeriko orange, Bergamot, Frappa and Coumantantas produced by micrografting from different source trees, were found free of all viroids and CPsV and were used as primary source material for the basic citrus plantation of the island and for further propagation to government mother stock plantations, private nurseries and growers. Shoot-tip grafting *in vitro* is continued for sanitation of all collected mother plants. (Th. Kapari-Isaia, L.C. Papayiannis and I.M. Ioannides).

### Sanitation of Greek *elite* citrus varieties

The main objectives of the project were the elimination of viruses and viroids from Greek elite citrus varieties. The micrografting *in vitro* technique was used to free valuable Greek citrus varieties from viruses and other pathogens. The initial mother plant material were: grapefruit (Shambar, Star Ruby), lemon (Adamopoulou, Vakalou, Zambetaki, Interdonato, Nouvel Athos, Verna), mandarin (Clementine of Poros, Chiotiko, Clasuelina, Encore, Marisol,



Page, Tardivo di Ciaculli, Clementine SRA-63, Nova), orange (Valencia of Poros, Late Navel of Argos, Moro, Navelate, Salustiana, Valencia Olinda, Navelina, Newhall, Washington navel). All mother trees were found free of *Citrus tristeza virus* (CTV), Citrus Psorosis Virus (CPsV), Citrus Infection Variegation Virus (CIVV) concave gum and impietratura, but were infected by Citrus Exocortis Viroid (CEVd) and/or other viroids. Scions derived from these

trees were grafted onto healthy sour orange rootstocks kept in a greenhouse at ARI so that new apical meristems were obtained for micrografting, or apical meristems were directly micrografted on young seedlings of trifoliates *in vitro*. Adamopoulou lemon produced by micrografting was found free of all viroids. Shoot-tip grafting *in vitro* is continued for sanitation of all collected mother plants. (Th. Kapari-Isaia, A.E. Voloudakis, Ev. Mar. Koutsoumari and L.C. Papayiannis).

### **Production, maintenance and distribution of healthy citrus material. Pre-basic citrus plantations**

All virus-free material selected or imported by the Horticulture Section of the Institute or produced locally by micrografting, is maintained in a pre-basic plantation under double insect-proof screen at the ARI Acheleia Experimental Station. A second, alternative prebasic plantation has been established at the ARI Zygi Experimental Station. To the present 60 citrus accessions are maintained at each plantation and are kept in clean state by application of strict sanitary measures and regular indexing in conjunction with optical monitoring for either fungal problems or genetic aberrations. The plantations provide the citrus material for the basic or mother plantations of the Department of Agriculture and the experimental glasshouses of the ARI. (Th. Kapari-Isaia and L.C. Papayiannis).

### **Programme for the control of *Citrus tristeza virus***

The main objective of the programme for the control of *Citrus tristeza virus* (CTV) initiated in 1992 is the systematic survey of citrus and the elimination of infected trees and/or groves wherever that is feasible. The survey has been conducted by indexing 10-20% of the trees of each grove and samples were tested in the Plant Virology laboratory by enzyme-linked immunosorbent assay (ELISA). From a total of 77,000 trees tested by ELISA, 4,470 trees were found infected (average disease incidence 5.8%). A total of 900 groves with 660,000 trees were tested. (Th. Kapari-Isaia and L.C. Papayiannis).



### **Evaluation of citrus rootstocks for tolerance to *Citrus tristeza virus* (CTV)**

The following citrus rootstocks are evaluated for their tolerance to CTV at the Xylotymbou Experimental Station: Carrizo citrange, Citrumelo, Volkameriana lemon, Gou Tou, Cleopatra mandarin and Sour Orange. All trees were grafted with the variety Washington navel sweet orange, and half of them were inoculated by blind bark inoculation with the local *Citrus tristeza virus* isolate 89-197. (Th. Kapari-Isaia and L.C. Papayiannis).



### Evaluation of five new sour orange hybrid rootstocks for tolerance to citrus viroids

The five citrus hybrids were the following: (1) Sour orange X Orange (*Citrus aurantium* L.x *Citrus sinensis*, (L.) Osbeck), (2) Sour orange x Satsouma (*Citrus aurantium* L. x *Citrus reticulata* blanco), (3) Sour orange x Citrumelo 1452 x Lemon (*Citrus aurantium* L.x *P. trifoliata* (L.) Raf x

*Citrus paradisi* Macf. x *Citrus limon*), (4) Sour orange x Volkameriana (*Citrus aurantium* L. x *Citrus volkameriana*) and (5) Sour orange x Carrizo (*Citrus aurantium* L X *Citrus sinensis* (L.) x *Poncirus trifoliata* (L.) Raf). The citrus rootstocks are being evaluated for their tolerance to citrus viroids at Zygi Experimental Station. (Th. Kapari-Isaia and L.C. Papayiannis).

### Production, maintenance and distribution of healthy stone-fruit material in pre-basic stonefruit plantations

All virus-free material is maintained in a pre-basic plantation under double insect-proof screen at the ARI Zygi Experimental Station. A second, alternative pre-basic plantation has been established at the Experimental Station at Saittas. To the present 50 stone-fruit accessions are included in either plantation, kept in clean state by application of strict sanitary measures and regular indexing in conjunction with optical monitoring for fungal problems or genetic aberrations. The plantations provide with basic stone-fruit material the mother plantations of the Department of Agriculture and the experimental glasshouses of the ARI. (Th. Kapari-Isaia and L.C. Papayiannis).

### Genetic variability of *Citrus tristeza virus* (CTV) isolates from Cyprus

*Citrus tristeza virus* (CTV) was first reported in Cyprus in 1968 and, until recently, virus detection has been mainly based on Mexican lime (*Citrus aurantifolia*) indexing, and ELISA tests. In view of a national project aiming at the disease management, the genetic variability among different CTV isolates was studied using molecular methods. The capsid protein gene (CP) from 31 isolates collected from Cyprus, as well as 4 collected from Greece, was amplified using Reverse Transcription (RT) Polymerase Chain Reaction (PCR). The amplified fragment was analyzed using restriction fragment length polymorphism (RFLP) and single strand conformational polymorphism (SSCP). The nucleotide sequence of the CP gene was determined, and phylogenetic analysis was performed. Results showed that 22 symptomless isolates from Cyprus clustered among the mild strains reported from Spain, Portugal, Africa and the USA. In addition, five isolates that were responsible for the decline of sweet orange, grapefruit and mandarin trees showed high similarity with strains reported from Africa (B249), whereas four other isolates, that caused stem pitting symptoms, clustered with T36, an American severe strain from Florida. All four Greek isolates were identical to strain T385 from Spain. (L.C. Papayiannis, Th. Kapari-Isaia and A.P. Kyriakou).



### Grapevine pre-basic plantations

Phytopathological deterioration of asexually propagated crops such as grapevines (*Vitis* spp.) has compelled for the enforcement of a series of measures for producing propagation material of a high sanitary status. As the efficient control of plant virus, virus-like and prokaryotic diseases by any type of cura-

tive treatments is currently impossible, new approaches are required. The European Union has recently imposed new directives on the distribution of grapevine material that involve phytopathological testing of plants for several plant pathogens. Utilization of “healthy” plant material seems nowadays the most promising tactic for ensuring good results in the control of these diseases. During the past 20 years, the ARI has established a long term project on the maintenance of healthy propagative grapevine material under “pre-basic” status. Approximately 20 local and 30 imported varieties are maintained under two insect-proof net houses at Zygi experimental station. These plants are biannually tested for a number of plant viruses proposed by EU directive 2005/43, including *Grapevine fan leaf virus*, *Grapevine fleck virus*, *Arabis mosaic virus* and *Grapevine leaf roll* associated viruses 1 and 3, viroids and several other prokaryotic organisms. Tests include adoption of pathogen-specific serological and molecular laboratory techniques. Virus-free grapevine plant cuttings are issued to the Department of Agriculture for further multiplication and distribution to Cypriot farmers. (L.C. Papayiannis and Th. Kapari-Isaia).

### Molecular typing of *Begomovirus* species involved in Tomato yellow leaf curl disease epidemics

Tomato yellow leaf curl disease (TYLCD) is considered one of the most important and devastating viral diseases of tomato crops worldwide. At least 11 virus species and numerous isolates have been associated with the disease, all assigned in the *Begomovirus* genus of the *Geminiviridae* family. In nature, these viruses are transmitted by the tobacco whitefly, *Bemisia tabaci* (Gennadius), in a persistent manner. During 2006-2010 an extensive survey was conducted in Cyprus on the epidemiology and characterization of the virus species involved in TYLCD. More than 2,000 samples of symptomatic tomato plants, 1,300 cultivated plant samples, and 4,500 weeds, were collected and analyzed for virus presence. Differentiation of *Begomoviruses* was based on various real-time TaqMan PCR assays developed in this study, as well as sequencing analysis. Results showed TYLCV as the only virus species associated

with TYLCD. Molecular characterization of TYLCV showed that TYLCV-IL (Israel) and TYLCV-MLD (Mild) strains co-exist in Cyprus, with an incidence of 90 and 10%, respectively. TYLCV-IL strain was also detected in bean (*Phaseolus vulgaris*), and pepper (*Capsicum annuum*) open field crops, as well as 49 different weed species that could play an important role in virus epidemiology by acting as alternative hosts during crop free periods. Sequencing analysis results showed that Cypriot TYLCV isolates possess high similarity with corresponding isolates from Israel, Lebanon, Turkey and other Mediterranean countries. (L.C. Papayiannis and N.I. Katis).



#### Host range and transmission studies of TYLCV isolates from Cyprus

The host range of two TYLCV strains (IL and MLD) isolates was studied using whitefly transmission tests in several plant species. Transmission efficiency was evaluated using four *B. tabaci* colonies which harbored different bacterial endosymbionts. The transmission capacity from alternative infected plant hosts to tomato was also studied. Our results indicate that both strains had a similar host range and were able to infect several commercial varieties of tomatoes, beans, peppers, as well as 18 weed species. Moreover, TYLCV transmission was somehow correlated with the presence of *Hamiltonella* sp., inside *B. tabaci* insects, as colonies



that harbored these bacteria showed higher transmission rates from and to tomato plants. Also, higher densities of viruliferous whiteflies showed increased transmission rates. Finally, transmission assays from infected secondary hosts, including weeds and other cultivated plants, onto tomato demonstrated that these alternative hosts could serve as important virus reservoirs, contributing significantly to disease outbreaks. (L.C. Papayiannis).

