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AIM AND SCOPE OF THE SYMPOSIUM

The production of fruits and vegetables will have to improve in the near future, in order to feed a growing and knowing population, while facing global changes and environmental issues. This entails limiting the dependence of horticulture on external inputs, promoting high standards of produce quality and maximizing ecosystem services.

INNOHORT symposium will bring together researchers from a wide horizon, willing to share their views and knowledge to design the integrated and organic horticultural cropping systems of tomorrow. Scientific breakthroughs also rely on the integration of different forms of knowledge in the innovation process.

One ambition of this symposium is also to examine to what extent gaps can be bridged between scientists from different backgrounds, between researchers and stakeholders, between research and action.

Program and abstract book

This booklet contains the general symposium program, followed by the abstract. Each session includes the page numbers where the abstracts for that session can be found. The oral abstracts (presenting author is underlined) are listed first in the order of their planned presentation during a session, then followed by abstracts under that topic that will be presented as posters, where they will be grouped by each of the 5 topics addressed. Also enclosed are the presentations of the workshops and field visits.

Organizers and financial support

INNOHORT 2015 is being held under the auspices of the International Society of Horticultural Science (ISHS), Commission Organic Horticulture. It builds upon previous meetings in Vignola, Italy (2008), Leavenworth, USA (2012) and Avignon (2013). INRA PACA, Ecodevelopment Unit, University of Avignon and TERSYS Federative Research Structure have provided fruitful support for the planning and execution of the symposium.

For their financial support, we warmly thank the Fruit GIS (Group of Scientific Interest), Research Projects (ARDU from INRA Smash MetaProgram and HEALTHYGROWTH within EU ERA Net CORE ORGANIC II), PACA region, ProNatura, APAL (Producers Association of Official AOC Lavender Essential Oil of Provence), Ciras & Synerly, and Domaine le Garrigon.

We also thank all the members of the organizing and scientific committees for their key contributions.
Monday 8th
12:00 pm - 2:00 pm  Registration material and posters arrangements (display, copy of presentations)

2:00 pm  Opening session — “Setting the scene”
Bonastre J-F, UAPV, Welcome address
Bariteau M. INRA PACA, Welcome address

Plenary
Bellon S. INRA PACA & Urban L. UAPV, TERSYS, Symposium rationale and objectives

Invited speakers
Donghan A. Innovative fruit tree architecture as a nexus to improve sustainability in orchards
Lescourret F., Poncelet C., Simon S. Insights on the ecological control of pests in horticulture
Desjardins Y. Health components and values of horticultural products

General discussion

5:30 pm - 6:30 pm  Poster session
Hall

5:30 - 6:30 pm  Business meeting of the ISHS Organic Fruit Work Group
Room1

5:30 - 6:30 pm  Workshop Blanke M. Ethylene absorbers along the food chain.
Room2

6:30 pm - 7:30 pm  Social Event — in the Garden

Tuesday 9th

3:00 am  TOPIC 1 – The biological dimensions of production (quantity and quality, nutritional and organoleptic): new knowledge to mobilize, from gene to the fresh product – Chairmen: N. Bertin & M. Lateur

Room 1
Oral presentations
Nevéu L.C. Productivity and fruit quality in integrated and conventional production systems of 2 species of Açaí
Durand-Huel M. Distribution of phenolic compounds across contrasting Citrus cultivars using a UPLC-MS approach
Graneli A. Variability in fruit volatile production. From volatile compounds to genes and back
Albert E. Genetic and genomic control of resistance to water deficit in cultivated tomato
De Oliveira L. Host factors for brown rot resistance in peach fruit

Poster presentations
Altinol Galée J. Characterization of Guava plants belonging to a germplasm bank and cultivated in organic systems
Prohens J. Strategies for the enhancement of local tomato varieties: a study case with varieties from the Spanish region of Valencia
Monforte A. The variability in European TRADitional TOMato varieties: a first survey of the TRADITOM resource
Gautier H. Consequences of high temperatures and drought on peach fruit production strongly depend on their period of occurrence
Gautier H. Impact of elevated temperatures on tomato fruit size and composition
Bureau S. NIRS and prediction of internal quality traits of fruits: comparison of three fruit species

General discussion

9:00 am - 12:30 pm  TOPIC 3 – Session 1 – Crop and quality management: cultural and post-harvest practices at various levels of organization – Chairmen: M. Tchamitchian & F. Weibel

Room 2
Oral presentations
Hazeling A. Assessment of agricultural biostimulants on diseases, tree growth, fruit yield and quality in an organic apple orchard
Siegward T. Differentiating oriental fruit moth and codling moth larvae using near-infrared spectroscopy
Borschinger B. New multiplex PCR method for rapid field characterization of the genetic diversity of Pseudomonas syringae
Malusa E. New fertilizers and soil amendments for organic horticultural crops: mechanisms of action and performance
Sorensen J. Strategies for cut-and-carry green manure production
Pepin S. Assessing the potential of biochar as a growing media component for potted plants
Dameron L. Recognition algorithms for detection of apple fruit in an orchard for early yield prediction

Poster presentations
Reighard G. Irrigation scheduling based on soil water volume increases profitability of peach production
Koot A. Half-high bush blueberry ‘Northblue’ plant growth in juvenile stage dependent on the fertilizers under organic conditions
Millan M. Mobilization of natural processes for better nitrogen availability in an organic orchard
Pepin S. Fertilization management for organic cucumber grown in raised demarcated beds
Law-Ogboro K. Enhancing soil nutrient status and cucumber yield through organic wastes on humid ultisol location
Law-Ogboro K. Effects of time of introduction of watermelon as live mulch on the performance of okra in humid ultisols.
Rom C. Ground cover management and nutrient source effects on growth and development of an organic apple orchard in US
Vladan F. Potassium coconut soap brings improvement for the woolly apple aphid control
Brashadaw T. Tree growth and crop yield of five cultivars in two organic apple orchard systems in Vermont, USA, 2006-2013
Owen J. Productivity in a low intensity and a high intensity 4-year organic vegetable crop rotation
Warlop F. Dirospilus suzukii, a growing threat for French horticulturists
Rychli K. San Jose Scale – the increasing problem of organic orchards

General discussion

12:30 pm - 2:00 pm  Lunch

2:00 pm  TOPIC 2 – Plant responses to biotic and abiotic stress factors: mechanisms involved, interactions and prospects for applications to organic and integrated production – Chairmen: P. Nicot & L. Urban

Room1
Oral presentations
Vincenzo G. Effects of severe water deficit on growth, non-structural compounds and polyphenols contents of peach fruit
Trinchera A. Rhizosphere interaction via AMF in an organic horticultural cropping system
Duvall H. A pyramiding strategy for resistance to root-knot nematodes
Meloidogyne spp. in Prunus rootstock material
Okiasu K. Effect of management and environmental factors on soil arthropod diversity in olive orchards in Crete
Rousselin A. Effects of cultural practices on Myzus persicae population dynamics in peach tree Prunus persica

Poster presentations
Parveaud C-E. Assessment of diseases susceptibility of peach cultivars
Vávra R. Dependence on leaf area and leaf number of apple trees on sum of temperatures
Mazzetti J-B. Effect of UVC and methyl jasmonate treatments on the biosynthesis of anthraquinone...
Caromel B. Screening tomato germplasm for resistance to late blight

2:00 pm  TOPIC 4 – Session 1 – Design and evaluation of integrated and organic horticultural cropping systems: innovative crop management and cropping methods – Chairmen: D. Granatstein & E. Malezieux

Room 2
Oral presentations
Tchamitchian M. M. Food systems or vegetables: we don't need to choose (introductory talk)
Rocuzzo G. Application of agro-ecology concepts to orange cultivation in Southern Europe
Zoppolo R. Area-wide pest management in deciduous fruits of Southern Uruguay
Boisclair J. Abundance of predatory bugs on ten flowering plant species with potential use in habitat management to control horticultural insect pests
Rocuzzo G. Application of agro-ecology concepts to orange cultivation in Southern Europe
Owen J. New agronomic techniques for high-quality organic sweet corn in maritime Canada
Bilen E. Performance of an organic vegetable rotation under Mediterranean experimental and on-farm conditions
Delate K. Ecosystem Services from Cover Crop-Based Organic Vegetable Systems
Penvern S. From orchard to agri-food system redesign to reduce pesticide use

Poster presentations
Owen J. Integrated cover cropping practices to reduce erosion in intensive, steep-sloped potato production
Permin B. Design and assessment of protected market gardening cropping systems suited to contrasted food systems
**Wednesday 16th - Field visits (2 parallel trips) and Gala Dinner**

**Thursday 17th**

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**Practical Session**

- Alaphilippe A. DEXiFruits, demonstration and test of an easy-to-use tool to evaluate the sustainability of fruit production systems.
## Sommaire

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### PARALLEL FIELD TRIPS

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Topics 1 and 3 (session 1) will be presented in parallel sessions on the 9th of June (am);

Topics 2 and 4 (session 1) will be presented in parallel sessions on the 9th of June (pm);

Topics 3 (session 2, am) and 4 (session 2, pm) will be presented in plenary sessions on the 11th of June.

Topic 5 will be presented in plenary session on the 12th of June (am).
HOW TO MANAGE FRUIT TREE ARCHITECTURE TO IMPROVE ECONOMIC AND ECOLOGICAL SUSTAINABILITY IN ORCHARDS

Alberto Dorigoni
E. Mach Foundation, San Michele a/A (IT)

Tree training drastically affects all cultural practices. After years of intense debate between different schools of thought, the fruit wall turns out to be more sustainable than long pruning systems for several reasons. Orchards trained in narrow and short rows are suitable to a set of opportunities, ranging from mechanization of thinning and weed control, summer pruning, winter window-pruning and minimum-drift tunnel sprayers, to the use of physical means like multi-task nets. New strategies linked to the fruit wall are under investigation, like inducing microclimatic modification by means of anti-rain nets or replacing tractor-driven traditional sprayers with multi-task microsprayers (also anti-frost and cooling) directly on the canopy. Orchard management can take advantage, as well as crop protection. Even worker safety is improved and both consumers and the environment can benefit from a strong reduction in chemicals and their drift. Totally pedestrian “viticulture-like” tree shapes potentially offer further advantages, from better light interception to simplification of cultivation techniques.

INSIGHTS ON THE ECOLOGICAL CONTROL OF PESTS IN HORTICULTURE

Françoise Lescourret, Christine Poncet, Sylvaine Simon
1 INRA AVIGNON, UR PSH (Plantes et Systèmes de cultures Horticoles), 84914 Avignon Cedex 9, France ; 2 INRA, Univ. Nice Sophia Antipolis, CNRS, UMR 1355-7254 Institut Sophia Agrobiotech, 06900 Sophia Antipolis, France ; 3 INRA, UE0695 Gotheron Experimental Unit for Integrated Research, 26320 Saint-Ma
cel lès Valence, France

In horticulture, strong market requirements regarding the visual quality of products and very high levels of pest risks have led to intensive use of pesticides worldwide. The need for environmentally friendly pest control, which has found echo in the development of IPM, is today exacerbated by pressing social demand and policy contexts such as the European directive on pesticides. At the same time, the growing interest of the scientific community for new disciplinary branches and concepts such as agroecology, ecosystem services and ecological intensification, calls for a renewal of the research on pest control.

A conceptual framework is presented that addresses the issue of the ecological control of pests in horticulture. It is based on key ecological concepts - food chain, biotic interactions, niche and dispersal. This framework stresses the trophic and non-trophic interactions occurring between the components of three trophic levels - plants, pests, and natural enemies. It highlights the effect of agroecosystem management on these components, namely on the niche dimensions and dispersal of pests and enemies, and its consequences on pest control. This management includes the addition of biodiversity - biological control agents, banker plants, semi-natural habitats ... It also consists in practices – choice of plant genotype, plant training, nutrition and watering, climate regulation - to control the functioning of the crop and that of the introduced plant biodiversity.

Examples deriving from greenhouse and orchard studies are shown to illustrate salient points of the conceptual framework. These two horticultural systems, although they share concerns about the intensive use of pesticides, show significant differences with a much higher level of command in the greenhouse regarding both the design and the management of the ecosystem.

This approach is of high potential in horticultural systems, where there is the possibility to combine various sources of biodiversity and various technical levers. However, more knowledge on the functioning of target ecological networks is required to improve its robustness at the farm level. In addition, the way to design ecological pest control schemes integrating relevant protection methods deserves attention. Finally, a major current challenge that makes the issue more difficult is the necessity to consider the ecological control of pests within a set of multiple agroecosystem services to manage.

ASSESSING HORTICULTURAL PRODUCT QUALITY IN THE PERSPECTIVE OF SYSTEM BIOLOGY AND NUTRITION ECOLOGY: NEW PERSPECTIVES ON THE ROLE OF PHYTOCHEMICALS ON HEALTH

Yves Desjardins
Institut de Nutrition et des Aliments Fonctionnels, Laval University, Québec, Québec, Canada,
Over the last 100 years, agricultural practices have changed tremendously, depending heavily on fossil fuels and external inputs to boost yields. During this time, we have relied on the new knowledge of chemistry to simplify agricultural ecosystems and have lost, by doing so, the feedback loops and retroaction capacity of these complex biological systems. Likewise, the diet of humans living in industrialized countries has been profoundly simplified over the last decades, a phenomenon that has led to a dramatic surge in the incidence of chronic diseases like obesity, diabetes, cardiovascular and neurodegenerative diseases. As for agriculture, clinicians and medical doctors have looked at pharmacological approaches or specific nutrients to cure these civilization diseases. The promotion of antioxidants as miracle supplements to the diet by the industry illustrates this fact. Unfortunately, this simplistic approach does not stand the strict test of system biology.

This presentation will thus illustrate through two examples the complex impacts of phytonutrients on health and the difficulty of using these constituents of fruits and vegetables to assess product quality. In the first of these examples, we will explore the prebiotic effect of polyphenols on the gut microbiota and the reduction of chronic inflammation and improvement of insulin sensitivity. In the second, we will briefly explore the role of abscissic acid, as a stress metabolite in plants and mammals, and its potential impact on glycemic control and energy metabolism. The presentation will conclude with a brief discussion on the concept of nutrition ecology, which is directly related to integrated and organic horticulture principles.
TOPIC 1

The biological dimensions of production (quantity and quality, nutritional and organoleptic): new knowledge to mobilize, from gene to the fresh product

Coordinators: Nadia Bertin & Marc Lateur

Understanding biological processes is an asset in mastering fruit production. This session will address issues such as: desired traits for material adapted to ecologically-based horticultural systems; specifications for cultivars and their interactions with rootstocks and training systems; adaptations (e.g. polygenic) to circumventing and durable resistances; nutrients dynamics and flows and their manipulation to the crop’s advantage; components of fruit development and quality as related with environment and technology.

Oral presentations (9th of June, am)

PRODUCTIVITY AND FRUIT QUALITY IN INTEGRATED AND CONVENTIONAL PRODUCTION SYSTEMS OF 2 SPECIES OF AÇAI CULTIVATED IN THE BRAZILIAN AMAZON REGION

Leandro Camargo Neves¹, Luis Cisneros-Zevallos², Ronaldo Moreno Benedette¹, Pablo de Freitas Alves³

¹ Federal University of Roraima, Brazil; ² Texas A&M University (United States of America); ³ Graduated student (agronomist) - Brazil

The purpose of this experiment was to verify the productivity and fruit quality (organoleptic and functional compounds) of 2 species of açai produced in a conventional and integrated system in the Brazilian Amazon region. This study was carried out at rural property in the South of Roraima State/Brazil, and the physical-chemical analysis was performed at Food Technology Laboratory, in the Federal University of Roraima. The architecture of the orchards consisted of alternate rows from 4 to 6-year old of Euterpe oleracea Mart. and Euterpe precatoria Mart., using a 4 x 4 m spacing. Twelve açai trees of each species and system were randomly selected and assessed for productivity and fruit quality (organoleptic and functional compounds) during three seasons (2011/12/13). The integrated system showed lower fruit productivity (4.4 to 6.7%) and, berries with 8.2 to 11.5% less of fresh mass and seeds 5.3 to 8.5% heavier, for both species, in comparison with fruits cultivated under conventional production system.

For both species, fruits from the integrated orchards showed a more intense purplish color, higher soluble solids content and lower titratable acidity than fruits from the conventional orchard. Fruit from the integrated orchard had higher contents of phenolic, anthocyanins, flavones and vitamin C and higher antioxidant activity (ORAC and DPPH) than fruits of both species from the conventional orchard. In the organic system the fruits presented higher incidence of rot (5.2 to 13.4% higher). The sensory panel showed the preference for fruits cultivated in the integrated system, taking in consideration taste and flavor parameters, for both species.

Keywords: Roraima State, Amazonia, antioxidant, E. oleracea Mart., E. precatoria Mart.

DISTRIBUTION OF PHENOLIC COMPOUNDS ACROSS CONTRASTING CITRUS CULTIVARS USING A UPLC-MS APPROACH (PHENOLIC COMPOUND LANDSCAPE IN CITRUS)

Marie Durand-Hulak¹, Luc P.R. Bidel², Christian Jay-Allemand³, Frédéric Bourgaud⁴, Yann Froelicher¹, Anne-Laure Fanciullino⁵

¹ CIRAD, UMR AGAP, F-20230 San Giuliano, France; ² INRA, UMR AGAP, 34060 Montpellier, France; ³ Université Montpellier II, UMR DIADE, F-34394 Montpellier, France; ⁴ Université de Lorraine, UMR 1121 Laboratoire Agronomie et Environnement Nancy-Colmar, 54518 Vandœuvre-lès-Nancy, France; ⁵ INRA, UR 1115, Plantes et Systèmes de Culture Horticoles, 84914 Avignon, France

The polyphenol family encompasses several classes of molecules corresponding to different branching points of the biosynthetic pathway. Citrus plants produce large amounts of phenolic compounds, especially flavanones, flavones and coumarins. Some of them are specific to Citrus. In Citrus, these bioactive compounds are involved in fruit quality as well as in plant defense and therefore are a target of breeding programs with some compounds being desired and some others avoided. Many studies have characterized their composition in Citrus. However, few studies reported several classes of polyphenols in a single analysis. In addition,
although phenolic compounds vary strongly with developmental and environmental conditions, these factors are often omitted thus preventing comparative analyses. To overcome these problems, we took care to collect plant organs experiencing similar environmental conditions. This step is essential to link biochemical data to the key steps of the pathway involved in genetic variability or shifts in metabolite biosynthesis in different tissues. Then, we developed a high-throughput procedure that permitted rapid reconstruction of the distribution of main classes of soluble polyphenols in contrasting tissues and genotypes. We evidence that the combination of datasets from contrasting tissues improved cultivar classification based on polyphenol contents. Drawing a map of the distribution of phenolic compounds across cultivars highlights potential regulatory nodes of the biosynthetic pathway. In addition to the steps catalyzed by rhamnosyltransferases, we proposed that the steps catalyzed by phenylalanine ammonia-lyase, the step conducing to 2',4'-dihydroxyacetic acid from p-coumaric acid and the step involving flavone synthase were important regulatory nodes in “Clementine” and “Star Ruby” grapefruit.

Keywords: Phenolic compounds, flavonoids, coumarins, Citrus, UPLC-MS, high-throughput method, phylogenetic relationships, tissular diversity, biosynthetic pathway

VARIABILITY IN FRUIT VOLATILE PRODUCTION. FROM VOLATILE COMPOUNDS TO GENES AND BACK

JL Rambla, W. Barrantes, A. Monforte, Antonio Granell
Instituto de Biología Molecular y Celular de Plantas, Valencia, Spain

We present our current understanding of the mechanisms involved in the biosynthesis of volatile compounds in the ripe tomato fruit and their genetic control, with a focus on those that have a key role in tomato flavour. The progress and difficulties in identifying not only genes or genomic regions but also individual target compounds with actual potential interest for plant breeding will be discussed. The ample variability in the presence or accumulation of different volatile compounds can be observed in experimental populations derived from interspecific crosses and also between heirloom varieties and even commercial hybrids. The identification of Quantitative trait loci (QTLs) for tomato aroma volatiles identified in experimental populations involving different wild tomato species have delivered some intriguing results as (i) the general lack of clear co-localization with structural genes involved the volatile biosynthetic pathways and (ii) the low coincidence on the genomic regions associated among different crosses, indicating that there is huge genetic variability in the control of volatile compound accumulation, giving ample opportunities to alter volatile composition by breeding efforts. Additionally, some genes have been identified as strong candidate genes that may be useful as markers or as biotechnological tools to enhance tomato aroma. Finally, and based on recent reports, the conjugation of volatiles to other metabolites such as sugars will be presented as they seems to play a key role in the modulation of volatile release.

Keywords: tomato, volatiles, fruit quality

GENETIC AND GENOMIC CONTROL OF RESPONSE TO WATER DEFICIT IN CULTIVATED TOMATO

Elise Albert 1, Yolande Carretero 1, Justine Gricourt 1, Esther Pelpoir 1, Romain Novaretti 1, Claire Duffes 1, Julien Bonnefoi 1, Mathilde Causse 1
1 INRA, GAFL, F-85000 Montfavet, France; 2 GAUTIER Semences, F-13630 Eyragues, France

In the next decade water will be increasingly limiting crop production, in particular in Mediterranean region. Improving plant water use efficiency (WUE) by studying genotype x water regime (G x WR) interactions is of main interest to improve plant adaptation to low water availability. At different degrees, plants can change their phenotypes (molecular, morphological and physiological levels) in response to environmental changes. These modifications relate to phenotypic plasticity. In Tomato (Solanum lycopersicum L.), extensively grown in Mediterranean region, first studies have shown genetic variability in the response to water deficit, but very few genes/QTLs have been identified and mostly in wild relative species. Studying water deficit in this fleshy fruit is of particular interest since a well mastered water deficit can stimulate secondary metabolism production, increasing plant defenses and concentration of compounds involved in tomato fruit quality at the same time. In our laboratory, we analyzed 119 recombinant inbreed lines (RIL population) and 142 unrelated cherry tomato (Solanum lycopersicum L. cerasiforme) accessions (GWA population), grown in greenhouse under two watering regimes (WR), in two locations (Morocco and France). Plants were phenotyped for plant phenology, plant vigor and fruit quality traits. We assessed genetic variability and G x WR interactions, for the above traits in the two populations. QTL and GWA analysis were conducted to identify QTL x watering regime (QTL x WR) interactions. The presentation will give a short overview of the research methods available to study genotype by environment interactions in plant and to present the first results of our research project. The possible use of slight water deficit to improve tomato fruit quality in future breeding programs will be investigated.

Keywords: Genotype x Environment interaction, QTL, GWAS, linkage mapping, water deficit, tomato

HOST FACTORS FOR BROWN ROT RESISTANCE IN PEACH FRUIT

Lino Leandro de Oliveira
INRA, GAFL, F-85000 Montfavet, France

Brown rot in peach fruits caused by the fungi Monilinia sp. is a common disease that can provoke as much as 30 to 40% losses of crop. Little is known on the fruit resistance factors and the infection process. The aim of this study is to investigate the factors of resistance of the fruit and their genetic control. This would provide a tool to rationalize genotype x cultural practices combinations in order to reduce brown rot incidence. Physical and biochemical characteristics of fruits (skin conductance, stomatal density, μcracks, surface compounds, epidermis phenolics) potentially linked to Monilinia resistance were investigated in cultivars contrasted for their susceptibility. Two segregating populations were phenotyped by infection tests in order to detect QTL
controlling brown rot resistance. Fruit cuticular conductance was characterized for one of the populations. Fruit infection was observed by microscopy. Preliminary results in contrasting genotypes for resistance to brown rot show significant differences of number of fruit stomata and variations of surface compounds and their levels. In the microscopy analyses, high number of cases of germination and penetration of fungi through stomata and microcracks were observed. The knowledge gained from these experiments will be integrated into an existing ecophysiological model in order to optimize concurrently fruit characteristics and cultural practices to reduce infection risks.

Keywords: Brown rot, Monilinia, resistance, phenotyping, microscopy, peach.

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CHARACTERIZATION OF GUAVA PLANTS BELONGING TO A GERMPLASM BANK AND CULTIVATED IN ORGANIC SYSTEM

Juliana Altairin Galli 1, M.C. de A. Palharini 2, M. D. Michelotto 3, M. B. B. Soares 4, A. L. M. Martins 1, I. H. Fischer 2

1 Apta Regional Center North, 15830-000, Pindorama-SP, Brazil; 2 Apta Regional Midwest, 17030-000, Bauru-SP, Brazil

Guava is one among many farmed species that has high genetic diversity. With the increased demand for organic products, the research sector is also giving greater attention and seeking to solve problems that we have in the production process. The present work had as objective to evaluate the physico-chemical characteristics of accessions of guava trees belonging to a germplasm bank, in order to identify materials with commercial aptitude for possibility of use in organic system. The production was calculated by counting the number of fruits per plant. For the evaluation of the fruits physical characteristics, were made the following assessments: fruit mass; longitudinal and transverse fruit diameter; mass and number of seeds; pulp firmness; peel and pulp coloration. For the fruits chemical characteristics, the parameters were evaluated: soluble solids; titratable acidity; pH; Ratio and ascorbic acid content. Generally speaking, the production of all guava accessions was lower than the obtained in publications held on commercial orchards. The accessions presented average fruit mass quite heterogeneous between 12.53 to 208.51 grams. Following the criteria form of fruits, piriformis or rounded, the accessions IAC-4, Monte Alto White, IAC-4-Cica and Campos could serve for the industry and the fresh consumption, while the other accessions, for fresh consumption. For fresh consumption, Kioshi 1 and Taquaritinga Common accessions worth mentioning, for they good sized fruits (> 100 g) and firm, important feature for transportation and marketing; feature good content of ascorbic acid; good soluble solids content (approx. 9° Brix) and low acidity, approximately 0.5% of citric acid; have piriformis format, rough skin, skin and pulp color desirable. Another accession that deserves attention is the EEF-3 by its high content of ascorbic acid (269.7 mg/100g) that can be used in breeding programs.

Keywords: Psidium guajava, production, quality.