#### Molecular detection of two Criniviruses associated with yellowing symptoms on tomato crops

*Tomato chlorosis virus* (ToCV) and *Tomato infectious chlorosis virus* (TICV) (genus: *Crinivirus*, family: *Closteroviridae*) are two emergent whitefly-transmitted viruses that have been associated with yellowing symptoms of tomato crops during the last two decades. A real-time, one-step reverse transcription (RT) TaqMan<sup>®</sup> polymerase chain reaction (PCR) assay

was developed and optimized for the multiplex detection of TICV, ToCV and an internal control of mitochondrion cytochrome oxidase subunit I (mtCOXI) gene from plants. In direct comparison, the assay was approximately 10,000-fold and 100-fold more sensitive than conventional one-step RT-PCR and two-step nested RT-PCR reported previously, respectively. Results showed that this method could successfully detect and discriminate these two virus species from infected tomato, other host plant species, and their whitefly vectors obtained from the Mediterranean basin. The technique also allowed the simple, fast and cost-effective testing of a large number of samples in surveys and certification schemes. The plant mtCOXI assay was tested successfully against a variety of plant species from 28 different families, suggesting that it could be used as a generic internal control test when processing plant tissues. (L.C. Papayiannis, I. Harkou and Y. Markou).

### **EUPHRESCO: European Phytosanitary Research Coordination Network**

EUPHRESCO is a European Research Area Network (ERA-NET) project for research policy development and implementation in the field of statutory and emerging plant pests, diseases and invasive species. The project is fully supported by the EU Council Working Party of Chief Officers for Plant Health Services (COPHS), The European Commission's Directorate General for Health and Consumer Protection (DG SANCO), the European and Mediterranean Plant Protection Organisation (EPPO) and the European Food Safety Authority (EFSA), all of which have European plant health responsibilities. EUPHRESCO draws together national research programmes to better serve the needs of EU phytosanitary policy, operations and science. Its Partners represent all of the key national phytosanitary research funders from the current 22 European partner countries. Additionally, there are 12 Observers from other Government Bodies in Europe, plus 2 international Observers. (L.C. Papayiannis and N.A. Seraphides).

### **Inter-laboratory evaluation of real-time PCR assays for the detection of Pospiviroids**

Viroids are infectious unencapsidated, small, circular, single-stranded RNA capable of autonomous replication in a host plant. Their genomes are typically 300-400 nucleotides in length and code for no proteins. The viroid genus *Pospiviroid* (Family *Pospiviroidae*) is the largest with 10 members at present: *Potato spindle tuber viroid* (PSTVd), *Tomato chlorotic dwarf viroid* (TCDVd), *Tomato apical stunt viroid* (TASVd), *Citrus exocortis viroid* (CEVd), *Columnnea latent viroid* (CLVd), *Chrysanthemum stunt viroid* (CSVd), *Iresine viroid* (IrVd), *Tomato planta macho viroid* (TPMVd), *Mexican papita viroid* (MPVd) and the recently discovered tentative member *Pepper chat fruit viroid*

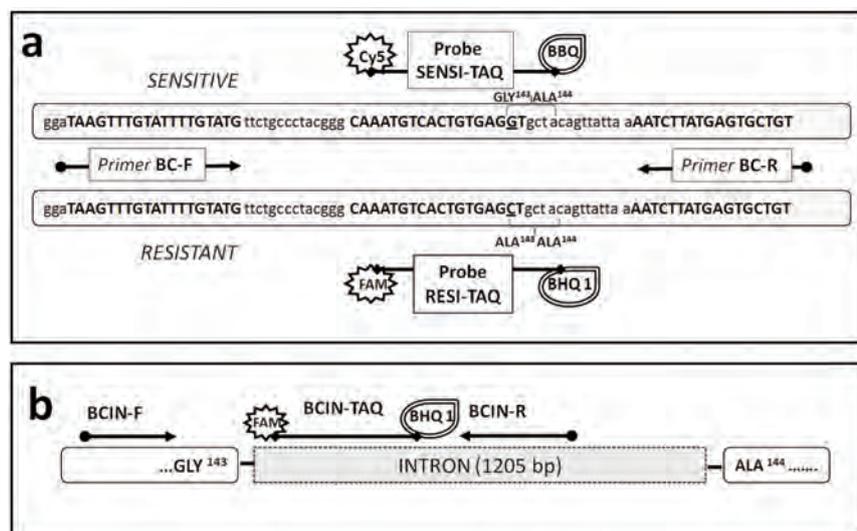


(PCFVd). In view of the EU phytosanitary ERA-net EUPHRESKO subproject entitled “The detection and epidemiology of pospiviroids”, assays based on real-time PCR (TaqMan<sup>®</sup>) that can detect a range of viroids in the genus *Pospiviroid* have been developed and evaluated. The assays are designed for detecting the viroids from tomato leaf material but detection from other solanaceous hosts of these viroids has been confirmed. These methods have been validated by a number of laboratories, including the Plant Pathology Lab of ARI, and comprise a reliable set of assays for the detection of CEVd, TASVd, CLVd and a generic assay which will detect the 6 viroids of concern to European tomato growers: PSTVd, TCDVd, CEVd, CLVd, TASVd, and CSVd.

### Frequency of G143A mutation and *cytb* intron presence in *Botrytis cinerea* populations from several hosts determined by TaqMan real-time PCR

Resistance of *Botrytis cinerea* to the quinone outside inhibiting (QoI) fungicides has been recently attributed to the G143A mutation, while in several pathogen isolates an intron has been detected at the 143 codon of the cytochrome *b* (*cytb*) gene, supposed to prevent the presence of the mutation in these isolates. In collaboration with the Aristotle University of Thessaloniki, 300 *B. cinerea* isolates were collected from several hosts in Greece and screened for resistance to the QoI fungicide pyraclostrobin. Resistance frequency was determined using a single discriminatory concentration and revealed that QoI-resistant phenotypes existed only within the population collected from strawberry fruit. Measurements of EC<sub>50</sub> values to pyraclostrobin, in the strawberry population, showed a bimodal sensitivity distribution. A real-time TaqMan<sup>®</sup> PCR assay was developed and applied for the detection of the G143A single nucleotide mutation and the presence of the *cytb* intron aiming to streamline the whole detection process by reducing the need for pre- and post- amplification manipulations. Results showed that isolates which were phenotypically resistant to pyraclostrobin possessed the G143A mutation. In addition, differences were observed among the sampled populations originating from different hosts in the genotypic structure of *cytb*. Individuals carrying the intron were present at high incidence in apple fruit and

greenhouse growing tomato and cucumber populations, whereas in strawberry population the intron frequency was lower. The intron presence was only identified in isolates that did not carry the G143A mutation, while none of the isolates carrying the



mutation possessed the intron. The results of the study suggest that a high risk for selection of QoI highly-resistant strains exists in crops extensively treated with QoIs, despite the widespread presence of fungal strains carrying the *cytb* intron. (S. Samouel, T. Veloucas, L.C. Papayiannis and G. Karaoglanides).

### **PEPEIRA: Epidemiology, economic impact and pest risk analysis of *Pepino mosaic virus***

PEPEIRA is a research project in the 6<sup>th</sup> framework programme of the EU that aims at developing an EU-wide Pest Risk Assessment (PRA) for *Pepino mosaic virus* (PepMV) in tomato. The project investigated the increased risk posed by new, biologically and genetically distinct strains of PepMV that have appeared in Europe and elsewhere recently and have the potential to be far more damaging on tomato but also other Solanaceous crops. To unravel the highly debated, putative role of seed transmission in the spread of PepMV, an extensive study on possible seed transmission was carried out. The project also addressed the issue of developing validated diagnostic protocols. The third annual consortium meeting was organized by Plant Research International in Wageningen during January 2010. (L.C. Papayiannis).

### **Detection, characterization and host range studies of *Pepino mosaic virus* in Cyprus**

*Pepino mosaic virus* (PepMV, Genus *Potexvirus*, Family *Flexiviridae*) is a mechanically transmitted viral disease that has emerged as a significant problem of greenhouse tomato crops in Europe and around the world. Although previous studies in Cyprus suggested that the virus was not present on the island, in 2009 tomato fruits from two major tomato production areas exhibited symptoms of yellow mosaic and discolouration, similar to those induced by PepMV. Consequently, an extensive survey was conducted in all tomato producing areas of the country to identify the incidence and prevalence of PepMV in protected and open field tomato crops. Analysis of 3,500 leaf samples from tomato plants and weeds with DAS-ELISA and real-time RT-PCR showed that PepMV was present in all tomato growing areas of the island. The virus was detected in both protected and open field tomato plants, as well as in 20 weed species in the families of *Amaranthaceae*, *Chenopodiaceae*, *Compositae*, *Convolvulaceae*, *Malvaceae*, *Plantaginaceae* and *Solanaceae*. All Cypriot isolates assayed belonged to the CH2 genotype. Biological assays with two Cypriot isolates showed that they could infect cultivat-



ed and weed species including *Vigna unguiculata*, *Solanum melongena*, *Nicotiana tabacum*, *Malva parviflora*, *Sonchus oleracea*, *Solanum nigrum*, *Convolvulus arvensis*, *Chrysanthemum segetum* and *Calendula arvensis*. To our knowledge, this is the first study to report *Chrysanthemum segetum* and *Calendula arvensis* as hosts of PepMV. (L.C. Papayiannis, C. Kokkinos and A. Alfaro-fernandez).

## New disease records in Cyprus

***Apium virus Y and Celery mosaic virus:*** During winter of 2010, symptoms of mosaic, vein clearing and vein banding and chlorotic line patterns were observed in parsley (*Petroselinum hortense*) and cilantro (*Coriandrum sativum*) cultures in the Lefkosa District. Diseased plants were collected and tested for viruses known to infect members of the *Apiaceae* family. Results showed that symptomatic plants were infected by *Apium virus Y* (ApVY) and *Celery mosaic virus* (CeMV), two members of the genus *Potyvirus* that can be transmitted by aphids and by mechanical means. (L.C. Papayiannis).