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STRATEGIES FOR THE ENHANCEMENT OF LOCAL TOMATO VARIETIES: A STUDY CASE WITH VARIETIES FROM THE SPANISH REGION OF VALENCIA

Maria R. Figàs 1, Salvador Soler 1, María José Díez 1, Antonio Granell 2, Antonio Monforte 2, Jaime Prohens 2

1 Institut de Conservació i Millora de l’Agrodiversitat Valenciana, Universitat Politècnica de València, Camí de Vera 14, 46022 València, Spain; 2 Plant Genomics and Biotechnology Lab, Instituto de Biología Molecular y Celular de Plantas, Consejo Superior de Investigaciones Científicas, Universitat Politècnica de València, Camí de Vera 14, 46022 València, Spain

Consumers demand for local tomato varieties is increasing due to their traditional association with better organoleptic properties and with the so-called “flavour of the past”. When these characteristics are combined with integrated or organic...
production, they result in added value commodities. Many local varieties of tomato can be found in the countries around the Mediterranean, and this diversity can be exploited for their enhancement by applying different strategies. In this work, we present the approaches used for the valorisation of local varieties from the region of València, as exemplified by the most locally appreciated types: ‘Valenciana’ and ‘De Penjar’. While the former has large heart-shaped fruits and relatively short shellfife, the latter has small fruits and long-shelf life caused by the alcobaça (alc) mutation. Given the wide diversity present in local tomatoes, a morphological characterization is required for their typification and identification of their distinctive or unique characteristics. Using both conventional and phenomics morphological descriptors it is possible to establish the morphological characteristics of the different types, which is important for obtaining quality marks or protected status for these materials. Ongoing molecular characterizations will provide specific genetic fingerprints that will assist in the precise identification of each of the local types and avoid variety authenticity infringements. The analysis of traits related to organoleptic and functional quality is allowing the identification of local materials with improved quality and market value. In this respect, combined selection for morpho- agronomic characteristics together with composition traits is resulting in the identification of local varieties with excellent combinations of agronomic performance and quality for the ‘Valenciana’ and ‘De Penjar’ types. All these strategies, based on the multiple characterization and selection of the best local varieties within each type are contributing to the enhancement of local tomato varieties.

**Keywords:** local types, characterization, molecular markers, selection, *Solanum lycopersicum*

THE VARIABILITY IN EUROPEAN TRADITIONAL TOMATO VARIETIES: A FIRST SURVEY OF THE TRADITOM RESOURCES

Antonio Granell (representing the TRADITOM Consortium), Antonio Monforte

Instituto de Biología Molecular y Celular de Plantas, Valencia, Spain

Europe is a secondary center of diversity for tomato, with hundreds of local varieties having evolved under different environments and selected for specific uses over the last 500 years. Traditional tomato taste, in addition to other important characteristics such as the ability to grow under low inputs, an extended shelf-life while maintaining fruit sound and good organoleptic characteristics, or a high content in bioactive compounds of interest for human health, are present in a range of European traditional tomato varieties. Traditional tomato resources deposited in public repositories or still available in small farms are of great interest for satisfying the increasing demand by consumers for high quality traditional tomatoes. They also represent a rich genetic resource that needs to be preserved and characterized in detail so that in combination with wild relative alleles can contribute to the development of elite varieties able to satisfy the demands of the consumers and the challenges imposed by climate change in a context of producing more and of better quality with less inputs. The general outline of TRADITOM, a recently funded H2020 project will be presented. The project is aimed at the enhancement of European local varieties of tomato for agricultural diversification with impact on food security and health. A first look at the genetic and phenotypic variability of European tomato local varieties will be described and put in the context of other tomato genetic resources currently available for the tomato researcher and breeder. The project approach, which involves a combination of omics strategies, will be presented.

**Keywords:** traditional Tomatoes, variability.

CONSEQUENCES OF HIGH TEMPERATURES AND DROUGHT ON PEACH FRUIT PRODUCTION STRONGLY DEPEND ON THEIR PERIOD OF OCCURRENCE

Fatima Adra 1, Ver cambre Gilles 1, Plénet Daniel 1, Bakan Bénédicte 1, Noblet Agathe 1, Ammar Aroua 2, Mickael Maucourt 45, Stéphane Bernillon 3 5, Catherine Deborde 3 5, Moing Annick 1 2, Gibon Yves 1 5, Hélène Gautier 1

1 INRA, UR1115 Plantes et Systèmes de culture Horticoles, 84914 Avignon, France ; 2 INRA, UMR 1268, B.I.A, 44316 Nantes ; 3 INRA, UMR1332, Biologie du Fruit et Pathologie, 33140 Villenave d’Ornon, France ; 4 Univ. Bordeaux, Biologie du Fruit et Pathologie, (same address) ; 5 Plateforme Météabolome du Centre de Génomique Fonctionnelle Bordeaux, MetabohUB, IBVM, Centre INRA Bordeaux, 33140 Villenave d’Ornon, France

In the context of climate change and increasing water scarcity, the adaptations of orchard management and irrigation strategy in order to maintain crop yield are needed. Maintaining crop quality is another major objective that has seldom been taken into account despite the consumer’s demand for better tasting fruits. Experiments have been carried out to evaluate the impact of climate change on fruit production and quality. Irrigation deficits or increased temperatures have been applied during different stages of the fruit development of Prunus persica L. Batch to determine the key periods and the key processes sensitive to extreme climate events.

During the initial stages of fruit development, both water limitation and increased temperature strongly promoted fruit abortion. Water limitation also strongly reduced fruit size at harvest and consequently fruit commercial value. On the other hand, elevated temperature led to an acceleration of the vegetative growth that could trigger a competition between fruit and leaf for assimilate supply, thus increasing fruit abortion. Water limitation during cell division also modified fruit cuticular properties and induced an increase in fruit transpiration.

Water limitation during peach stone formation did not affect the diameter and the flesh composition of the ripe fruit. When water limitation was applied later, i.e. during fruit expansion and ripening, fruit growth was delayed but the sugar content of the fruit flesh was improved (metabolic composition estimated using robotized biochemical phenotyping and metabolomic profiling).

These results underline that the initial stages of fruit development are critical. They are very sensitive to water deficit and increased temperature, which impact final fruit yield and composition. Considering these responses, a cooperative work must be engaged between eco physiologists and geneticists to design new peach genotypes better adapted to Climate Change.
Keywords: peach, water deficit, temperature; fruit; growth; quality, metabolomics.

IMPACT OF ELEVATED TEMPERATURES ON TOMATO FRUIT SIZE AND COMPOSITION
Juan Manuel Ruiz 1,2, Oscar Ayala 1, Doriane Bancel 2, Jean-Claude L’Hôtel 2, Patrick Orlando 2, Valérie Serra 2, Béatrice Brunel 2, Michel Génard 2, Hélène Gautier 2
1 Colegio de postgraduados, Institucion en ensenansa e investigacion en ciencias agricolas, Montecillo, Texcoco, State of Mexico, Mexico; 2 INRA, UR1115 Plantes et Systèmes de culture Horticoles, 84914 Avignon, France

Several studies have been devoted to analyze the consequences of water shortage on horticultural crop production, but less is known about the effects of elevated temperatures. Increasing temperature will affect the growth and developmental rate of organs; it will also affect several processes mediated by enzymes such as photosynthesis, respiration and metabolism. This study was aimed to identify the key processes and metabolic pathways sensitive to elevated temperature in tomato at the fruit level.

Two experiments were carried out under glasshouse on Solanum lycopersicum L. Cv. Money Maker. During the first experiment, heating systems have been positioned below the selected truss to increase fruit temperature and continuously obtain four different temperature regimes (+3, +6, +9 °C and the control), taking the fruit temperature of control plants as a reference. During the second experiment, fruit were subjected to an offset temperature (+6°C) at different periods of the day or night compared to the control to determine whether increased temperature during day and night had the same effect or not on fruit composition.

Heating the fruit from 20 days post-anthesis until harvest shortened the fruit developmental duration and diminished fruit final size at harvest. It did not affect fruit dry matter content, but it increased fruit content in malate, glucose, calcium, potassium, phenolic compounds and rutin, whereas it decreased sucrose content and had no effect on vitamin C content. These results underline that fruit size and composition at harvest strongly depend on pre-harvest temperature experienced by fruit. Moreover distinguishing elevated temperature during the day or during the night underlines that the accumulation of phenolic compounds strongly depends on night temperature experienced by fruit. Further works are necessary to determine the genericity of these effects on fruit size and composition considering several species and cultivars.

Keywords: tomato, temperature; fruit; growth; quality, sugars, acids

NIRS AND PREDICTION OF INTERNAL QUALITY TRAITS OF FRUITS: COMPARISON OF THREE FRUIT SPECIES
Sylvie Bureau 1,2, Gabrieli Alves de Oliveira 1,2,3, Catherine M.G. Renard 1,2, Adaucto Bellarmino Pereira-Netto 4, Fernanda de Castilhos 4
1 UMR408 Sécurité et Qualité des Produits d’Origine Végétale, INRA, Université d’Avignon, 84000 Avignon, France; 2 Université d’Avignon et des Pays de Vaucluse, UMR408 Sécurité et Qualité des Produits d’Origine Végétale, 84000 Avignon, France; 3 Graduate Program in Food Engineering, Paraná Federal University, 81531-980 Curitiba, Brazil; 4 Food Engineering, Paraná Federal University, 81531-980 Curitiba, Brazil

The near infrared spectroscopy (NIRS, 800-2500 nm) is known as a non-destructive rapid tool to study internal fruit quality. This technique appears indeed suitable for the determination of soluble solids content (SSC) and titratable acidity (TA). The objective of this work was to study the effect of the fruit structure on the model performance to predict SSC and TA, based on the comparison of correlation coefficient R2 and root mean square error of cross-validation (RMSECV). The chosen fruits were passion fruit, tomato and apricot. Good performance was obtained for apricot with R2 of 0.93 and 0.95 and RMSEP (in %) of 3.3% and 14.2% for SSC and TA respectively. For passion fruit and tomato, the models appeared not satisfactorily accurate to predict SSC and TA in relation to lower R2 and higher RMSEP. NIR technology was appropriate to evaluate the internal fruit quality of apricot, but less for tomato presenting a heterogeneous internal structure and not for passion fruit presenting a thick skin.

Keywords: Near infrared spectroscopy, fruit structure.
TOPIC 2

Plant responses to biotic and abiotic stress factors: mechanisms involved, interactions and prospects for applications to organic and integrated production

Coordinator: Philippe Nicot & Laurent Urban

The health of horticultural systems is affected by environmental conditions. This session will explore health issues at various levels, from plant to landscape: knowledge of microbial community on leaf surfaces as influenced by management practices; methods to predict the influence of beneficial microorganisms on pathogens or pest complex; achievements and outcomes in biocontrol R&D (“top-down”, “bottom-up”, “push-pull” approaches); effects of field and landscape management on biodiversity, epidemiology of crop enemies and species regulation...

Oral Presentations (9th of June, pm)

EFFECTS OF SEVERE WATER DEFICIT ON GROWTH, NON-STRUCTURAL COMPOUNDS AND POLYPHENOLS CONTENTS OF PEACH FRUIT

Mitra Rahmati, Gilles Vercambre, Gholam Hossein Davarynejad, Mohammad Bannayan, Majid Azizi, Michel Génard

INRA AVIGNON, UR PSH (Plantes et Systèmes de cultures Horticoles), 84914 Avignon Cedex 9, France

Little is known about the direct effect of drought on fruit metabolism and thereby on the non-structural compounds (carbohydrates, organic acids and polyphenols) contents and its indirect effect through dilution. In this study the sensitivity of peach fruit composition to three water stress levels in semi-arid conditions, as well as the origin of variations in fruit composition – not only in carbohydrates and organic acids, but also in secondary metabolites such as polyphenols were assessed. Fruits grown under drought conditions were significantly smaller. Drought increased the dry matter content, the structural dry matter (SDM) content and the firmness of the fruit due to lower water import to fruits although drought reduced the fruit surface conductance and its transpiration. The concentration of each non-structural compound was impacted by different water deficit levels either through the decrease in dilution and/or modifications of their contents: SDM ratio. The increase of the sweetness index in fruits grown under drought conditions was related to the increase in hexoses and sorbitol concentrations. The increase in stress intensity resulted in higher malic acid concentration and content: SDM ratio, but lower those of citric and quinic acids. Polyphenol concentration and content were strongly affected by the severity of water scarcity. The increase in the concentration of total carbohydrates and organic acids at harvest was mainly through a decrease in fruit dilution, whereas higher concentrations of polyphenols were also strongly resulted from an impact on their metabolism.

Keywords: Prunus persica L.; drought; fruit surface conductance; carbohydrates; organic acid; structural material; sweetness.

RHIZOSPHERE INTERACTION VIA AMF IN AN ORGANIC HORTICULTURAL CROPPING SYSTEM. EFFECT OF LIVING MULCH ON ORGANIC ARTICHOKE MYCORRHIZATION

Alessandra Trinchera¹, Elena Testani³, Corrado Ciaccia¹, Gabriele Campanelli², Fabrizio Leteo², Stefano Canali¹

¹ Consiglio per la ricerca in Agricoltura e l’analisi dell’economia agraria - Centro di ricerca per lo studio delle Relazioni tra Pianta e Suolo (CRA-RPS), Rome (Italy); ² Consiglio per la ricerca in Agricoltura e l’analisi dell’economia agrarian - Unità di ricerca per l’orticultura (CRA-ORA), Monsampolo del Tronto (AP, Italy)

In a multi-crop system, such as a designed-organic horticultural one, the cash crop, the agro-Ecological Service providing Crops (ie., living much, cover crops, etc.) and the weeds share the same space, by communicating each other and exchanging water and nutrients through the root network, in which the AMF infection could play a key-role in overcoming P deficiency and, more generally, nutrient and water stresses. Our hypothesis is that, in such tailored organic systems, the ESCs promote the belowground plant-microorganisms interactions through AMF infection, so as to improve nutrient uptake by the cash crop. In order to verify this hypothesis, in a two-year experiment, artichoke (Cynara cardunculus L. var. scolymus L.) was intercropped with a selected mix of cover crops in a randomized block design with
two factors: the living mulch (LM and no LM) and the artichoke cultivar (Mazzaferrata and Jesino). Electron scanning microscopy and optical microscopy were applied on artichoke roots at the end of the cropping cycle for evaluating AMF infection. Artichoke yield and N-P vegetation content were also determined for evaluating the effect of AMF infection on nutrient uptake.

At comparable crop yield, proliferation of root hairs, increase of mucilage exudation and a higher mycorrhization was recorded in LM artichokes respect to the no LM one (control), with a corresponding tendency to increase plant N and P uptake, suggesting that the greatest plant biodiversity in living mulch treatments, that is the coexistence of different plant species in confined spaces, promoted the fungi infection of neighboring roots, overcoming the competition for water and nutrient among the different plant species. The recorded cultivar-dependent result appears as an effective eco-physiological response of Jesino artichoke, higher sensitive respect to Mazzaferrata one, to ensure a proper P supply under potential nutritional stress conditions.

**Keywords:** living mulch, artichoke, root, mycorrhizal infection, electron scanning microscopy (SEM)

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**A PYRAMIDING STRATEGY FOR RESISTANCE TO ROOT-KNOT NEMATODES MELOIDOGYNE SPP. IN PRUNUS ROOTSTOCK MATERIAL**

Henri Duval 1, 2, C Van Ghelder 2 and D Esmenjaud 2

1 INRA, UR Génétique et Amélioration des Fruits et Légumes (UGAFL), 84914 Avignon, France ; 2 INRA, UMR Institut Sophia-Agrobioihtecte (ISA), INRA1355, CNRS7254, Université de Nice, 06903 Sophia Antipolis, France

Many Prunus species are used pure or in interspecific crosses as rootstocks for apricot, peach or almond crops. The wide genetic variability within the Prunus genus allows to breed a high diversity of rootstocks. Besides their graft-compatibility with the variety, rootstocks need a vigor fitting the growing system and an adaptation to the different types of orchard soils that may notably be waterlogged, dry or calcareous. However, stone fruit crops Prunus spp. grown under mediterranean climates are severely damaged by root-knot nematodes (RKN) Meloidogyne spp. and breeding for RKN-resistant rootstocks is a promising control alternative to nematicide ban. Resistance (R) genes that confer different spectra to the predominant species M. arenaria, M. incognita and M. javanica have been identified and mapped in plums (Ma and Rjav), peach (RMia) and almond (RMja). Thus sustainable resistance in Prunus is based on pyramiding of R genes in interspecific rootstock material to take into account the risk of resistance breaking in the durable plant-nematode interaction for perennials. In the INRA rootstock breeding program, marker-assisted-selection (MAS) for the Ma and RMia genes have been developed and some hybrid rootstocks carrying one or two R genes have been preselected. In Morocco, first trials in peach orchards infected with several RKN species have confirmed the expected R spectrum of these preselections in comparison with the susceptible control rootstock GF677. Identification of markers for the RMja almond gene will open the way to MAS of interspecific rootstocks ‘almond x peach x plum’ carrying three genes, one from each Prunus species.

**Keywords:** Rootstock breeding, Nematodes, Resistance, Prunus, stone fruit

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**EFFECT OF MANAGEMENT AND ENVIRONMENTAL FACTORS ON SOIL ARTHROPOD DIVERSITY IN ORGANIC, CONVENTIONAL AND INTEGRATED OLIVE ORCHARDS IN CRETE**

Vasileios Gkisakis 1,2,4, Dimitrios Kollaros 3, Paolo Bárberi 2, Ioannis Livieratos 4, Emmanouil Kabourakis 1

1 Ecological Production Systems, Institute of Viticulture and Horticuture, National Agricultural Research Foundation, Heraklion, Crete, Greece ; 2 Institute of Life Sciences, Scuola Superiore Sant’Anna (SSSA), Pisa, Italy ; 3 Laboratory of Ecology, School of Agriculture, Technological Educational Institute (TEI) of Heraklion, Crete, Greece ; 4 Department of Sustainable Agriculture, Mediterranean Agronomic Institute of Chania (MAICh), Crete, Greece

Research on the relation between the olive agroecosystem diversity and factors of disturbance and environment has been rather poor, despite its importance over a large area. The main objective of this study was to explore soil arthropods diversity response to management regimes and specific explanatory variables, including management practices, climate and landscape. Focus on the functional arthropod diversity was also pursued. The aim was to optimize the efficiency of soil arthropod diversity management in olive orchards under different production systems, considering as well other specific variables.

Soil arthropod diversity was monitored seasonally, for two years, in organic, conventional and integrated olive orchard, in Crete, Greece. Constant monitoring of soil management practices, climate conditions and landscape complexity was applied. A countergroup of functional taxa were defined, with respect to biological pest control and nutrient cycling services. Comparisons between management systems were performed and ordination techniques were used with soil management practices, landscape complexity and weather conditions as explanatory variables. The results showed that Coleoptera, Formicidae and Araneae were the most abundant, following similar studies. Higher number of total catches, appeared in the organic orchards, however differences were not statistically significant. Diversity did not present a constant pattern or significant differences among management systems. Organic management explained the biggest fraction of arthropod variability; however the total variability explained was rather low. Among factors used as explanatory variables, temperature, humidity, landscape complexity and pesticide application appeared to be most important.

Less intensive olive production systems favoured soil arthropod diversity. However, management system was the least decisive factors determining arthropod community composition. Climate conditions and heterogeneity of farming practices applied in commercial olive production, proved to be main explanatory factors, beyond the management system followed. The different responses of the arthropod taxa to the corresponding disturbances were also stressed.

**Keywords:** olive, soil arthropods, diversity, functional, management, disturbance, climate.
EFFECTS OF CULTURAL PRACTICES ON MYZUS PERSICAE POPULATION DYNAMICS IN PEACH TREE PRUNUS PERSICA

Aurélie Rousselin, Marie-Hélène Sauge, Gilles Vercambre, Danièle Bevacqua, Françoise Lescourret, Marie-Odile Jordan
INRA, UR 1115 Plantes et Systèmes de culture Horticoles (PSH), 84914 Avignon Cedex 9, France

The green peach aphid, Myzus persicae, is a major pest in peach orchards. In order to find alternatives to the use of chemicals for aphid control, it is crucial to better understand interactions between aphid population dynamics and tree status: growth, nutrient and water uptake and modification of biochemical composition. M. persicae acts as a flush feeder on peach tree. Thus, aphid abundance is expected to be maximized on vigorous non-stressed plants. We aim at evaluating the relevance of cultural practices as means of control of plant vigor and, as a result, of aphid population. We conducted an experiment on potted trees with 4 combinations of water (W+/W-) and nitrogen (N+/N-) supplies, and 3 intensities of winter pruning. Then we infested each tree manually. We monitored shoot growth, water and nitrogen status of the tree and aphid population levels during two months. Results showed strong positive effects of shoot growth and nitrogen level on aphid population, whereas water supply had a slighter impact. The results of this study will be used to formalize and develop an aphid’s module in QualiTree, a fruit tree model simulating the fruit development under various cultural practices.

Keywords: pest control, Hemiptera, Aphididae, Myzus persicae, Prunus persica, nitrogen fertilization, irrigation, aphid population dynamics, vegetative growth.

Poster Presentations (9th of June, pm)

ASSESSMENT OF DISEASES SUSCEPTIBILITY OF PEACH CULTIVARS IN EXPERIMENTAL PLOTS AND ON-FARM FOR ORGANIC AND LOW-INPUT SYSTEMS. BASELINE OF FRENCH CASE STUDIES

Claude-Eric Parveaud¹, Johanna Brenner¹, Sophie-Joy Ondet¹, Christelle Gomez¹, Gilles Libourel¹, François Warlop¹, Laurent Brun², Vincent Mercier², Guy Clauzel², Jean-Marc Audergon¹.

¹ GRAB, 84 911 Avignon Cedex 9, France; ² INRA UERI Gotheron, F-26320 St-Marc-Lès-Valence; France; ³ INRA GAFL Avignon, 84143 Montfavet Cedex, France

The choice of the cultivar is one of the keystones to reduce pesticide input in peach orchards. Breeders have selected peach cultivars that have mainly been assessed on yield and fruit quality in conventional farming systems. The disease susceptibility was not considered as a key criterion. Despite a great turn-over of new peach cultivars, their suitability for organic and low-input systems remains unknown for most of them.

A first program has been carried out from 2001 to 2008 in order to assess peach leaf curl, powdery mildew and aphid susceptibilities of 28 cultivars in a farm network and experimental stations. A high variability of leaf curl and powdery mildew susceptibilities was observed among the cultivars. In 2009, the two most promising cultivars have been included in a second assessment program among 10 other cultivars. A randomized experimental plot design took into account the spatial distribution of the disease pressure. The variability of peach leaf curl susceptibility between cultivars was strongly influenced by the disease pressure. Since 2011, susceptibility to peach leaf curl, aphids, blossom and Coryneum blight of 10 established peach cultivars has been assessed in a network of commercial organically farmed plots. Methodological considerations include the interaction between disease epidemiology, design and management of the orchard and the observed cultivar responses to specific pathogens. The potential and limits of farmers’ implication in cultivar assessment is discussed.

Keywords: cultivar susceptibility, fruit quality, Taphrina deformans, Monilia sp., Sphaeratheca pannosa var. persicae, organic farming.

DEPENDENCE ON LEAF AREA AND LEAF NUMBER OF APPLE TREES ON SUM OF TEMPERATURE AND ITS UTILIZATION IN PROTECTION AGAINST SCAB

R. Vávra ¹, T. Litschmann, V. Falta, M. Jonáš.
¹ Research and Breeding Institute of Pomology Holovousy Ltd. Holovousy 1 508 01 Horice, Czech Republic

Protection against apple scab is very difficult due to the change of resistance of the pathogen Venturia inaequalis to chemical agents and due to the climate change. More frequently and longer lasting periods of wet conditions which are very favourable for the development of the pathogen but very aggravating treatment against scab is making protection against apple scab complicated. This contribution evaluates the measurement of leaf area and leaf number in four apple
varieties ‘Idared’, ‘Golden Delicious’, ‘Melrose’ and ‘Rubin’ in 2013 and 2014 in Holovousy (Czech Republic) during the growing period. Measurements were carried out on at least four representative trees of each variety on several labelled shoots and leaf rosettes in five repetitions on every tree. Determination of leaf area was performed by a non-destructive method based on multiplying two measured data (leaf widths and lengths) and the result was multiplied by a coefficient 0.71. The leaf growth measurement was recorded in the varieties at weekly intervals and on leaf rosettes twice a week during growing period. There was obtained extensive observational material containing several thousand of measurements from sprouting leaves to July periods when there were not recorded further enlargement of leaf area and increase of their number. In both processed years were demonstrated relatively close linear relationship between leaf area, number of leaves and daily sum of effective temperatures above 5°C. After evaluating of the number and area of individual leaf in percentage of the maximum value were found that there are no significant differences between the varieties and years. These results were used to create a simple web application that allows apple growers determine the relative changes in the leaf number and the size of leaf area depending on data from a nearby weather station between two terms for instance between the last treatment and new infection of pathogen V. inaequalis causing apple scab.

Keywords: leaf area, leaf number measurement, apple scab, Venturia inaequalis, scab resistance.

EFFECT OF UVC AND METHYL JASMONATE TREATMENTS ON THE BIOSYNTHESIS OF ANTHRAQUINONE DERIVATIVES IN RUBIA TINCTORUM

Jean-Baptiste Mazzitelli 1, Amina Benmessoud 1, Carole Mathe 1, Jawad Aarrouf 2, Laurent Urban 2, Cathy Vieillescazes 1

1 IMBE UMR7263/ IRD237, Avignon University/ CNRS/ IRD/ AMU, Restoration Engineering of Natural and Cultural Heritage, Faculty of Sciences, 84000, Avignon, France; 2 Laboratoire Physiologie des Fruits et Légumes (EA 4279), Université d’Avignon et des Pays du Vaucluse, 84916 Avignon, France

Rubia tinctorum, also called madder, is a tinctorial plant belonging to the Rubiaceae family. Madder is part of natural heritage of the region of Avignon, where this crop’s production was very important during the XVIIIth and XIXth centuries. Madder was employed since the ancient times: painters used madder lacquer as a medium for their paintings. Moreover, this natural substance was also used for dyeing textiles in many parts of the world.