***Cucumber vein yellowing virus associated with watermelon decline:*** A severe decline of watermelon vines was observed during the summer of 2010 in Ammochostos district. Diseased plants exhibited symptoms of brownish leaves, defoliation and wilting, followed by rapid collapse of mature plants. Samples were collected and tested for fungal, bacterial and viral infection. Results showed that the only pathogen identified was *Cucumber vein yellowing virus* (CVYV), a *Bemisia tabaci* transmitted virus that belongs to the *Ipomovirus* genus of the *Potyviridae* family. The virus has been reported in greenhouse cucumbers during previous surveys, but this was the first report of CVYV on watermelon in Cyprus. (L.C. Papayiannis).

## SOIL SCIENCE

The activities of the Soil Science Section concern soil fertility improvement, plant nutrition, soilless culture, wastewater reuse, integrated water resources management and agricultural engineering. Research on soils aimed at preventing soil degradation through the implementation of certain agricultural systems and the application of organic additives. Particular attention has been given to the mechanism of soil improvement through rotation systems incorporating legumes. Field and laboratory work has been undertaken to investigate soil microbial respiration and nitrogen mineralization in soils mixed with plant residues, and the rate of release of inorganic nitrogen in soils after the incorporation of manure or compost. Composting of organic waste and plant residue has also been recently initiated.

Plant nutrition and soilless culture experiments concern greenhouse vegetables and aromatic plants in order to generate up-to-date, practical and location-specific information. Plant nutrition aspects have been examined when nutrients in irrigation water exceed recommended levels or salty water is used. Different types of hydroponic systems and substrates were tested taking into consideration production water efficiency and fertilizer expenditure. Ongoing research relates to closed hydroponic systems and nutrient uptake concentrations.

Research on integrated water resources management is currently devoted mainly to wastewater reuse in agriculture. Field experiments are performed for appraising the effects of wastewater reuse for irrigation purposes on the environment and on public health. Also, a field survey regarding these effects has been carried out in all districts of Cyprus.

Research in agricultural engineering examines the potential use of biomass for biofuel (biodiesel, bioethanol, biogas, and solid fuel) and energy production under Cyprus conditions. Moreover, agricultural engineering is actively involved in a large number of EU and RPF Research Projects: «Adaptation of agricultural production to climate change and the limited water resources-Adapt2change», «Designing an environmental friendly management scheme for agrochemicals plastic packaging waste-Agrochepack», «Testing of new technology greenhouse plastic covers-GreenFilm», and «Study of the growth of micro-algae for the production of biodiesel-Med-Algae».

## PLANT NUTRITION AND SOILLESS CULTURE

Research activity focused on the production of greenhouse vegetables, particularly strawberry, lettuce, and aromatic plants in order to generate up-to-date, practical and location-specific information. Different types of growing systems and substrates have been tested. A parallel activity concerns the design and application of hydroponic systems adapted to Cyprus

conditions taking into consideration production, water and fertilizer efficiency. Plant nutrition aspects when nutrients in water for irrigation exceed recommended values or salinity water is used to prepare nutrient solutions were examined. Finally, there is participation in three EU projects whose main objectives are: to develop and implement halophytes utilization, to facilitate sustainability taking into consideration production and health in berry production, and to minimize demand for water in the agricultural sector.

### Salinity affects quality of green and red baby lettuce. Part I. Photosynthesis, yield and sensory quality

The main objective of this work was to study the responses of baby lettuce (*Lactuca sativa* L. green romaine cv. 'Paris Island', and red-pigmented cv. 'Sanguine'), to different NaCl solution concentrations (0, 5, 10, and 20 mM). The study was conducted in a hydroponic floating system. Photosynthetic parameters (photosynthetic rate, stomatal conductance, transpiration and intercellular CO<sub>2</sub>), yield (leaf mass) and quality (colour, pigmentation, and sensory index) were determined. Generally, higher values of photosynthetic parameters but lower yield and less time to commercial maturity were obtained with green romaine than with red-pigmented lettuce. Fresh leaf mass was reduced at 20 mM NaCl, in both cultivars. The reduction of leaf mass depended on the limited water accessibility for baby leaves. Photosynthetic rate was suppressed at high salt concentration through stomatal restriction, aiming at the retention



of water, which resulted also in limited CO<sub>2</sub> availability. Nevertheless, no limitations were observed in photosynthetic pigments. Therefore, stomatal closure was the dominant factor limiting photosynthesis. Regarding quality, salinity improved anthocyanin content and coloration in red lettuce and sensory indices were enhanced in green lettuce. (D. Neocleous, A. Koukounaras, A. Siomos and M. Vasilakakis).

### Salinity affects quality of green and red baby lettuce. Part II. Mineral nutrients and nutritional quality

The purpose of this study was to examine the responses of baby lettuce

(*Lactuca sativa* L. green romaine cv. 'Paris Island', and red-pigmented cv. 'Sanguine'), to different NaCl solution concentrations (0, 5, 10 and 20 mM). The studies were conducted in a hydroponic floating system. Mineral nutrient content and nutritional quality were determined. Mineral content in baby leaves was connected to cultivar and altered by salinity stress. Salinity reduced macronutrients concentration, whereas micronutrients were less affected in both cultivars. Moreover, salinity was linearly correlated to the accumulation of sodium and chloride ions in baby leaves. However, visual symptoms of nutrient deficiency did not occur in either the green or the red cultivar. The treatment of 20 mM NaCl increased phenolics and subsequent antioxidant activity in red-pigmented lettuce, whereas this was not the case in the green cultivar. Our study indicates that the use of saline waters could be of practical relevance in hydroponically grown red-leafed lettuce in order to enhance bioactive phytochemicals and antioxidant activity. Based on the observed mineral and nutritional compound contents in green and red lettuce cultivars, it could be drawn that coloured varieties in lettuce salads may be recommended (D. Neocleous, A. Koukounaras, A. Siomos and M. Vasilakakis).



### Effects of cultivars and coco-substrates on soilless strawberry production in Cyprus

This experiment was conducted to generate up-to-date, practical and location specific information for soilless strawberry production in Cyprus. Commercial 'fresh' strawberry plants (*Fragaria x ananassa* Duch) of three cultivars ('Camarosa', 'Festival' and 'Ventana') were cultivated from October 2010 to June 2011, in a plastic greenhouse using coco-substrates from three different brands (BVB, Wonder Soil, Pelemix) wrapped in polyethylene slabs and placed on polygal troughs in a two-level-pyramid layout (20.6 plants/m<sup>2</sup>). Harvesting started in January and lasted until the beginning of June. The total yield obtained from the three cul-



tivars was similar (439 g/plant) but ‘Festival’, and ‘Ventana’ produced higher yield of ‘extra’ category fruits. In addition, fruit weight was higher in ‘Ventana’ (14.7 g/fruit) followed by ‘Festival’ (13.6 g/fruit) and lower in ‘Camarosa’ (11.0 g/fruit). Early yield (January-April) obtained as a percentage of the total production, ranged from 73.3% with ‘Camarosa’ to 77.5% with ‘Ventana’ and 82.9% for ‘Festival’. No differences were observed in productive characteristics or early yield according to substrates. However, water consumption was higher in Pelemix and Wonder Soil (395 l/m<sup>2</sup>) compared to BVB (369 l/m<sup>2</sup>). Water use efficiency, expressed as amount of water consumed to produce one kg of fruit fresh weight, was lower in ‘Ventana’ and ‘Festival’ (42 L/kg) compared to ‘Camarosa’ (49 L/kg). ‘Festival’ and ‘Ventana’ produced fruits of higher taste-related compounds content, whereas ‘Camarosa’ yielded fruits higher in content of antioxidant compounds, particularly anthocyanins, flavanoids and phenolics, hence higher antioxidant capacity. Progressive harvesting from January to May improved fruit quality characteristics, bioactive compounds and subsequent antioxidant activity of fruits. **(D. Neocleous).**

#### **Productive potential of basil, mint, thyme and melissa in soilless culture**

Commercial plants of *Occimum basilicum* (basil), *Mentha viridis* (mint), *Thymus vulgaris* (thyme) and *Melissa officinalis* (melissa) were cultivated in a plastic greenhouse from January to October, 2011 using Polygal troughs and polyethylene bags filled with coccosoil in a horizontal setup with a planting density of 21.7 plants/m<sup>2</sup>. The total yields obtained from mint, basil, melissa and thyme were 18.5, 15.3, 12.6 and 7.7 kg/m<sup>2</sup> respectively. These results veri-



fy our previous results suggesting higher production yields than those reported for open field cultivation. Regarding water use efficiency, mint and basil needed 37 and 41 l water/kg fresh product, respectively, while melissa needed 48 and thyme 55 l/kg. From these results it can be drawn that soilless culture of aromatic crops enables increase in yield and improves water and fertilizer use efficiency. Proper management of the harvesting period to facilitate off season product can increase the commercial importance of these crops. **(D. Neocleous)**.

#### **Adjustment of K: Ca: Mg ratio when Ca exceeds recommended levels in the nutrient solution of hydroponically grown strawberry**

Calcium occurs frequently in excess in the irrigation water in Mediterranean countries. The aim of the present study was to investigate the responses of strawberry (*Fragaria x ananassa* Duch 'Camarosa') to adjustment of K and Mg supply and the K: Ca: Mg ratio in the nutrient solution when Ca exceeds recommended levels. Treatments were defined as follows: Treatment A was a basic nutrient solution (BNS) which contained 6 mM K, 3 mM Ca, and 1.4 mM Mg (EC of 1.8 dS/m); Treatment B (highCa) contained increased Ca concentration (5 mM) and K and Mg levels as in treatment A (EC of 2.2 dS/m); Treatment C (highall), where the increase in the Ca concentration to 5 mM was accompanied by commensurate increases in the K and Mg levels (EC of 2.8 dS/m); Treatment D (compensation) wherein the increase in the Ca concentration (5 mM) was accompanied by commensurate decreases in the K and Mg levels so as to maintain the same EC as in Treatment A (EC of 1.8 dS/m). When water for irri-



gation contains Ca in excess, maintaining the concentrations of K and Mg in the standard levels (highCa) should be recommended as it leads to high productivity with no limitations in physiological parameters, growth, nutrient availability, or quality. On the other hand, providing additional amounts of nutrients to maintain cationic ratio (highall) increased EC and

negatively affected physiological parameters, growth, and fruit yield, and changed the balance between K, Ca and Mg in leaves. Furthermore, a large part of the nutrients was drained to waste. The balance of K, Ca and Mg in leaves was also affected when the proportions of K and Mg were decreased in the cationic ratio of the supplied solution (compensation). Fruit quality remained unaffected by the supplied solution. (D. Neocleous and D. Savvas).