Madder roots contain dyes with an anthraquinonic (anthracene-9,10-dione) skeleton corresponding to heterosidic and aglycone molecules. The heterosidic dyes are composed by molecules with an anthraquinonic part (aglycone) and a primeverosone one ([6-O-β-D-xylpyranosyl-β-D-glucose]). The major heterosidic dyes are lucidin primeveroside, ruberhythric acid (alizarin primeveroside), galiosin (pseudopurpurin primeveroside) and rubiadin primeveroside. The main aglycone compounds are alizarin, purpurin, pseudopurpurin, lucidin, xanthopurpurin and rubiadin. These colored compounds are secondary metabolites and they derive from the shikimate and Rhomer (non-mevalonate) pathways. The anthraquinones contents can be increased by application of abiotic stresses. In the present study, two types of stress were tested (exposition to UVC and spray of methyl jasmonate, an eliciting molecule), with the aim of increasing the production of anthraquinonic compounds to improve the accumulation of dyes in madder roots. Dyes were extracted from roots by using an ultrasonic process to preserve the dyes population and optimize the yield of extraction. Liquid chromatographic analyses were performed to characterize and to quantify the most important heterosidic and aglycone molecules. All experiments showed an impact of abiotic stresses on secondary metabolites contents. UVC applications increased the production of alizarin, lucidin and their heterosidic precursors (ruberhythric acid and lucidin primeveroside respectively). Methyl jasmonate treatments improved the concentrations of alizarin, lucidin and purpurin in madder roots but reduce galiosin concentration. Abiotic stresses such as UVC and elicitor treatments could thus be used to increase dye production in madder crop.

Keywords: anthraquinones, abiotic stress, methyl jasmonate, UVC radiation, Rubia tinctorum.

SCREENING TOMATO GERMLASM FOR RESISTANCE TO LATE BLIGHT

Bernard Carome, Hamers C., Touhami N., Renaudineau A., Bachellez A., Massire A., Damidiaux R., Lefebvre V.

INRA, UR1052, Génétique et Amélioration des Fruits et Légumes (GAFIL), 84143 MONTFAVET Cedex, France

Late blight, caused by Phytophthora infestans, is a re-emerging damaging disease in tomato crops, under wet environments. In organic tomato production, copper-based fungicides are used to directly control late blight. Due to environmental concerns, the use of fungicides has to be reduced and growing resistant cultivars is an alternative. The three resistance genes introgressed into tomato cultivars since the 1970s, named Ph-1, Ph-2 and Ph-3, have been overcame by new populations of P. infestans. It has been demonstrated in several pathosystems that polygenic resistance is more durable than monogenic resistance, so, there is a need for new resistance genes or QTLs, and to combine them in order to build durable resistance to P. infestans.

A highly aggressive isolate of P. infestans (Pi100) was collected on tomato, near Avignon (FRANCE) in 2012. Pi100 didn’t overcome the resistance conferred by the Ph-3 gene, but overcame the resistance conferred by the Ph-2 gene. Nevertheless, Ph-2 confers a residual resistance effect to the Pi100 isolate, as the progression of the disease was slowed down in all cultivars carrying Ph-2. We elaborated a resistance assay, to identify tomato accessions with a resistance level better than that of cv. Pieraline, carrying Ph-2. Using Pi100, we screened 150 accessions of Solanum pimpinellifolium, S. lycopersicum var. cerasiforme and controls for resistance to P. infestans. We identified four accessions with partial resistance to Pi100, with a resistance level better than that observed on Pieraline. In addition, we confirmed that four accessions from S. habrochaites, already reported in the literature as late blight resistant, also blocked
the Pi100 life cycle. Crosses are underway to generate progenies for QTL mapping. Several combinations of resistance genes and/or QTLs will be evaluated with a set of isolates representative of *P. infestans* diversity, to estimate the potential durability of these combinations.

**Keywords**: tomato, *Phytophthora infestans*, disease resistance, germplasm screening, genetic resistance.

### CHANGE OF BROWNING DISORDER AND PHENOLIC COMPOUNDS UNDER CONTINUOUS AND INTERMITTENT LIGHT CONDITION ON BUTTERHEAD LETTUCE LEAVES (LACTUCA SATIVA L.) DURING STORAGE

**Phrutiya Nilprapruks**, Florence Charles, David Roux, Véronique Vidal, Huguette Sallanon

Université d’Avignon et des Pays de Vaucluse, Laboratoire Physiologie des Fruits et Légumes (EA 4279), 84018 Avignon, France

The development of browning disorder is a widespread indicator to quality of vegetables because there is a significant impact on appliance of vegetables and it is unacceptable for customers. The aim of this study is to investigate a biochemical change that related to browning disorder under different light conditions at low temperature of storage. Lettuce leaves were stored under three conditions; darkness, continuous light at 50 mmol.m\(^{-2}\).sec\(^{-1}\) and intermittent light at 50 mmol.m\(^{-2}\).sec\(^{-1}\), which were switched between 2 hours light per 2 hours dark cycle for 2 days, and then the lettuce leaves were stored under dark condition. The results indicated that both of continuous and intermittent light were able to inhibit browning disorder on edge-cutting and there was also a significant effect on the reduction of polyphenol oxidase activity (PPO). On the other, an augmentation level of phenylalanine ammonia-lyase activity (PAL) and phenolic compound such as chlorogenic acid, chicoric acid and quercetin-3-O-glucoside were induced by light. The content of chlorogenic acid under continuous light condition was higher than dark condition and intermittent light condition whereas the content of chicoric acid and quercetin-3-O-glucoside under continuous light and intermittent light condition were not significantly different. In addition, light had also a significant impacted on increasing of level of carotenoid and ascorbic acid. Similarly, malondialdehyde content (MDA) that is able to confirm an occurrence of oxidative stress in cell, was increased under continuous light.

**Keywords**: Lettuce, Phenolic compounds, Polyphenol oxidase activity (PPO), Phenylalanine ammonia-lyase activity (PAL) and Ascorbic acid

### BEHAVIORAL RESPONSE OF GREEN PEACH APHID TO VOLATILES FROM DIFFERENT ROSEMARY CLONES

**Tarek Dardouri**

INRA, UR1115 Plantes et Systèmes de culture Horticoles, 84914 Avignon cedex 9, France

The green peach aphid (*Myzus persicae* (Sulzer)) is a general pest and potentially dangerous. Intercropping of companion plants such as rosemary (*Rosmarinus officinalis* L.) with horticultural crops (pepper) has been proposed as an innovative approach to optimize the protection against this aphid. The volatile organic compounds (VOCs) emitted by rosemary has been shown to have repulsive effect on this aphid. The objective of this study was to identify among five clones of rosemary, those which can be effective against *M. persicae* and identify their emitted COV. Sixteen compounds were identified by analysis of emitted VOCs by GC-MS; each clone is characterized by a specific profile, showing the existence of chemical variability. The effects of VOCs emitted by different clones of *M. persicae* were monitored using an olfactometer. V. Splindler exhibited the higher repulsive efficiency. The variations in VOCs profiles (emitted by different clones), could partially explain the observed difference of repulsive effects on *M. persicae*. This work is a preliminary study to understand the action of rosemary VOCs on *M. persicae* in an attempt to propose innovative low input cropping systems.

**Keywords**: *Myzus persicae*, Rosemary, volatile organic compounds (VOCs), repulsive effects
TOPIC 3

Crop and quality management: cultural and post-harvest practices at various levels of organisation.

Coordinators: M. Tchamitchian & F. Weibel

Biological processes are influenced by techniques along food or value chains. This session will deal with optimizing technical management, with the aim to reduce off-farm inputs and achieve more stable performances. Soil and nutrient management will be considered, through the enhancement of soil quality, the roles and affects integration on cover crops and other techniques (e.g. tillage)... Matching production and protection is also a key issue, including methods (training, pruning...) likely to play a part on both local environmental conditions and fruit quality. Decision tools and systems, including those implemented by producers and extensionists, are also considered in this topic.

TOPIC 3 SESSION 1 (Parallel, 9th of June, am)

Oral Presentations

ASSESSMENT OF AGRICULTURAL BIOSTIMULANTS COMPARED WITH SULFUR-BASED FUNGICIDES ON DISEASES, TREE GROWTH, FRUIT YIELD AND QUALITY IN A CERTIFIED ORGANIC APPLE ORCHARD IN VERMONT, USA

Ann Hazelrigg 1, L.P. Berkett 1, H.M. Darby 1, J. Gorres 1, R.L. Parsons 2

1 Department of Plant and Soil Science, University of Vermont, Burlington, VT 05405, USA ; 2 Department of Community Development and Applied Economics, University of Vermont, Burlington, VT 05405, USA

Disease management in organic apple orchards in Vermont is focused on controlling diseases with sulfur fungicides. The objective of this two-year study was to evaluate the target and non-target effects of an organic disease management system containing agricultural biostimulants compared to two sulfur-based systems on foliar and fruit diseases, tree growth, yield and fruit quality. Trees were arranged in a completely randomized design of five three-tree replications in a certified organic orchard. The two sulfur-based systems differed in the number of applications; in the third system, sulfur was replaced with biostimulants including pure neem oil, liquid fish, an activated microbial inoculant, and equisetum and stinging nettle teas. Each biostimulant application also included kelp meal, unsulfured organic molasses and yucca extract emulsifier. The biostimulant system did not successfully manage apple scab and rust diseases as well as the sulfur-based fungicide systems, and had variable results with other diseases. No differences were observed among the three systems in tree growth parameters; however, the length of the study may not have been sufficient to determine effects. Differences in the incidence of disease among the three systems were reflected in extrapolated figures for gross income per hectare, which takes into account fruit yield and quality. In the higher fruit-bearing year of the study, it was estimated that the gross income per hectare of the biostimulant system would be significantly lower than the reduced-sulfur system and the full-sulfur system by at least 5,800 USD and 12,000 USD, respectively. It is estimated that the full-sulfur system would have generated approximately 6,500 USD more gross income per hectare than the reduced-sulfur system suggesting the number of sulfur sprays can influence fruit quality and income. Further evaluation of agricultural biostimulants is necessary before growers replace the standard sulfur fungicides for apple disease management in Vermont orchards.

Keywords: apple scab, rust disease, integrated pest management, ‘Ginger Gold’, ‘Honeycrisp’, ‘Liberty’.

DIFFERENTIATING ORIENTAL FRUIT MOTH AND CODLING MOTH LARVAE USING NEAR-INFRARED SPECTROSCOPY

Myriam Siegwart, Floriane Bouvier, Sandrine Maugin, Alain Lecomte, Claire Lavigne

INRA, UR 1115 Plantes et Systèmes de culture Horticoles (PSH), 84914 Avignon Cedex 9, France

Cydia pomonella and Cydia molesta are two important lepidopteran pests that may co-occur in apple orchards and are difficult to differentiate in the larval stage. We investigate the possibility of using near-infrared spectroscopy (NIRS)
coupled with partial least squares (PLS) analysis to distinguish the larvae of the two species. We further assess whether wild individuals can be differentiated using laboratory strains of the two species for model calibration. The NIRS spectra of C. molesta and C. pomonella differed most in the wavelengths between 1,142 nm and 1,338 nm. Using these wavelengths, PLS analysis allowed the differentiation of C. molesta and C. pomonella at the larval stage with very low error, but only as long as both the calibration and prediction sets for individuals had the same origin (either both from the laboratory or both from the field). Errors that appeared when using laboratory individualscorrelation between individuals for calibration were due to the divergence of the C. pomonella laboratory strain, most likely following evolution during rearing. Thus, NIRS appears to be a promising tool for the easy, rapid identification of individuals in the field, provided that it is calibrated based on a subset of field individuals.

**Keywords:** Cydia pomonella, Cydia molesta, Grapholita molesta, monitoring, taxonomy

### NEW MULTIPLEX PCR METHOD FOR RAPID CHARACTERIZATION OF THE GENETIC DIVERSITY OF PSEUDOMONAS SYRINGAE IN ORCHARDS AND CROPS

Benoit Borschinger1,2, Charlotte Chandeysson3, Claudia Bartoli7, Caroline Guillbaud1, Luciana Parisi1, Jean-François Bourgeay2, Elise Buisson1, Cindy Morris1

1 INRA, Unité de Pathologie Végétale, 84140 Montfavet, France ; 2 INRA, Laboratoire des Interactions Plantes Micro-organismes, Auzeville, 31326 Castanet Tolosan, France ; 3 Institut Méditerranéen de Biodiversité et diologie marine et continentale (IMBE), Université d’Avignon et des Pays de Vaucluse, UMR CNRS IRD Aix Marseille Université, 84911 Avignon, France

Bacterial blight of fruit trees caused by *Pseudomonas syringae* causes significant economic losses worldwide. With the expansion of bacterial canker of kiwi caused by *P. syringae pv. actinidiae* (Psa) and bacterial canker of apricot caused by *P. syringae pv. syringae* (Pss), identification of reservoirs of pathogenic strains is required. One potential reservoir is ground covers in orchards. A solution could be the development of ecological engineering practices, particularly ground cover management in order to reduce their impact as a source of inoculum for bacterial diseases of fruit trees caused by *P. syringae* and increase their role as a reserve for microorganisms that are antagonistic to pathogens of fruit trees. However, with the recent discovery of the complexity of the phylogeny of *P. syringae* and the existence of phylogroups containing more aggressive strains than others (Psa in phylogroup 1, Pss in phylogroup 2), one of the first goals is the development of a specific molecular detection method, by PCR, allowing rapid and accurate identification of the different phylogroups of *P. syringae*. This would be much more efficient than the only method currently available - sequencing of specific conserved genes used in phylogenetic identification. The simple implementation of this new method of genotyping makes it possible to screen samples of very large size with little effort. This method can be deployed to develop methods of control of bacterial blight, and can be used as a generic mean of detecting and monitoring orchards and crops. Indeed, the use of a technique targeting a single pathovar may be insufficient, as it is not uncommon for plants to be simultaneously attacked by several different strains of *P. syringae*. The method of detection and identification of phylogroups will be presented and a concrete example for specific samples (ground cover, buds, twigs) from orchards of apricot and kiwi will be described.

**Keywords:** *Pseudomonas syringae*, genetic diversity, multiplex pcr, orchards

### THE MIRID BUG TUPIOCORIS CURCIBITACEUS: POWERFUL SPONTANEOUS NATURAL ENEMY IN TOMATO GREENHOUSES IN LA PLATA, BUENOS AIRES, ARGENTINA

Marina Del Pino, Massi M., Gamboa S.

Cuso de Horticultura y Floricultura, Facultad de Ciencias Agrarias y Forestales, Universidad Nacional de La Plata, La Plata, Buenos Aires, Argentina.

The Horticultural Belt of La Plata is the most important of Argentina, with a great area covered with greenhouses and high technology implemented. Tomato is the most important crop in this protected conditions. Insect control is based principally by the used of synthetic products, but the biological control with spontaneous natural enemies is specially interesting because of the presence of large areas with wild vegetation. They are functional as source of beneficial insects. Greenhouses are unheated plastic structures with roll-up sides for ventilation that allow exchanges within internal and external environment. The objective of this work was to verify the effectiveness of biological control with spontaneous natural enemies from outside, by analyzing the relationship between population of whiteflies *Trialeurodes vaporariorum* (Westwood) and *Bemisia tabaci* (Gennadius) (Hemiptera: Aleyrodidae) which are two of the main pests of tomato in the area, and the natural enemy the generalist predatory mirid bug *Tupiocoris curcibitaceus* (Spinola) (Hemiptera: Miridae), detected in 2006 in organic crops of tomatoes. 86 tomato greenhouses were surveyed from 2008 to 2015 and they were weekly monitored, recording whitefly adults (in leaves) and whitefly nymphs (leaflets), and nymphs and adults of the mirid (whole plant). Mean population peaks of each arthropod, and predatory prey ratio, as the ratio mirid nymphs and whiteflies nymphs, were calculated. The pest population was low in almost all crops where the mirid bug population was abundant. The number of nymphs of the mirid was very high in some plots (over 10 nymphs per plant); it was found that 0,5 predatory prey relationship indicates a turning point in the population curve of the pest, valuable data for control measures to avoid damaging the natural enemy. No other effective control of these pests could be observed with other natural enemies as *Eretmocerus* spp. (*Hymenoptera: Aphelinidae*), also present.

**Keywords:** biological control, biocontrol agents, mirid bugs, horticulture, greenhouses.
NEW FERTILIZERS AND SOIL AMENDMENTS FOR ORGANIC HORTICULTURAL CROPS: MECHANISMS OF ACTION AND PERFORMANCE.

Eligio Malusa, Sas-Paszüt L1, Ciesielska J1, Grzyb Z.S1, Chalańska A.2, Kalají M.H.2, Stepień W.2

1 Research Institute of Horticulture, Sklerniewice, Poland; 2 Warsaw University of Life Sciences – SGGW, Warsaw, Poland

The preservation of organic matter in the soil is crucial to assure its physical, chemical and biological fertility. The continuous development of new processing technologies, particularly for the treatment of industrial organic wastes, is providing new potential matrices to produce organic fertilizers. Extracts from plants and particularly from seaweeds, beside the input of nutritional elements also as liquid fertilizers for foliar application, contain several bioactive molecules which improve the tolerance to both biotic and abiotic stresses of the crops resulting in higher yield. By-products of coal mining (lignite), particularly when composted in a matrix composed of N-rich organic by-products (e.g. from dairy production) and inoculated with selected microorganisms (e.g. white fungi), allow to deliver to the soil a high amount of humic substances that positively affect its chemical, physical and biological properties as well as plant growth and yield. Microbial-based products can foster plant nutrition, particularly in organic and integrated management systems, due to effects that can span from plant nutrition to increase nutritional quality, from enhanced tolerance to abiotic stresses to plant protection, either from soil- and air-borne pathogens. However, the formulation of inocula with a reliable and consistent effect under field conditions and a correct application method are key to their successful application. The results from work carried out within the “EkoTechProdukt” project in Poland on strawberry, apple and sour cherry will be presented highlighting the possibility of transforming key organic sources into resources that can enhance soil fertility and improve plant growth and yield, as well as showing the effects these products have on plant physiology and soil microbiology, in an effort to better explain their mechanism of activity and potential applications in organic and integrated horticulture.

Work financed by EU Program of Regional Development – Operational Program „Innovation Economy”, contract nr UDA-POIG.01.03.01-10-109/08-00.

Keywords: organic fertilizers, biofertilizers, soil biological fertility, plant physiology

STRATEGIES FOR CUT-AND-CARRY GREEN MANURE PRODUCTION

Jorn N Sorensen, Kai Grevensen

Aarhus University, Faculty of Science and Technology, Dept. of Food Science, Kirstinebjergvej 10, 5792, Aarslev, Denmark

To fulfil an increasing demand of organic certified fertilizers, there is a need to develop new fertilizer sources for organic high-value cash crops. One possibility is to grow green manure crops that are harvested and transported to fields where the fertilizers are required. In a three-year experiment, a range of legume crops were harvested at three to four developmental stages. Further, during the growing season each green manure crop was re-harvested two to four times according to the specific developmental stages. The legume species investigated were alfalfa, white clover, red clover, and a grass clover mixture (Italian ryegrass and red clover). Besides these perennial crops also some annual crops were tested: broad bean, lupine, and pea. The results showed that during a full growing season 400–600 kg per ha of nitrogen (N) were produced by the perennial green manure crops. This production was obtained by four cuts at early, three cuts at middle or two cuts at late developmental stage. The annual crops produced around 200 kg N per ha from two harvest of the above-ground plant parts per season. Harvesting the seeds that is one harvest only, resulted in equal amounts of nitrogen per ha. At later developmental stages at harvest, the concentration of nitrogen in the plant material decreased resulting in increased carbon to nitrogen (C:N) ratios. Therefore, frequent cuts resulted in cut-and-carry green manures with low C:N ratios suitable for in-season fertilization of high-value cash crops. Tests of the fertilizer effects of the different cut-and-carry green manures showed that the yield of vegetable crops increases at decreased C:N ratio and that the nutrient effect is comparable and competitive to animal manure.

Keywords: green manure, legume, nitrogen, organic fertilizer

ASSESSING THE POTENTIAL OF BIOCHAR AS A GROWING MEDIA COMPONENT FOR POTTED PLANTS

M. Dorais1, C. Martinez2, M. Diop3, M. Thériault4, C. Ménard5 and Steeve Pepin6

1Agriculture and Agri-Food Canada, Centre de recherche et d’innovation sur les végétaux, Université Laval, Québec, QC, Canada, G1V 0A6; 2Faculté des Sciences de l’Agriculture et de l’Alimentation, Université Laval, Québec, QC, Canada G1V 0A6; 3Centre de recherche et d’innovation sur les végétaux, Dept. of Soil and Agri-Food Engineering, Université Laval, Québec, QC, Canada G1V 0A6.

Adding biochar to growing media can be a promising avenue for increasing the sustainability and productivity of potted organic plants. Indeed, there have been numerous reports that soil amendment with biochar increases the biological and physicochemical properties of different types of soil by promoting the development of microbial populations and soil mineralization rates, by improving porosity, particle aggregation and soil structure, by enhancing ion exchange capacity (cations and anions), by reducing nutrient losses to surface water and by minimizing the emission of greenhouse gases such as N2O and CH4. Thus, the goals of this study were 1) to evaluate for six types of organic soil the effect of soil biochar amendments (0 to 50% v/v; particle size of 0-150 mm) on tomato growth and root susceptibility to Pythium ultimum, and 2) to evaluate for a peat based substrate the effect of soil biochar amendment (0 to 30% v/v; particle size of 2-4 mm) on plant growth and nutrient use efficiency of sweet pepper, geranium and ornamental basil. Two experiments were conducted in a greenhouse located at Laval University (46°49’N, 71°15’W) in a randomized complete block design with three to five replicates. Regardless the types of soil, our results showed that soil amendments with a high percentage of biochar (50% v/v) decreased tomato plant height and total dry mass when tomato plants were grown on a peat mix growing media and a sandy loam (p<0.05). However, there was no interaction
between biochar amendment and soil *P. ultimum* inoculation, thereby suggesting that biochar did not suppress or promote tomato root colonization by *P. ultimum*. In addition, biochar amendment had no significant effect on the root colonization by mycorrhizal fungi. For any studied species and organic soils, no positive effect of biochar soil amendment on plant growth parameters was observed. However, we conclude that a proportion up to 30% of biochar can be used in replacement of peat for organic potted plants without any significant negative effect on plant growth and disease sensitivity.

**Keywords:** biochar, peat substitute, *Pythium*, tomato, geranium, basil, sweet pepper

**RECOGNITION ALGORITHMS FOR DETECTION OF APPLE FRUIT IN AN ORCHARD FOR EARLY YIELD PREDICTION**

*Lutz Damerow;* Michael Blanke

Institute of Agriculture Engineering, University of Bonn, Germany

The challenge in the cultivation of perennial horticultural tree crops is estimating the number and diameter of fruit on a tree as early as possible to achieve yield estimates for farm operations, fruit trade, retailers and storage facilities. Apple recognition algorithms based on colour features are presented to estimate the number of apple fruits and develop early predicting models of apple yield. Fifty cv. ‘Gala’ apple digital images were captured twice on one, the preferred Western side of the tree row with a variability of between 70 and 170 fruit per tree, under natural daylight conditions at Bonn, Germany. Several image processing algorithms and fruit counting algorithms were used to analyse the apple images in both periods. Finally, an apple recognition algorithm with colour difference R-B and G-R was developed for apple images after June drop, and two different colour models were used to segment the ripening period’s apple images. The algorithm was tested on 50 images in each period. Close correlation coefficients R2 of 0.80 and 0.85 were obtained for two developmental periods between apples detected by the fruit counting algorithm and those manually counted. Two sets of data in each period were used for modelling yield prediction of the apple fruits. In the calibration data set, the R2 values between apples detected by the fruit counting algorithm and actual harvested yield are from 0.57 for young fruit after June drop to 0.70 in the fruit ripening period. In the validation data set, the R2 value between the number of apples predicted by the model and actual yield at harvest from 0.58 to 0.71. The proposed model shows a great potential for early predicting yield for individual trees in an orchard. The present results on apple and innovative algorithms may be applicable to many other fruit crops like citrus, pear, peach, apricot, kaki, nectarine and almond.

**Keywords:** Apples, Colour, Precision Horticulture, Modelling, Yield prediction

**SESSIONS: HALF-HIGHBUSH BLUEBERRY ‘NORTHBLE’ PLANT GROWTH IN JUVENILE STAGE DEPENDENCE ON FERTILIZERS IN ORGANIC CONDITIONS**

*Angela Koort 1,2, M. Starast 1, and T. Tasa 1*

1Department of Horticulture, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences ; 2Bioskov Øst, Haugausund, 5781 Lofthus, Ullensvang, Hardanger, Norway.

The aim of this research was to find out how different natural manufactured fertilizers influence the vegetative growth of young blueberry plant in abandoned peat field conditions. The study was carried out in the years 2006-2009 in South-Estonia. The plantation was established with one-year-old half-highbush blueberry (*Vaccinium corymbosum* x *Vaccinium angustifolium*) ‘Northblue’ plants on an abandoned peat-extracted field in the spring 2006. Six fertilizers were used in the experiment, including the synthetic mineral fertilizer Cropcare (6-6-19) and five natural (containing organic and

**Poster Presentations (9th of June, am)**

**IRRIGATION SCHEDULING BASED ON SOIL WATER VOLUME INCREASES PROFITABILITY OF PEACH PRODUCTION**

*Gregory Reighard, W. Greg Henderson*

Clemson University; School of Agricultural, Forest and Environmental Sciences, Clemson, South Carolina, 29634, USA

Peach fruit development during Phase III requires ample water to maximize fruit size potential. Growers in the southeastern U.S. tend to irrigate for long intervals (24+ hrs) during the 2 weeks before expected ripening date regardless of ambient soil water content. Irrigation based on soil water capacity at critical soil depths of active root uptake would reduce overwatering and save pumping and water costs while not impacting peach fruit growth. Soil moisture sensor technology developed by Earthtec Solutions (Vineland, NJ) was evaluated in a 5 yr-old ‘Scarletprince’ peach orchard on a Faceville sandy loam in Johnston, South Carolina to determine water content at different depths and the extraction of water by roots over time. Irrigation was applied according to soil water capacity in the active root uptake zones. The data showed that peach roots withdrew water primarily in the 0-20 cm zone, whereas deeper water (>30 cm) was little used by the trees and therefore long irrigation intervals were not necessary. Beginning irrigation at a 25% deficit below a soil water volume capacity of 22.5% and stopping when the desired soil water capacity was reached at the 20 cm depth was the most efficient use of water for this orchard and soil type. The amount of water used by the orchard was reduced by as much as 60% and the effect on fruit size was economically significant. Percent large fruit (> 7 cm) increased with scheduled irrigation based on soil water capacity at 20 cm compared to a grower standard that irrigated with long intervals of watering until deep soil saturation prior to fruit ripening. This technology proved to be cost effective and conserved water, which being of surface origin was limited in availability during previous droughts.