### **Euroberry Research: from Genomics to Sustainable Production, Quality & Health (Food and Agriculture COST Action FA863)**

Berry production is an economically significant part of agriculture in most European countries. The main objective of this COST Action is to improve the quality and production of berries to benefit consumers' health, to maintain profitable and sustainable European production and also to ensure a supply of fresh, high quality products. Improvement of berry cultivation efficiency and increased commercial value of the fruit will help in meeting the expense of higher labour cost. (D. Neocleous).

### **Putting Halophytes to Work - From Genes to Ecosystems (Food and Agriculture COST Action FA0901)**

Halophytes are plants that complete their life cycle in saline conditions. Halophytes have a major role to play in future agriculture and in restoration of affected areas. Deepening our understanding of halophytes and saline ecosystems will help combat salinisation, soil erosion, loss of biodiversity and bioproductivity. Under this scope, the ARI participates in Cost Action FA0901 titled: "Putting halophytes to work – from genes to ecosystems". The main objective of this Action is to collate existing knowledge of halophytes from gene function to ecosystems that will impact on conservation and management of saline environments and agricultural productions. (D. Neocleous and P. Dalias).

## INTEGRATED WATER RECOURSES MANAGEMENT AND IRRIGATION

In recent years, wastewater reuse for agricultural crop irrigation has become a common practice in Cyprus. More than 70% of treated wastewater, representing 11 to 12 x 10<sup>6</sup> m<sup>3</sup> per annum is currently used for crop irrigation. Appraisal of treated wastewater irrigation effects on soil physicochemical properties and on public health has been carried out in 2011. Tomatoes have been irrigated with treated wastewater supplied from Lemesos and Anthoupolis Wastewater Treatment Plants (WWTP), and with control water derived from a well located in the Athalassa Research Station. Irrigation with treated wastewater from both WWTPs sustained soil electrical conductivity at lower levels in comparison to well water irrigation, whereas no statistically significant differences were reported regarding other soil physicochemical properties, such as pH, organic matter content, total C, total N and heavy metal content. Furthermore, no microbial contamination was detected in tomato fruits in all treatments. Results revealed that treated wastewater constitutes a valuable and safe water resource that can be integrated into Cyprus water resource balance for mitigating water shortage. (**A. Christou and G. Maratheftis**).



## SOIL FERTILITY IMPROVEMENT

Productivity improvement measures for rain-fed lands need to be more extensively applied in Cyprus as there are physical, economic and environmental limits in the exploitation of irrigation. Considerable alternatives are provided by fallowing, sewage sludge application under preconditions, such as the rate of heavy metal accumulation, but mainly by legume inclusion in rotation systems. The comparative evaluation of agricultural practices and cropping systems in relation to their effects on soil productivity is being studied at the Acheleia Experimental Station in the course of a long-term plot experiment. Wheat is planted after vetch treated in three different ways, or after fallow, or after the incorporation of dried sewage sludge or straw. Production and wheat grain characteristics are compared to conventional wheat monoculture which received no organic inputs. Greatest yield surplus and N assimilation until now has been obtained in treatments where wheat followed vetch especially when this is incorporated in soil at anthesis, supporting the well documented hypothesis that agrosystems containing N-fixing legumes have greater productivity.

However, grower profit and economic viability considerations could also be drawn from the results of the vetch for grain treatment. Leaving vetch to seed is known to result in lower yields of following year cereals compared with those following incorporation of vetch during flowering. This is due to accumulation of assimilated N in legume grain. However, current results showed that this eventual translocation of N to seeds does not at all abolish positive effect of vetch on next years' production even though residual effects were not so lasting. Additional income provided by selling legume grain makes this treatment a considerable alter-



native option for farmers.

Conservation of soil water during fallow has been called upon as an explanation of increased yields after fallow. However, as shown in previous works of the ARI, other prerequisites for this positive effect to occur need to operate, such as a normal fallow-year rainfall and much lower rainfall in the wheat year, and a deep heavy-textured clay soil for water storage. Under the climatic conditions of Cyprus, fallow does not always result in water storage in soil and not always this water had a positive effect on subsequent cereal crop. Results from the three rotation cycles that have already been completed in the present experiment have shown that apart from soil humidity, the number and timing of cultivations are also important in the fallow effect as they determine the amount and quality of wild vegetation litter biomass incorporated in the soil, therefore the nutrient provision to subsequent crop. **(P. Dalias)**.

### Composting

Although immature compost products can be used beneficially, especially when these are to be incorporated in soil for the building up of soil organic matter, many uses of compost require a mature product that prevents nutrients present in the soil from being immobilized. Mature compost will not adversely affect seed germination and plant development due to reduced oxygen or nitrogen availability and/or the presence of phytotoxic compounds. Work on composting of organic residues and on the potential for using the produced material in agriculture has been recently initiated. This work will initially attempt to investigate the possibility of controlling the stability of compost by manipulating the composition of the initial mixture of residues. **(P. Dalias)**.

### Fertilizer replacement value of sewage sludge

Fertilizer nitrogen equivalency estimates of sewage sludge are essential to attain benefits



from its application to agricultural fields while minimizing agronomic failure and environmental risks. Using an outdoor pot experiment, where sludge was applied to the upper layer of the soil in pots, an estimate of the rate of dried sewage sludge application needed to replace a given amount of inorganic fertilizer was performed. The nitrogen

replacement values obtained were referred to grain yield of barley, biomass production, or overall plant N uptake. Equivalencies were acquired from the response curves of the above crop characteristics in relation to the rate of sludge application. Results have shown that the pattern of C and N allocation to grain and straw was different between the inorganic fertilizer and the sewage sludge treatment presumably due to the timing of mineral N provision. When the same grain yield was obtained in these two treatments, straw yield and grain N content was greater at the sludge fertilized crop. Fertilizer N equivalency value of sewage sludge, therefore, should inevitably refer to the single crop yield component that is mostly aimed at by the producer. **(P. Dalias).**

## AGRICULTURAL AND ENVIRONMENTAL ENGINEERING

### Application of renewable energy sources in agriculture

Greenhouse horticulture and floriculture is endangered, since heating during winter is absolutely necessary to maintain production. Heating, however, contributes to a considerable increase in production costs. Therefore, alternative energy sources, like solar, wind, shallow geothermal, biomass etc., should be considered. The work carried out deals with the possibility of using biomass from agriculture and forestry as a renewable energy source. Alternative energy plants are investigated so as to select plants that could be used as potential energy sources for solid fuel production, without interfering with the food or feed chain. Biomass can be processed in briquettes, pellets or loose chips. Such plants are: *Acacia saligna* and *Leucaena leucocephala*. Furthermore, biomass could be used for the production of liquid bio-fuels, such as bio-diesel and bio-ethanol for transportation and biogas for energy production. Different plant species are being tested in order to select the most suitable ones for the production of bio-fuels under Cyprus conditions, exploiting also the possibility of utilizing the water from treatment plants that cannot be utilized otherwise. Some of the species tested in this program are: *Sinapis alba*, *Ricinus communis*, *Onopordum cyprium*, *Ferula communis*, *Cynara cardunculus* and *Asphodelus aestivus*. **(P. Polycarpou).**

### Agrochemical plastic packaging waste management

The MED European Research Project: AGROCHEPACK, with Title: “Design of a common agrochemical plastic packaging waste management policy and pilot implementation in the Municipalities of Nigrita and Cellamare” that started in 2009, continued through 2010/11. The project comprises a partnership between Greece, Cyprus and Southern Italy, thus covering the geographical area of the eastern Mediterranean. It aims at designing an environmentally friendly management scheme for agrochemical plastic packaging waste by transfer of

know-how from Labelagriwaste, and at implementing an effective pilot scheme of agrochemical plastic waste management in three different municipalities in Greece, Italy and Cyprus. All three municipalities share common characteristics, such as strong agricultural identity and poor management of agrochemical waste. Another common characteristic is that the mismanagement of the abovementioned waste leads to: a) the direct pollution of nearby water resources (such as the river Strymon in one of the municipalities, Nigrita, Greece) with the inevitable contamination of the Mediterranean sea; b) the release of harmful substances to the environment (e.g. dioxins) by the uncontrolled burning of these hazardous wastes in the fields; c) the waste of material that may be used for recycling and/or energy recovery. (**P. Polycarpou and P. Dalias**).

### **Adaptation of agricultural production to climate change and the limited water resources**

The European project ADAPT2CHANGE: “Adaptation of agricultural production to climate change and the limited water resources”, “Adapt agricultural production to climate change and limited water supply LIFE 09 ENV/GR/000296” started in September 2010. Lead Partner is TEI Larissa’s in Greece and the ARI is the Partner for Cyprus. The project is funded by 50% by the EU and involves the University of Athens, the Agricultural Research Institute of Cyprus, TEI Piraeus, and Europliroforisi S.A. The overall project objective is to show the adjustment of agricultural production to climate change and limited water supply. In particular, it aims to reduce the water used in agricultural production by introducing a method of recycling water through a closed, fully automated hydroponic greenhouse system. The project aims to develop and demonstrate in rural areas in Greece and Cyprus the possibility of increasing agricultural production in a sustainable and environmentally friendly manner, while reducing consumption of energy and natural resources such as water and increasing the income of farmers. (**P. Polycarpou and D. Neocleous**).

### **New technology in greenhouse plastic covers**

The Project funded by the RPF “GreenFilm” started also in 2011 and concerns the testing of new technology greenhouse plastic covers that involve nano-particles as pigments that offer special properties to the cover (**P. Polycarpou**).