**Keywords:** Prunus persica, fruit size, soil water capacity, soil moisture sensors

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Peach fruit development during Phase III requires ample water to maximize fruit size potential. Growers in the southeastern U.S. tend to irrigate for long intervals (24+ hrs) during the 2 weeks before expected ripening date regardless of ambient soil water content. Irrigation based on soil water capacity at critical soil depths of active root uptake would reduce overwatering and save pumping and water costs while not impacting peach fruit growth. Soil moisture sensor technology developed by Earthtec Solutions (Vineland, NJ) was evaluated in a 5 yr-old ‘Scarletprince’ peach orchard on a Faceville sandy loam in Johnston, South Carolina to determine water content at different depths and the extraction of water by roots over time. Irrigation was applied according to soil water capacity in the active root uptake zones. The data showed that peach roots withdrew water primarily in the 0-20 cm zone, whereas deeper water (>30 cm) was little used by the trees and therefore long irrigation intervals were not necessary. Beginning irrigation at a 25% deficit below a soil water volume capacity of 22.5% and stopping when the desired soil water capacity was reached at the 20 cm depth was the most efficient use of water for this orchard and soil type. The amount of water used by the orchard was reduced by as much as 60% and the effect on fruit size was economically significant. Percent large fruit (> 7 cm) increased with scheduled irrigation based on soil water capacity at 20 cm compared to a grower standard that irrigated with long intervals of watering until deep soil saturation prior to fruit ripening. This technology proved to be cost effective and conserved water, which being of surface origin was limited in availability during previous droughts.

**Keywords:** Prunus persica, fruit size, soil water capacity, soil moisture sensors
Mobilization of natural processes for better nitrogen availability in an organic apricot orchard

Muriel Millan, Garcin A., Jay M., Chéreau R., Zeller B.
Ctfil 751, Chemin de Balandran, 30127, Bellegarde, France ; Ctfil / ESA Angers, France ; INRA Nancy, Biogéochimie des Écosystèmes Forestiers, France

French production of stone fruits under organic farming (OF) is widely insufficient to cover the increasing markets demand in organic fruits. One of the main causes is the difficulty to maintain sufficient yields in OF with regard to Integrated Fruit Production (IFP). Nitrogen is recognized as one of the major factors to maintain yields in agriculture. The availability of nitrogen in sufficient amounts at the key stages of tree growth acts directly on tree vigour and fruit production and indirectly by increasing tolerance of trees to pests and diseases. On a plot located in Gard department (France), an organic apricot orchard was set up with an agro-ecological approach favoring natural processes within the orchard while limiting the dependence on external inputs on the farm, by mobilizing various eco-systemic services. A mixture of 6 species of legumes was sowed one year before plantation of the orchard. The objective was to make the apricot trees benefit from the biological nitrogen fixation (BNF) by legumes in symbiosis with Rhizobia bacteria in root nodules. With the aim of estimating the percentage of nitrogen derived from the atmosphere (Ndfa), we used the d15N natural abundance method. Analyses of two nitrogen isotopes N14 and N15 were made in the leaves of apricot trees and in the soil at two depths (0-5 and 5-10 cm); in two orchards of comparable age, one in OF with legumes in the inter-row, the other one in IFP without legumes. The results show that d15N in apricot tree leaves cultivated in an organic production system is slightly lower than in an orchard in IFP, without legumes. At both depths of soil sampled d15N is lower in the OF plot. These observations clearly indicate that part of N needs for apricot tree results from the contribution of N contained in the biomass of legumes. Furthermore, it is possible that the apricot trees obtain a certain amount of nitrogen via a direct transfer from root to root. A follow-up during the year 2015 could consolidate the obtained results and allow the quantity of nitrogen supplied by legumes to be calculated more precisely.

Keywords: organic farming, agroecology, stone fruit, apricot, nitrogen, legume, BNF.

Fertilisation management for organic cucumber grown in raised demarcated beds

M. Dorais, M. Thériault and Steeve Pepin
1Agriculture and Agri-Food Canada, Centre de recherche et d’innovation sur les végétaux, Université Laval, QC, Canada, G1V 0A6 ; 2Centre de recherche et d’innovation sur les végétaux, Dept. of Soil and Agri-Food Engineering, Université Laval, Quebec, QC, Canada G1V 0A6

One of the main challenges in production of greenhouse organic vegetables is to achieve a balanced nutrient composition of organic amendments and a timely nutrient release with plant nutrient uptake that will insure high productivity and limit any leaching or emission into the environment. Since the soil should provide the main portion of nutrients to the plant, solid fertilizers are regularly supplied. However, little is known about the fertilisation management of organic greenhouse vegetables grown in raised demarcated beds where root development is confined. The goal of this study was to determine the effect of mulches and the fertilisation frequency on plant nutrient availability and cucumber plant productivity. Two experiments were conducted at Les Serres Lefort located at Ste-Clotilde, QC, Canada (45°14’N; 73°66’W). In the first experiment, four mulch treatments were compared: 1- plastic mulch, 2- coir mulch, 3- white and red clover, and 4- arugula (Eruca sativa) living mulches. In the second experiment, fertilizers were applied every 1- week, 2- two weeks, 3- three weeks, and 4- four weeks. The same total amount of nutrients was given for each treatment based on plant nutrient uptake. The experimental design was a 4 x 4 Latin square with 43 to 51 plants per experimental unit. Results showed that the soil electrical conductivity (EC) was higher when a clover and arugula living mulches were used compared to coir mulch. However, no significant difference between mulch treatments was observed for plant growth parameters, fruit size, yield and fruit quality. Soil microbial activity, assessed by the fluorescein diacetate hydrolysis method, was higher under the plastic mulch and lower under the clover living mulch treatment. During the second experiment, the fertilization frequency treatments had little effect on the soil EC. No significant difference (p<0.05) was observed for plant growth parameters, fruit size, fruit yield and fruit quality. However, soil microbial activity was slightly higher when fertilizers were given weekly, while root colonization by mycorrhizal fungi was higher when fertilizers were applied every three weeks. At the end of the experiment, soil respiration was higher for the 3-week interval fertilisation treatment compared to the other treatments. From these results, we can conclude that a 3-week fertilisation interval reduced the labour required for the fertilizer application.
without any negative effect on plant growth and productivity. On a short-term basis, there was no positive effect of using living mulches. Results will also be discussed in term of nutrient use efficiency and soil salinization.

Keywords: fertilisation frequency, greenhouse vegetable, living mulch, nutrient use efficiency, soil salinization.

ENHANCING SOIL NUTRIENT STATUS AND CUCUMBER YIELD THROUGH ORGANIC WASTES ON HUMID ULTISOL LOCATION

Kolawole Edomwonyi Law-Ogbomo, Osaigbovo A.U and Ogedegbe S.A

Department of Crop Science, Faculty of Agriculture, University of Benin, PMB 1154, Benin City, Nigeria

A field trial was conducted at the Teaching and Research Farm of the Faculty of Agriculture, University of Benin an ultisol humid area of South-South Nigeria to evaluate the potential of organic wastes for improving soil nutrient status and yield of cucumber. The trial was laid out using randomized complete block design with three replications. The treatments were rabbit manure, goat manure, swine manure, cattle manure, NPK 15:15:15 and control. Organic wastes were applied at 15 t ha⁻¹ while NPK 15:15:15 was applied at the rate of 400 kg ha⁻¹. Data were collected on soil chemical properties, goat and fruit yield of cucumber subjected to analysis of variance. The soil routine analysis indicated that the soil was acidic sand with low nutrient content. The organic wastes contained essential nutrients in appreciable amount. Organic wastes compared favourably with NPK on growth and fruit yield of cucumber. The fruit yield of cucumber was positively influenced by the treatments: highest fruit yield was obtained in plots treated with NPK. However, fruit yield of cucumber obtained with organic wastes were statistically similar and compared favourably with the yield from plots where NPK was applied. At the end of the trial, organic wastes improved soil pH while NPK treated plots and control showed increased in soil acidity. Organic C and exchangeable K were higher in organic wastes treated plots than in NPK and control. Organic wastes compared favourably with NPK for total N and exchangeable K. It is recommended that rabbit manure, goat manure, swine manure and cattle manure could be used as organic fertilizer for high productivity of cucumber and soil productivity maintenance under intense and continuous cropping of humid ultisol location.

Keywords: fruit yield, growth, nutrients, soil chemical properties.

EFFECTS OF TIME OF INTRODUCTION OF WATERMELON (CITRULLUS LANATUS) AS LIVE MULCH ON THE PERFORMANCE OF OKRA (ABELMOSCHUS ESCULENTA L.) IN HUMID ULTISOLS

Kolawole Edomwonyi Law-Ogbomo and Osaigbovo A.U

Department of Crop Science, Faculty of Agriculture, University of Benin, Benin City, Nigeria

A field experiment was conducted during the 2012 and 2013 cropping seasons at the Teaching and Research Farm of the Faculty of Agriculture (University of Benin, Benin City, Nigeria) to determine the effects of time of introduction of watermelon as live mulch on the performance of okra in humid ultisols. The trial involved five treatments: No mulch (T0), two weeks after sowing (T1), one week before sowing (T2), at sowing (T3), one week after sowing (T4), in a randomized complete block design replicated three times. Data collected were: plant height, stem girth, number of leaves, leaf area index and total dry matter. At two weeks after sowing, there was no significant difference among treatments except for the number of leaves. At four weeks after sowing, there were significant differences in stem girth, plant height, number of leaves, leaf area index and total dry matter. At 50 % flowering day, there was no significant difference in days to 50 % flowering, stem girth and plant height among the treatments. However, there were significant differences in the number of leaves, leaf area index and total dry matter. The highest pod yield (8.53 t ha⁻¹) was obtained from T0 which was statistically comparable to T1 (6.27 t ha⁻¹) and T2 (8.36 t ha⁻¹) but significantly different T3 (4.63 t ha⁻¹) and T4 (4.30 t ha⁻¹). Live mulch introduced at T1 and T2 experienced enhanced growth and yield of okra compared to T3 and T4. Additional yield of live mulch would serve as an added advantage to them. However, the watermelon as live mulch failed to produce marketable pods due to fruit flies and viral infestation. For the humid ultisol, attempts should be made to use cucumber and other low spreading crops as live mulch in place of watermelon.

Keywords: fruit yield, leaf area index, plant height, stem girth, total dry matter.

GROUND COVER MANAGEMENT AND NUTRIENT SOURCE EFFECTS ON GROWTH AND DEVELOPMENT OF AN ORGANIC APPLE ORCHARD IN THE SOUTHERN US

Curt Rom 1, Jason McAfee 2, Heather Friedrich 2, M. Elena Garcia 3, Jennie Popp 3, Mary Savin 4, Donn T. Johnson 5

1Department of Horticulture; Center for Agricultural and Rural Sustainability, University of Arkansas. Fayetteville, AR USA ; 2Department of Horticulture, University of Arkansas. Fayetteville, AR. USA ; 3Department of Agricultural Economics and Agribusiness; Center for Agricultural and Rural Sustainability, University of Arkansas, Fayetteville, AR. USA ; 4Department of Entomology, University of Arkansas, Fayetteville, AR. USA ; 5Department of Crops and Soil Sciences, University of Arkansas, Fayetteville, AR. USA

Organic fruit production in the Southern US has been limited by insufficient regional production systems research and demonstration. Producer surveys indicated that two primary areas of information need were controlling competitive vegetation and providing appropriate levels of nutrition in organic production systems. Further, the impacts of changing ground cover management and nutrition on tree development, growth and productivity, soil quality, and the incidence of pests and disease have not been investigated in this region. The University of Arkansas established an organically managed orchard trial of ‘Enterprise’/M26 in March 2006. The objective of the experiment was to study the effects of four groundcover management treatments [municipal green compost (GC), wood chips (WC), shredded paper (SP), and mow-blow (MB)] and three organic nutrient source treatments [control (NF), composted poultry litter (PL), and commercial organic fertilizer (CF)] with the goal of...
developing recommendations for organic management in the region. The effects of these treatments on tree growth and production, nutrient content, soil physical and chemical properties, soil biology, and pest infestations and infections were measured during orchard establishment and maturation. Tree survival was best when treated with compost and wood chips and least with the mow-blow system. Trees without supplemental nutrition had the lowest survival. Across years of the study, trees treated with shredded paper had the lowest weed density under the tree canopy. Although ground cover management system affected tree growth and size in the first year, by sixth growing season, there were no significant difference in tree trunk cross-sectional area, tree height, or canopy volume among treatments, although trees grown with WC had approximately 30% larger trunk cross-sectional area than those grown with SP or MB. There were no significant differences in tree size due to nutrient source treatments although trees without supplemental nutrition were the smallest. In early cropping, trees treated with SP or MB had significantly lower cumulative yields. However, by the fourth cropping season, there were no significant differences among treatments for annual or cumulative yields. However, trees with wood chips had the highest yields while trees with mow-blow had the lowest. Similarly, trees without supplemental nutrition had the lowest yields. Trees with mow-blow or with no supplemental nutrition had the highest incidence of summer rots. Treatments provided a range of nutrient availability from deficient to very high levels of N. Trees responded curvilinearly to the amount of N applied for most growth characteristics. The use of GC ground covers and composted PL resulted in significantly higher available NO3. Control of plum curculio, San Jose scale and summer rots are still obstacles to fruit productivity and quality.