### **Study of the growth of micro-algae for the production of biodiesel**

The European ENPI Project “MED-ALGAE” was signed in December 2011 and involves the study of the growth of micro-algae for the production of biodiesel. ARI is the Lead Partner coordinating the Project. Efforts have been currently intensified in order to find alternative fuels to replace petroleum products and reduce greenhouse gas emissions. One of the main

problems with biodiesel is to have available sufficient raw material for production. A solution to this problem seems to be the cultivation of microalgae found in seawater or wastewater. The microalgae have a higher yield for biodiesel production in relation to energy crops. The consortium consists of research organizations, academic institutions, energy agencies, private organizations from 6 countries: Cyprus, Greece, Italy, Malta, Lebanon, and Egypt. This is a new technology project which can contribute to the goals of the EU strategy on “Climate change and energy.” The methodology includes all stages in the production of biodiesel from microalgae. Furthermore, the project aims to collect all available data on microalgae in the participating countries, to conduct a study on the available state-of-the-art technologies and also to provide feasibility studies for the implementation of research findings. (**P. Polycarpou, I.M. Ioannides and P. Dalias**).

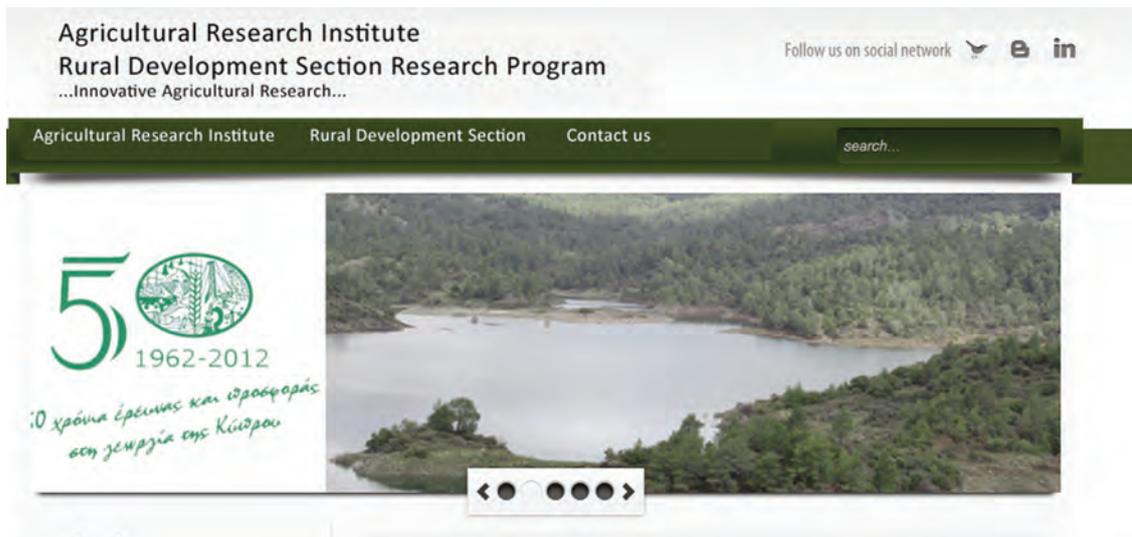
## RURAL DEVELOPMENT

The Rural Development Section manages the research programme titled “Rural Development and Trade of Agricultural Products”. It also participates in the following EU research programmes funded by the 7<sup>th</sup> Framework Programme: three European Research Area Network cooperation programmes (ERA-NET), and an Information and Communication Technology Policy Support Programme (ICT-PSP). The Section also participates in a project funded by the Research Promotion Foundation. Moreover various agro-economic studies are performed. The Section is also responsible for the maintenance of the local area network (ARINET), dissemination of activities through ICTs and social networking media channels. It is also responsible for the maintenance and content management of the official website of the Institute, as well as for the websites of various research programmes.

### INFORMATION AND COMMUNICATION TECHNOLOGY IN AGRICULTURE

#### **Information society in rural areas: knowledge sharing using information and communication technology (ICT)**

In 2010, the research project “Information Society in Rural Areas: Knowledge Sharing Using Information and Communication Technology” (ICT4RD – <http://ruraldev.ari.gov.cy>) was initiated, aiming to study the current practices of agricultural research information sharing and the new opportunities that emerge by exploiting ICT. To examine the usage of Personal Computers (PC) and the Internet by Cypriot farmers, a stratified random sample of 949 producers was developed, covering all areas under the effective control of the government of the Republic of Cyprus. The sample was based on applicant-beneficiaries of the Rural Development Plan 2007-2013, and specifically on beneficiaries of the Measures 1.5.1 “Modernization of agricultural holdings” and 1.2 “Setting up of young farmers”. The majority of the beneficiaries cultivate fruits and vegetables, potatoes and cereals, while most beneficiaries engaged in animal production were sheep and goat farmers, cattle farmers and swine farmers. Between October 2010 and March 2011 219 rural communities were visited for personal interviews wherefrom 526 questionnaires were completed. This high response rate (55.4%) demonstrates the keen interest of farmers in this research topic. Using a structured questionnaire, the participants were asked to answer several questions related to the usage of PC and the Internet for business purposes. The results of the study showed that 60.6% of the participants make direct use of the PC and 54.2% of the Internet. A higher percentage (68.4%) of producers stated use the Internet, either directly or through others (children, spouse, friend, etc.), for business purposes. The study suggests that farmers use the Internet to access agricul-



tural related information, mainly about machinery and low cost inputs (67.3%) and for reading electronic newspapers and magazines (44.4%). It is worth mentioning that the overwhelming majority (95%) of farmers believe that the Internet, whether they use it or not, is a useful source of information, and 23.4% of those stated “very satisfied” by its usage for the farm. Finally, 51.7% of farmers believe that the Internet can help increase their productivity, 60.6% that it can help improve the quality of their products, and reduce production costs (73.8%), while 38.4% of the respondents believe that it can help them become innovative. The statistical analysis of the survey was carried out using the statistical package, IBM SPSS Statistics version 2.0. In Table 1 the descriptive statistics of the selected determinants are presented. Of the participants 88% are male. Age distribution showed farmers with age of up to 28 years as under-represented, whereas in the remaining categories the percentage count is about the same. Regarding the education level, 51% had completed secondary education and 22% tertiary education. In relation to income, 56% of farmers belong to the low-to-small and medium income groups (€5,000 to €20,000), and 37% to the medium to high income groups ( $\geq$  €20,000). Concerning farm activity, the majority of the farming population is engaged in crop production and 23% in livestock production. Regarding the employment type, 64% of samples are full-time farmers and 36% are part-time farmers. Another interesting result is that 40% of the farmers are members of a Producers Organization. Farmer locality was distributed as follows: 28% live and work in the Lemesos district, 20% in the Larnaka district, 18% in the Paphos district and 6% in Ammochostos. The small sample population from the district of Ammochostos is attributed to the fact that the greater part of the district is under Turkish military occupation. Furthermore, 41% of the respondents live and work in lowland areas, 33% in semi-mountainous areas, and 25% in mountainous areas. (G. Adamides and A. Stylianou).

**Table 1.** Population percentage (N=526) for factors affecting PC and Internet usage by farmers

Variable	Population percentage
<b>Gender</b>	
Male	88
Female	12
<b>Age</b>	
Up to 28 years of age	7
Between 29 to 39	23
Between 40 to 50	29
Between 51 to 61	25
<b>Education</b>	
Fulfilled Secondary Education	51
Fulfilled Tertiary Education	22
<b>Income</b>	
€5 000 to €20 000	56
€20 000 and above	37
<b>Agricultural activity</b>	
Crop farming	65
Livestock farming	23
<b>Employment type</b>	
Full time	64
Part time	36
Members of a Producers Organization	40
Non-members	60
<b>District</b>	
Ammochostos	6
Larnaka	20
Pafos	18
Lemesos	28
<b>Farm location</b>	
Lowland	41
Semi-mountainous	33
Mountainous	25

### Robot technology in agriculture

The research project titled “The supportive role of robotics technology for sustainable agriculture” (AgriRobot - <http://agrirobot.ouc.ac.cy>) is funded by the Research Promotion Foundation and deals with the aspect of human-robot interaction (HRI) and examines how humans can interact efficiently and effectively with robots to carry out agricultural tasks. The supportive role that robots can play in the field, or inside a greenhouse, can help in the development of sustainable agriculture. This can be accomplished by the introduction of existing robotic technology that can augment farmers’ capabilities in carrying out repetitive and tedious agricultural tasks. In addition the introduction of robots can help tackle the high costs of production deriving from increased labor costs, and overcome the observed shortage of labor. Though certain agricultural tasks, such as fruit picking, may be considered simple when per-



formed by humans, such tasks are considered very complex for a robot because it involves identifying a ripe fruit through, possibly overlapping tree branches, reaching to grasp the fruit, without damaging it and placing it in a container. The research methodology focuses on the area of the user interface (UI) design, implementation and evaluation, specifically for a human-robot interaction system. It involves the study of the volatile literature in the areas of human-computer interaction (HCI), human-robot interaction, and agricultural robotics. (G. Adamides).

### Virtual open access agriculture and aquaculture repository

The Section participates in the ICT-PSP funded project “Virtual Open Access Agriculture & Aquaculture Repository: Sharing Scientific and Scholarly Research related to Agriculture, Food, and Environment” (VOA<sup>3</sup>R – <http://voa3r.eu>). The VOA<sup>3</sup>R platform (<http://voa3r.cc.uah.es/>) aims at re-using existing and mature metadata and semantics technology to deploy an advanced, community-focused integrated service for the retrieval of relevant open content and data that includes explicit models of the scholarly methods and procedures used and of the practical tasks targeted by applied research. The service will enable researchers to formulate their information needs in terms of elements of the scientific methods established in their field (variables, techniques, assessment methods, kinds of objects of interest, etc.) combined with topical descriptions as expressed in metadata. The community approach will enable the enhancement of information seeking, with extended evaluation elements that complement and go beyond the traditional, anonymous peer review process whose results are not made available openly. (G. Adamides).



### Coordination of ICT and Robotics in Agriculture and Related Environmental Issues

The Section represents the ARI at the ERA-NET “Coordination of ICT and Robotics in

Agriculture and Related Environmental Issues” (ICT-AGRI - <http://db-ictagri.eu>), which addresses research on the application of Information and Communication Technology and Robotics in Agriculture and related Environmental Issues. The ARI participates in this project as an Observer Organization. **(G. Adamides)**.

### **International cooperation**

The Section represents the ARI at the ICT Regional Agricultural Information System Steering Committee of the Association of ARIs in the Near East and North Africa (ICT-RAIS AARINENA). To this end, between October 4 to 6, 2011, it had participated in the “Training-of-trainers workshop on coherence in information for agricultural research for development (CIARD)”. In 2011 a Memorandum of Understanding (MOU) between the ARI with the Ben-Gurion University of the Negev, Israel was signed. The two Institutions agreed to consult with each other and the area of collaboration is: Agricultural Robotics and Information Communication Technologies (ICT-Robotics). **(G. Adamides and G. Papadavid)**.

### **Dissemination activities**

The Section is responsible for the dissemination of the ARI activity. For this purpose it maintains the ARI website (<http://www.ari.gov.cy> – in Greek, and <http://arinet.ari.gov.cy> – in English), as well the digital version of the ARI library catalogue (WebAGRIS) at <http://library.ari.gov.cy/agris>. The WebAGRIS is an open access system containing more than 300 digitized versions of all of ARI publications since 1965.

With the emergence of the social networking media, the Rural Development Section makes use of two such tools: twitter and blogging. The Twitter account @ari\_rd is used to share information about several topics related to agriculture and rural development, while the blog website of ARI, at <http://blog.ari.gov.cy>, is for sharing articles, news and updates from the ARI research activities. Both tools (blogging and micro-blogs) are a relatively new and popular communication channel that allows people to post and share information, with an added value; it enables the active participation of all stakeholders in the discussion, providing a variety of impacts on collaborative work. **(G. Adamides)**.

## **AGRICULTURAL ECONOMICS**

Revised NORM prices are provided for agricultural inputs and outputs of the main crop and livestock enterprises of Cyprus, based on the inflation rate of the past years; these prices will be used in the context of the new Cyprus Rural Development Plan, regarding Modernization of agricultural holdings (Measure 1.5.1: Improvement of the competitiveness

of the agricultural sector and the overall performance of the agricultural holdings via the enhancement of the physical capital). **(G. Papadavid and A. Stylianou).**

Commissioned by the Ministry of Agriculture, Natural Resources and the Environment, two studies were performed towards the Midterm Financial Framework 2014-2020: 1. Economic impact of the remote geographical position of Cyprus on the Cypriot agricultural sector; 2. Effect of climate variability and climate change on crop production and water resources in Cyprus. **(M. Markou and A. Stylianou)**

### **Remote sensing laboratory**

The Remote Sensing Laboratory was established at the Acheleia Experimental Station in order to provide scientific data for many applications in agriculture but also for environmental research applications. The Laboratory has been involved in two research projects regarding crop evapotranspiration and its contribution is expected to prove valuable for all the ARI Sections through collaborative research. **(G. Papadavid).**

### **Relationships between rural areas and agriculture in Europe**

The ARI is a member of the consortium of the ERA-NET cooperation project titled “Facing sustainability: new relationships between rural areas and agriculture in Europe” (RURAGRI - <http://www.ruragri-era.net/>). The aim of the project is to bring together the cooperated research parties from EU member states, record their current research activities and conduct joined research. **(M. Markou, G. Adamides and V.A. Vassiliou).**

The Section represents the ARI in the project titled “Coordination of the Agricultural Research in the Mediterranean Area” (ARIMNet <http://www.arimnet.net>). This project is an ERA-NET action supported and funded under the 7<sup>th</sup> Framework Program (FP7) of the European Commission. The project aims at coordinating national research activities, at identifying common research interests among Mediterranean countries, and at fighting fragmentation and exploiting synergies. **(M. Markou, G. Adamides and V.A. Vassiliou).**

### **Farm Accountancy Data Network (FADN)**

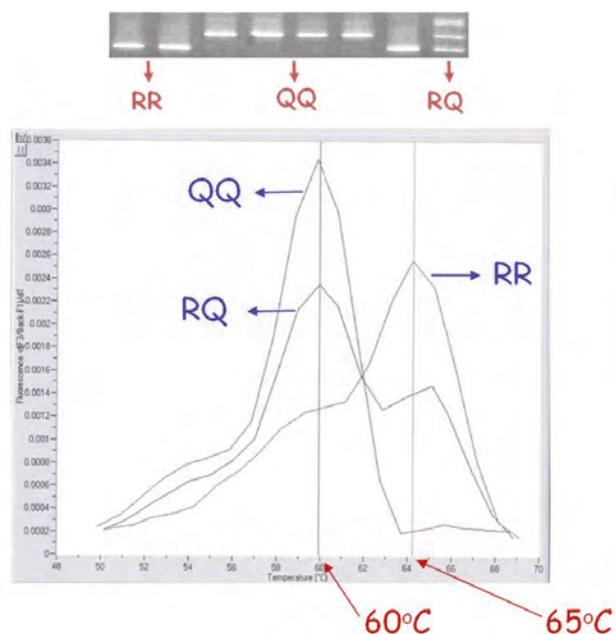
Returns for 444 farm units referring to the accounting year 2009, and 468 farm returns for the accounting year 2010, were submitted to the Community FADN Committee in 2010 and 2011, respectively. The data was collected through personal interviews from a relevant sample and processed according to the existing regulations. The 2011 Cypriot selection plan for holdings participating in the FADN sample was submitted to the Community FADN Committee. **(M. Markou).**

## AGROBIOTECHNOLOGY

The Agrobiotechnology Section was established in 2008. Its purpose is to provide solutions to arising agricultural problems with the application of advanced, modern techniques using state-of-the-art laboratory equipment. The research activity of the Section focuses on the following scientific areas: Molecular Biology, Agricultural Chemistry, Food Technology and Agricultural Microbiology. Along with its research activities, the Agrobiotechnology Section performs chemical analyses in support of research programmes pursued by other Sections of the Institute.

### MOLECULAR BIOLOGY

The Molecular Biology Laboratory (MBL) of the ARI conducts research on plants and animals. Plant research focuses on the development and exploitation of molecular markers for barley (**I.M. Ioannides and D.A. Fasoula**). Watermelon colonisation by arbuscular mycorrhizal fungi was assessed using real time PCR. Molecular biology techniques were used for the identification of fast pesticide-degrading bacteria as well as nitrogen fixing bacteria (**I.M. Ioannides and M. Omirou**). In animal research, the molecular fingerprinting for goats has continued, and 610 goat samples were tested for scrapie disease. The data were submitted to the laboratory molecular data bank for further analysis. Also, a nucleus unit with all the different goat genotypes was established. In addition, genetic analysis of blood samples of the Chios sheep (1,292 samples) has continued in order to identify and select genotypes resistant to scrapie disease. Presently at the ARI, the Chios sheep nucleus unit counts 500 breeding ani-



mals exclusively of the scrapie resistant genotype ARR/ARR (**I.M. Ioannides and G. Hadji-pavlou**). Research on insects has continued by testing samples (270) of the olive fruit fly, (*Bactrocera oleae* Gmelin) for mutant identification and characterization in a single polymerase chain reaction (PCR) (**I.M. Ioannides, N.A. Seraphides, D.A. Fasoula and M. Omirou**).

### Testing for possible genetic modification in corn

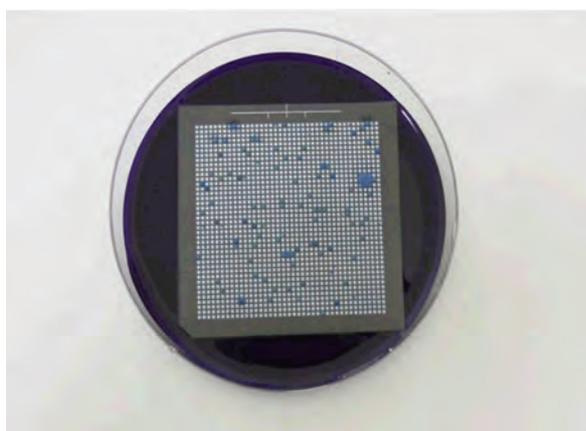
In September 2003, the House of Representatives of the Republic of Cyprus incorporated the Directive 2001/18/EC on the deliberate release to the environment of genetically modified organisms (GMO) into national law [N.160(I)/2003]. The Ministry of Agriculture, Natural Resources and Environment has designated the MBL of the ARI as the Competent Authority for technical and scientific issues regarding the above legislation. All necessary steps on behalf of the MBL are taken to fulfill this mandate. These include acquisition of appropriate equipment, training, etc. During 2010/11 the MBL performed 736 molecular analyses on 46 samples for possible presence of genetic modification in imported corn and soy grains (**I.M. Ioannides**).

### AGRICULTURAL CHEMISTRY

The main research activities of the Agricultural Chemistry Laboratory (ACL) concern the safety of agricultural products. Two new analytical methods were developed to facilitate new research programme collaborations. The first deals with the quantification of pesticides mainly in soil and other substrates, and the second concerns the microwave-assisted extraction and quantification of essential oils from mint. During 2010/11 the ACL performed 15,876 chemical analyses on 4,308 samples (**M.Omirou, G. Maratheftis and I.M. Ioannides**).

### FOOD TECHNOLOGY

The Food Technology Laboratory (FTL) was established at the beginning of 2010. Its purpose is to conduct research in the field of food production, aiming in the production and availability of quality, nutritious, safe and organoleptically acceptable food products. Currently, the FTL is involved in four research projects. Two projects concern the isolation and evaluation of natural products as food ingredients. Oil from rocket seeds (*Eruca sativa*) and essential oil from mint (*Mentha spicata*) have been extracted and tested for their *in-vitro* antioxidant activity showing promising



results (**G. Maratheftis, M. Omirou and C. Stavridou**). Public health issues have been examined regarding the irrigation of tomato plants with treated waste water. Our studies showed no microbial contamination with specific human pathogens in the fruits (**G. Maratheftis and A. Christou**). Finally, assessment of the effect of processing and cooking on the nutritional and anti-nutritional attributes of cowpeas (*Vigna unguiculata*) has been initiated (**G. Maratheftis, D.A. Fasoula and M. Omirou**).

## AGRICULTURAL MICROBIOLOGY

Research in the Agricultural Microbiology Laboratory during 2010/11 related to environmental microbiology and biotechnology as well as climate change. A pesticides bioremediation project is in progress and more than 25 bacterial strains that showed high potential for dissipation properties have been isolated and characterized (**M. Omirou and I.M. Ioannides**). The first on-farm pesticide bioremediation system in Cyprus has been established at Zygi Experimental Station under a continuous monitoring programme. Moreover, research on the effect of mycorrhizal inoculation on watermelon production under water stress conditions was conducted (**M. Omirou and I.M. Ioannides**). More than 100 strains of nitrogen-fixing bacteria have been isolated and characterized from various local cowpea ecotypes. In addition, the diversity of mycorrhizal fungi found in the roots of those ecotypes has been examined (**M. Omirou, D.A. Fasoula and I.M. Ioannides**). Recently, research activity on microorganisms related to soil nitrogen cycle and plant growth promotion was initiated aiming at reducing the use of nitrogen fertilization (**M. Omirou and I.M. Ioannides**).



## VARIETY EXAMINATION CENTRE

Research activity focused on the trials essential for the registration of varieties of several agricultural species. In order to become tradable varieties must be registered in the National or Common Catalogue. For the purposes of registration of a variety in the National Catalogue of Varieties an application must be submitted to the Designate Authority (Department of Agriculture) by the improver, the legal conservator, or their authorized legal representative residing in Cyprus. Examination of varieties for purposes of registration in the National Catalogue requires the trials described below.

### **Distinctness, Uniformity, and Stability (DUS trials)**

The DUS trials have duration of at least two years and include observations on morphological, physiological and agronomic characteristics of varieties according to the protocols of Community Plant Varieties Office (CPVO) and the International Union for the Protection of New Plant Varieties (UPOV). During the growing season 2009/10 two barley varieties (08/09 1/E V.11 and 08/09 FA V.3), two wheat varieties (Acheleia and Giolou) and three groundnut varieties (Ntopia, Kouklia and Nikoklia) were subjected to first year trials. The results were reported to the Designate Authority (Department of Agriculture). In the 2010/11 growing sea-



son the same varieties, except for the barley varieties which were not given permission to continue, were tested for the second year. Additionally, one triticale variety (SIS TC1) was tested for the first year. (**K. Minas**).

### Value for Cultivation and Use (VCU trials)

The VCU trials are strictly conducted in the territory of Cyprus by the Variety Examination Centre and have duration of at least two years for all crops except alfalfa for which the duration of trials is three years. During the 2009/10 growing season the aforementioned barley varieties 08/09 1/E V.11 and 08/09 FA V.3, the wheat varieties Acheleia and Giolou, and the groundnut varieties Ntopia, Kouklia, and Nikoklia were tested for the first year. Alfalfa variety Ntopia was tested for the second year. Results were reported to the Designate Authority (Department of Agriculture). In the 2010/11 growing season the same varieties (except for the two barley varieties) were tested for the second and third year, respectively, and one triti-



cale variety (SIS TC1) was tested for the first year. The final decision for the variety registration in the National Catalogue is granted by the Technical Committee of Multiplicative Material and Seeds. **(K. Minas)**.

### Optimization of hay cereal yields to feed sheep and goats in Cyprus

In 2010 a new research program concerning the cultivation of fodder plants was launched. In the first year, five species were evaluated at four different growing stages with respect to yield and quality. **(K. Minas)**.

## PUBLICATIONS IN 2010-11

### Journal Papers and Chapters in Books

- Antoniadis, V., C.D. Tsadilas, and P. Dalias. 2010. Evaluation of sewage sludge as a soil amendment in relation to nitrate leaching. *Agrochimica* 54:91-102.
- Efthimiou, K.E., A.P. Gatsios, K.C. Aretakis, L.C. Papayiannis, and N.I. Katis. 2010. First report of *Pepino mosaic virus* infecting greenhouse cherry tomatoes in Greece. *Plant Disease* 95:78-79.
- Ganopoulos, I.V., E. Avramidou, D.A. Fasoula, G. Diamantidis, F.A. Aravanopoulos. 2010. Assessing inter- and intra- cultivar variation in Greek *Prunus avium* by SSR markers. *Plant Genetic Resources: Conservation and Utilization* 8(3):242-248.
- Kakani E.G, N.E. Zygouridis, K.T. Tsoumani, N.A. Seraphides, F.G. Zalom, and K.D Mathiopoulos. 2010. Spinosad resistance development in wild olive fruit fly *Bactrocera oleae* (Diptera: Tephritidae) populations. *Pest Management Science* 66(4):447-53.
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- Newton, A.C., T. Akar, J.P. Baresel, P.J. Bebeli, E. Bettencourt, K. Bladenopoulos, J.H. Czembor, D.A. Fasoula, A. Katsiotis, K. Koutis, G. Kovacs, H. Larsson, M. Pinheiro de Carvalho, J. Russell, T.M. dos Santos, and M. vaz Patto. 2010. Cereal landraces for sustainable Agriculture. *Agronomy for Sustainable Development* 30:237-269.

- Papayiannis, L.C., S.C. Hunter, T. Iacovides, and J.K. Brown. 2010. Detection of Cucurbit yellow stunting disorder virus (CYSDV) in cucurbit leaves using sap extracts and real time TaqMan reverse transcription (RT) polymerase chain reaction (PCR). *Journal of Phytopathology* 158:487-495.
- Papayiannis, L.C., T.A. Iacovides, N.I. Katis, and J.K. Brown. 2010. Differentiation of *Tomato yellow leaf curl virus* and *Tomato yellow leaf curl Sardinia virus* using real-time TaqMan PCR. *Journal of Virological Methods* 165:238-245.
- Fasoula, D. An overlooked cause of seed degradation and its implications in the efficient exploitation of plant genetic resources. 2011. *Plant Genetic Resources: Conservation and Utilization* 9(2):321-323.
- Kyriacou, M.C. 2011. Influence of a postharvest hot water treatment on the development of green mould (*Penicillium digitatum* (Pers.:Fr.) Sacc.) and on the quality of 'Mandora' fruit (*Citrus reticulata* Blanco x *Citrus sinensis* [L.] Osbeck ). *Journal of Horticultural Science and Biotechnology* 86(4):359-365.
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- Negri, V., D. Fasoula, M. Heinonen, V. Holubec, M. Musayev, G. Spataro, M. Vetelainen and R. Vogel. 2011. European on-farm conservation activities: an update from six countries. In *Agrobiodiversity conservation* (eds. Maxted, N., M.E. Dulloo, B. Ford-Lloyd, L. Frese, J.Iriondo, and M. Pinheiro de Carvalho). ). CABI, Oxfordshire, UK, pp.327-332.
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- Papayiannis, L.C., N.I. Katis, A.M. Idris, and J.K. Brown. 2011. Identification of weed hosts of *Tomato yellow leaf curl virus* in Cyprus. *Plant Disease* 95:120-125.
- Samuel, S., L.C. Papayiannis, M. Lerocq, T. Veloukas, M. Hahn, and G.S. Karaoglanidis. 2011. Evaluation of the incidence of the G143A mutation and *cytb* intron presence in the *cytochrome bc-1* gene conferring QoI resistance in *Botrytis cinerea* populations from several hosts. *Pest Management Science* 67:1029–1036.

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- Vassiliou, V.A., E. Kazantzis, and Anthemis Melifronidou-Pantelidou. 2011. First report of the nipa palm hispid *Octodonta nipae* on Queen Palms, in Cyprus. *Phytoparasitica* 39:51-54.

#### Conference Papers and Presentations

- Christoforou, M., L.C. Papayiannis, G. Neophytou, D. Tsaltas, P. Fellas, and N. Ioannou. 2010. Identification and quantification of potato cyst nematodes in Cyprus. *Proceedings of the 15<sup>th</sup> Pan-Hellenic Phytopathological Conference*, p.93. October 5-8, 2010. Corfu, Greece.
- Christophorou, M., D. Tsaltas, L.C. Papayiannis, G. Neophytou, P. Fellas, and N. Ioannou. 2010. Identification and mapping of potato cyst nematodes in Cyprus using molecular tools and geographical information systems. *Proceedings of the 13<sup>th</sup> Congress of the Mediterranean Phytopathological Union*, pp.221-222. June 20-25, 2010. Rome, Italy.
- Christou, A. 2011. Implications on soil physiochemical properties and the environment and public health risk assessment from wastewater reuse for irrigation in Cyprus. *Proceedings of the 25<sup>th</sup> Conference of the Hellenic Society of Vegetable Sciences*, pp.185 November 1-4, 2011. Lemesos, Cyprus.
- Dalias, P., M.D. Omirou, C. Costa, C. Papastefanou, A. Nantos, C. Ehaliotis, D. Karpouzas. 2010. Dissipation of pesticides used in the citrus industry in different compost-derived biomixtures. *Proceedings of the 7<sup>th</sup> International Conference ORBIT*, June 29–July 3, 2010. Heraklion, Greece.
- Demetriou, C.N., L.C. Papayiannis, A. Gatsios, C. Orphanidou, I. Fotiou, and N.I. Katis. 2010. Host range and characterization of Criniviruses and whitefly-vectors associated with tomato yellowing in Greece. *Proceedings of the 15<sup>th</sup> Pan-Hellenic Phytopathological Conference*, p.173. October 5-8, 2010. Corfu, Greece.

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- Efthimiou, K.E., A.P. Gatsios, K.C. Aretakis, L.C. Papayiannis, and N.I. Katis. 2010. Identification of *Pepino mosaic virus* in greenhouse cherry tomatoes in Greece. *Proceedings of the 15<sup>th</sup> Pan-Hellenic Phytopathological Conference*, p.175. October 5-8, 2010. Corfu, Greece.
- Efthimiou, K.E., A.P. Gatsios, K.C. Aretakis, L.C. Papayiannis, and N.I. Katis. 2010. First report of *Pepino mosaic virus* in Greece. *Proceedings of the 25<sup>th</sup> Conference of the Hellenic Society for Horticultural Science*, p.291. November 1-4, 2011. Lemesos, Cyprus.
- Hadjipavlou, G., and S.C. Bishop. 2010. Performance of growth model and random regression methods in dissecting age-dependent QTL. *Proceedings of the 9<sup>th</sup> World Congress on Genetics Applied to Livestock Production (WCGALP)*, p.111. August 1-6, 2010. Leipzig, Germany.
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- Kyriacou, M.C., and G. Soteriou. 2010. Compositional, optical and physical quality change postharvest in grafted watermelon [*Citrullus lanatus* (Thunb) Matsum & Nakai] cultivars. *International Horticultural Congress*, August 22-27, 2010. Lisboa, Portugal.
- Neocleous, D. 2010. Effects of cultivars and substrates on soilless strawberry production in Cyprus. *International Horticultural Congress*, August 22-27, 2010. Lisboa, Portugal.
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### Other Publications

- Al Ibrahim, A., B. Boulouha, C. Gregoriou, M. El-Kholy, M. Ksantini, N. Seraphides, and S. Shdiefat. 2010. Olive Gap Manual. Good Agricultural Practices for the Near East & North Africa Countries. *FAO ISBN 978-92-5-106348-4*, 260p. Food and Agriculture Organization of the United Nations, Regional Office for the Near East, Cairo, Egypt.
- Papayiannis, L.C. 2010. *Pepino mosaic virus* (PepMV): A new virus disease of tomato crops in Cyprus. *Enimerotko Deltio 1*, Agricultural Research Institute Publications (ISSN 1986-1370). Nicosia, Cyprus (in Greek). 18p.
- Hadjipavlou, G. 2011. Improvement of productive and reproductive characteristics and disease management of farm animals. A review of research activity from 1975 onward at the Animal Production Section of the Agricultural Research Institute. *Enimerotiko Deltio 2*, Agricultural Research Institute Publications (ISSN 1986-1370). Nicosia, Cyprus (in Greek). 30p.
- Papayiannis, L.C. 2011. Tomato yellow leaf curl disease and its whitefly vector (*Bemisia tabaci* Gen-nadius). *Enimerotko Deltio 3*, Agricultural Research Institute Publications (ISSN 1986-1370). Nicosia, Cyprus (in Greek). 40p.

## SEMINARS

A total of 14 seminars were presented in 2010 and five in 2011. The seminars were chaired by Messrs G.A. Soteriou and A. Kyratzis.

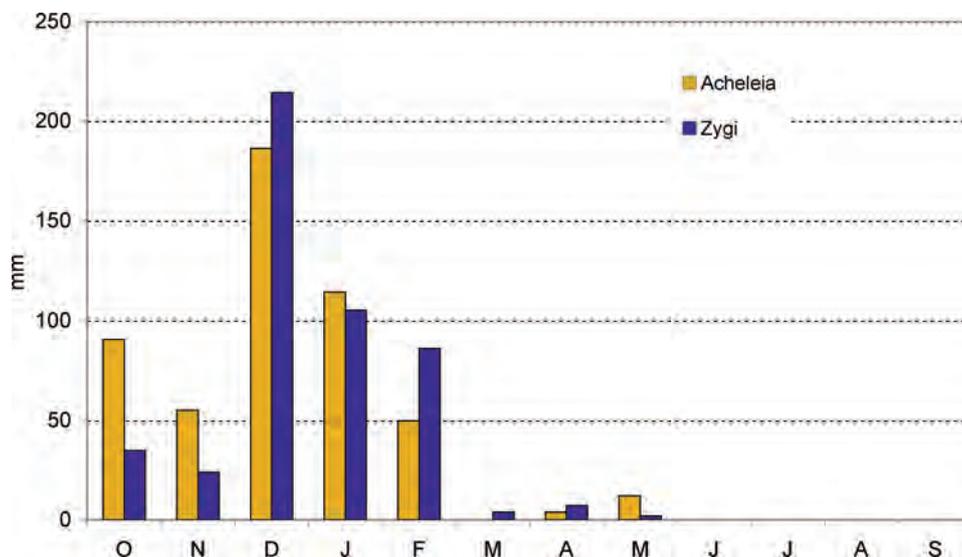
- January 14, 2010 G. Minas: Micropropagation in modern agriculture.
- January 28, 2010 A. Kyratzis: The Agricultural Research Institute's Genebank.
- February 18, 2010 M.C. Kyriacou and G.A. Soteriou: Yield and quality of watermelon late cultivars in relation to rootstock and postharvest storage.
- March 11, 2010 G. Karaoglanides: Genetic variation and sensitivity profile of *Botrytis cinerea* in fungicides
- March 18, 2010 Workshop on citrus culture:
- G. Aristides: Citrus culture in Cyprus
  - A. Georgiou: Citrus rootstock evaluation
  - Th. Kapari- Isaia: Micropropagation in vitro, molecular and genetic characterisation of new citrus rootstocks
- March 24, 2010 Workshop on citrus tristeza virus:
- M. Bar-Joseph: What should the Mediterranean citrus industries learn from the Greening/Huanglobing epidemics in America?
  - A. Kyriakou: Viral and other diseases of citrus in Cyprus
  - P. Kyriakopoulou: Viral and virus-like diseases of citrus crops in Greece
  - D. Dimou: Tristeza ante portas?
  - Th. Kapari-Isaia: Management of citrus tristeza virus in Cyprus
  - L.C. Papayiannis: Molecular characterization of citrus tristeza virus isolates from Cyprus
- April 14, 2010 Th. Kapari-Isaia: Citrus tristeza virus and other diseases threat to Cyprus citrus

## Seminars

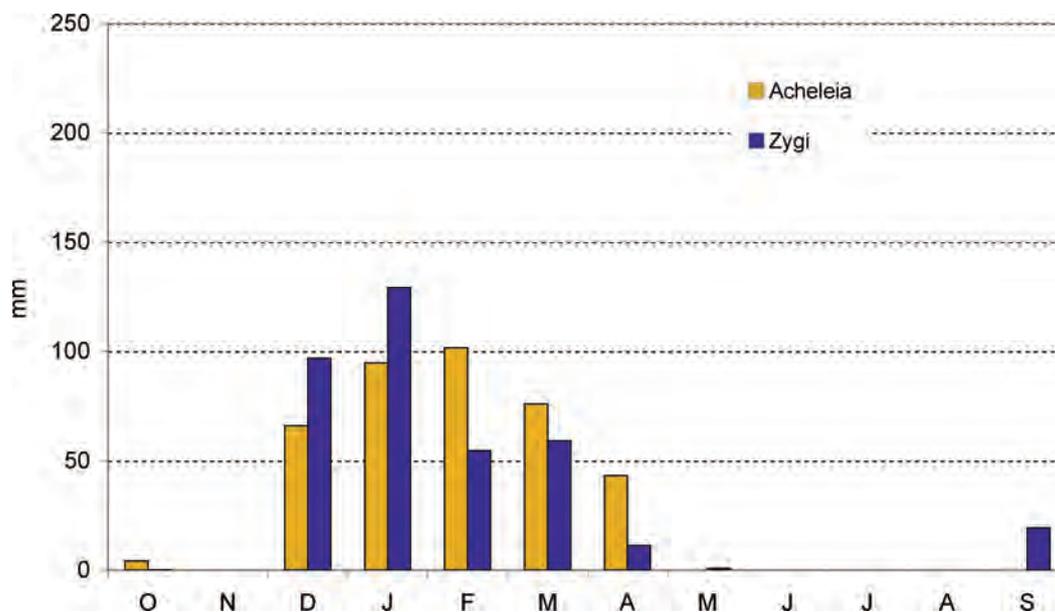
- April 29, 2010      Workshop on vegetable crop protection:
- G. Chatzikostantis: Vegetable cultivation in Cyprus
- Ant. Melifronidou: Plant Health authorities in Cyprus
- G. Papadoulis: Mites of greenhouse cultures
- N.A. Seraphides: *Tuta absoluta* (Lepidoptera: Gelechiidae): a new tomato pest in Cyprus
- V.A. Vassiliou: Investigation of insecticide resistance of *Bemisia tabaci* in Cyprus
- L.C. Papayiannis: Virus diseases infecting vegetable crops in Cyprus
- May 20, 2010      G. Hadjipavlou: Genetic approaches for the improvement of productive and reproductive characteristics and disease management of farm animals
- June 3, 2010      D. Sparaggis: Cyprus sheep and goat production: problems and perspectives
- June 17, 2010     G. Adamides: Using ICT for agricultural research development
- June 24, 2010     Th. Kapari –Isaia: Elimination of citrus viruses in Cyprus and Greece
- July 8, 2010      D. Neocleous: Hydroponics in commercial practice
- July 15, 2010     S. Ioannou and M. Giannakopoulou: Standard results analysis from Cypriot Farm Accountancy Data Network (2004-2008)
- November 4, 2010 J. Filis: Plant parasitic nematodes in Cyprus
- February 17, 2011 C. Stavridou: Use of aromatic plants in agriculture
- March 24, 2011    M. Omirou: Pesticides remediation using microorganisms: BIOBEDS
- March 31, 2011    P. Dalias: Fertilizer value of manure
- May 19, 2011      G. Adamides: Robotics in agriculture: principles of human-robot interaction
- June 30, 2011     M.C. Kyriacou: Postharvest heat treatment of fresh fruits and vegetables

## WEATHER CONDITIONS

Rainfall data from the meteorological stations of the Agricultural Research Institute at Acheleia and Zygi.



**Figure 1.** Monthly rainfall at Acheleia and Zygi, for the period October 2009 - September 2010. During this meteorological year, rainfall was 478 mm at Zygi (120% of normal at the station) and 512 mm at Acheleia (127% of normal).



**Figure 2.** Monthly rainfall at Acheleia and Zygi, for the period October 2010 - September 2011. During this meteorological year, rainfall was 371 mm at Zygi (93% of normal for the station) and 385 mm at Acheleia (95% of normal).

## FINANCE

	2010	2011
	€	€
State Officers	3,235,709	3,216,561
Government Hourly Paid Staff	2,252,710	2,276,307
Operating Expenses, Maintenance and Repairs	435,695	384,382
Personnel Training/Conferences,Seminars and Other Events	41,321	7,680
Purchase of Stationery, Mobile Machinery and Equipment	24,486	13,257
Erection, Extensions and Improvement of Buildings	409,428	189,206
Research and Experiments for Plants	1,303,050	1,222,178
Research and Experiments for Animals	477,962	468,966
Other Research and Experiments	125,327	141,147
Programmes Financed by Foreign Organisations and/or Other Sources	110,892	49,524
Harmonisation Programme with the Acquis Communautaire	104,169	92,126
Projects Cofinanced by Community Funds	36,932	86,202
<b>Total</b>	<b>8,557,681</b>	<b>8,147,536</b>

## LIBRARY INVENTORY

	Total number of volumes	
	2010	2011
Books (including bound journal volumes)	9,341	9,645
Journals from Government funds	71	71
Journals free-of-charge or on exchange basis	53	53
Proquest Data Base		



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