Keywords: Apple, Malus x domestica, organic, ground cover management, fertilizers, nutrients, growth, yield, compost, wood chips

POTASSIUM COCONUT SOAP BRINGS IMPROVEMENT FOR THE WOOLLY APPLE APHID CONTROL

Vladan Falta 1, Psofa Vlachova 2, Leskot Roman 3
1Crop Research Institute, 161 06, Prague, Czech Republic; 2Biocont Laboratory, 664 42, Modrice, Czech Republic

Woolly apple aphid (Eriosoma lanigerum) is a common and sometimes very problematic pest of apple orchards. The pest is spreading in the orchards where the abundance of natural enemies is decreased after applications of non-selective insecticides. The aphid also appears in dense orchards with unbalanced pruning and fertilization. The secretion of waxy exudates is a common habit of E. lanigerum. These exudates create white waxy cover of the aphid body. Although aphid itself is sensitive to the most aphicides the waxy cover often causes a failure of common spray program. The aim of our trail was to destroy waxy barrier with potassium coconut soap Cocana. Several small-plot and semi-field trials were done in intensive apple orchards in the Czech Republic during 2013 and 2014. Within these trials we sprayed 1 - 2% Cocana solutions in high water volume (1000 l/ha) against developed E. lanigerum colonies. The aphicides were either applied some hours after Cocana or as a tank-mix together with Cocana. In case of the first option we found following efficacies: acetamiprid (67.3 – 97.7 %), pirimicarb (98.0 %), spinosad (56.0 %), azadirachtin (48.6 %). Quite high efficacies were also observed in case of orange oil (d-limonen) two and three days after application (53.0 – 93.0 %), but after one week the efficacy was low (13 %). In case of Cocana 2% and acetamiprid in tank-mix we found efficacies 64.0 – 95.8 %. Based on our results the ideal concentration of Cocana appears to be 1.5 – 2 %.

This research was supported by the Ministry of Agriculture of the Czech Republic (Q1J210209).

Keywords: woolly apple aphid, control, potassium coconut soap.

TREE GROWTH AND CROP YIELD OF FIVE CULTIVARS IN TWO ORGANIC APPLE ORCHARD SYSTEMS IN VERMONT, USA, 2006-2013

Terence Bradshaw 1, Lorraine P. Berkett 1, Heather M. Darby 2, Robert L. Parsons 3, Sarah L. Kingsley-Richards 1, Renae E. Moran 4, and Elena Garcia 5
1University of Vermont, Burlington, VT 05405, USA; 2University of Maine, Monmouth, ME 04259M, USA ; 3University Arkansas, Fayetteville, AR 72701, USA

Adequate tree growth and crop yield are essential to the long-term success of orchard systems and these are often challenges when systems are managed organically in the northeastern U.S. The objective of this project was to evaluate horticultural performance of five apple cultivars (‘Ginger Gold’, ‘Honeycrisp’, ‘Liberty’, ‘Macoun’, and ‘Zestar!’) grown under organic management in a both a newly planted orchard (Orchard 1) and in a top-grafted established orchard (Orchard 2). Results summarize tree growth and crop yield of each cultivar and in both production systems over eight seasons from 2006-2013. There were no differences in tree survival among the cultivars in Orchard 1, where survival ranged from 97.8% to 100%. However, only 65.8% of ‘Macoun’ and 63.2% of ‘Zestar!’ trees survived in Orchard 2. There were cultivar differences in tree growth parameters within the two orchard systems. In both orchards, ‘Ginger Gold’ had the highest, or was among the cultivars with the greatest, shoot growth, tree height, and tree width. ‘Ginger Gold’ was also among the highest-yielding cultivars in all years in Orchard 1, and in three of six years in Orchard 2. ‘Macoun’ had among the lowest crop yield in most years in both orchards. ‘Ginger Gold’ and ‘Honeycrisp’ had among the highest cumulative yield per tree in Orchard 1. ‘Ginger Gold’ in Orchard 2, had the highest cumulative yield per tree of all cultivars. These results combined with analyses of disease and arthropod incidence and economic performance comparing the five cultivars within each orchard system will aid growers in their decision-making to select cultivar(s) and orchard establishment methods for an organic production system.

PRODUCTIVITY IN A LOW INTENSITY AND A HIGH INTENSITY 4-YEAR ORGANIC VEGETABLE CROP ROTATION

Josée Owen 1, S. Fillmore 2 and S. Leblanc 1

1 Potato Research Centre, Agriculture and Agri-Food Canada, Fredericton, New Brunswick, Canada; 2 Atlantic Food and Horticulture Research Centre, Kentville, Nova Scotia, Canada

In maritime Canada, organic vegetables are typically produced on farms without livestock, and often with limited nutrient inputs from off-farm. In order to maintain soil quality, a minimum four-year rotation is often advised comprising a single vegetable crop followed by grain and legumes. A fully phased organic rotations experiment was established in New Brunswick, Canada, to compare this traditional organic rotation with a four-year organic rotation producing three vegetable crops using imported nutrients and innovative cover cropping strategies to return organic matter to the soil. Effects of the rotations on productivity and soil quality parameters were measured. Butternut squash, the vegetable crop common to both rotations, yielded between 25.9 and 43.9 tonnes per hectare, with no significant difference in yield between the production systems. In the high intensity rotation, yields of lettuce (8.2 t ha⁻¹) and sweet corn (22.4 t ha⁻¹) were also obtained. In the low intensity rotation, soil organic matter fluctuated over four years of study, with a trend of maintaining around 3.2%, while in the high intensity rotation, soil organic matter also fluctuated but showed an increasing trend over four years. Results from other data, including soil bulk density, plant available N at two soil depths, plant available soil P, indicate the feasibility of designing integrated cropping systems augmented with innovative cover crop techniques enabling growers to produce a three marketable vegetables and diversify risk in a four year rotation while building soil quality and improving sustainability.

Keywords: stockless systems, crop rotation, soil quality; organic, yield.

DROSOPHILA SUZUKII, A GROWING THREAT FOR FRENCH HORTICULTURISTS


The spotted-wing Drosophila (SWD), Drosophila suzukii, has become a major agricultural pest in France since 2010. All regions get concerned for the last two years, with more damage in southern areas on important crops such as cherry, strawberry, raspberry or even fig, apricot and peach during risky years like 2014. A national research and dissemination project (Casdar, supported by the French Ministry of Agriculture) has been launched in 2013 until the end of 2015. It brings together 13 major French partners of on-farm research to screen and assess all possible prophylactic and control means: mass trapping, plant protection with chemical and natural compounds, insect-proof nets, biological control, functional biodiversity. Results are interesting but still incomplete; it seems like weather conditions remain the main factor influencing damage levels. Although insect-proof nets reach a near full efficacy, they look difficult to set up in strawberry production in greenhouses, or in cherry orchards for time and financial reasons. Plant protection with some conventional products generally allow a satisfying control of populations when the strategy is made with larvicides combined with adulticides, but this often requires an intensive spraying schedule. Organic compounds do not allow a satisfying protection when populations increase. Cultivation practices may however be different for top fruits and soft fruits (berries). Both conservation biological control and classical biological control (with inculcative releases of parasitoids) have been studied and seem to be contributive, but need some more research. The paper will detail some results encountered.

Keywords: Drosophila suzukii, pest management, cherry, strawberry, integrated fruit production

SAN JOSE SCALE – THE INCREASING PROBLEM OF ORGANIC ORCHARDS

Katerina Rychlá and Václav Psofa

1 Mendel University, Zemedelska 1, 61300, Brno, Czech Republic; 2 Biocent Laboratory, Mayerova 784, 664 42, Modrice, Czech Republic

The San Jose Scale (Diaspidiotus perniciosus) is a wide spread pest in the Czech Republic. Its harmfulness is increasing over the last years. The European Union removed this pest from the list of quarantine pests because of its extension in almost all European States. The scale develops on vegetative organs, blossoms and fruits. It occurs the most on bark of trunk and branches. Due to suction of plant saps the trees may die. The only stage that is sensitive to treatments is a crawler. Possible control methods are limited to applications of oil based preparations in early spring in organic agriculture. In the scope of our research we aimed to two main issues. Firstly we are testing different pheromone traps (Wing Trap, delta trap, open trap) suitable for monitoring of the San Jose Scale male occurrence in three different orchards. The Wing Trap achieves the highest catch of males but the delta trap is the best for user handling. The second area of our research is testing of different preparations suitable for organic agriculture against San Jose Scale nymphs. In 2013 the highest efficacy was achieved with preparation Naturalis (Beauveria bassiana) 59.6 – 60.9 %. Quite good efficacy was recorded with preparation RockEffect (Pongamia pinnata oil) 41.8 – 56.9 %. In 2014 the highest efficacy was achieved with preparation Naturalis up to 85,2 %.

Keywords: San Jose scale, pheromone trap, temperature model, apple, pear, Beauveria bassiana, spinosad, Pongamia pinnata oil
TOPIC 3 SESSION 2 (Plenary, 11th of June, am)

Oral Presentations

COMBINATIONS OF VARIETAL AND TECHNICAL INNOVATIONS FOR THE SUSTAINABLE AND INTEGRATED MANAGEMENT OF ROOT-KNOT NEMATODES: THE GEDUNEM PROJECT


1 INRA PACA, UMR 1355, Institut Sophia Agrobiotech, Sophia Antipolis, France; 2 INRA PACA, UR0767, E codéveloppement, 84914 Avignon, France; 3 INRA Montpellier, UE0411, Sciences pour l’Action et le Développement, Domaine Expérimental de Alénya Roussillon, 66200 Alénya, France; 4 IRD, UMR CBGP, Agropolis, 34988 Montferrier Sur Lez Cedex, France; 5 INRA PACA, UR1052, Génétique et Amélioration des Fruits et Légumes, 84143 Montfavit, France; 6 GRAB, Groupe de Recherche en Agriculture Biologique, 84 911 Avignon, France; 7 APREL, Association Provençale de Recherche et d’Expérimentation Légiurienne, 13210 Saint-Rémy de Provence, France; 8 Chambre d’agriculture du Var, 83400 Hyères, France.

The current restrictions on the use of chemical nematicides have contributed to increase root-knot nematodes (RKN) problems in horticultural crops. In this context, plant resistance (R) appears as the most effective method of control, but the restricted number of cultivated vegetable species with RKN R-genes available (tomato, pepper), and the possible occurrence of virulent nematodes able to reproduce on R-plants may constitute a severe threat to this control strategy. To increase the sustainability of the protection, a scientific challenge is to build cropping strategies based on the combination of genetic resistance with cultivation practices (crop rotations including susceptible, resistant, and non-host plants, intercropping management such as “nematicidal” cover crops, solarisation…). The Gedunem project aims at assessing such innovative strategies in a multi-site experimental design including organic and conventional cropping systems in research stations and commercial farms in the South of France. It involves analytical and systemic aspects: (1) impact of agronomic practices on the parasite pressure in the soil and on ecological diversity including other nematode species and pathogens, (2) linkage between the decrease of RKN populations in the soil and increase of R-genes durability, and (3) acceptability assessment of such varietal and technical innovations by farmers. Multidisciplinary approaches are combined to foster synergistic and long-term goals. The diversity of partners combining research and extension agents and associated forces brings all the complementary expertise needed for answering specific short-term questions as well as generic mid- to long-term expectations. First results suggest a strong reduction of RKN infestation rate in the soil (up to 90%) after solarisation (at central rows) or cultivation of sorghum or R-peppers (combining two R-genes) as trap crop green manure. The experimental design also demonstrated a satisfying level of resistance of the R-pepper (high, durable, stable at high temperature) and its effectiveness as trap crop with a good potential of soil colonization by pepper roots. Moreover, the buried dry matter for R-pepper is equivalent to that of traditionally-used sorghum (30 T/ha). This opens opportunities for breeding in Solanaceae. After 3 years of experiments, these strategies seem to limit the emergence of virulent nematodes on R-crops and increase the non phytoparasitic species (useful saprophagous) in the soil, but these results still have to be confirmed for the long run.

The Gedunem project (2012-2015) is carried out with the financial support from the French INRA métaprogramme SMaCh-Sustainable Management of Crop Health.

Keywords: root-knot nematodes, integrated pest management, crop rotation, resistance gene durability, agronomic practices, sustainable management.

ANAEROBIC SOIL DISINFESTATION (ASD): A STRATEGY FOR CONTROL OF SOIL BORNE DISEASES IN STRAWBERRY PRODUCTION

Carol Shennan 1, Joji Muramoto 2, Mark Mazzola 2, Shashika Hewavitharana 1, Graeme Baird 1, Lucinda Toyama 1, Steven Koike 3, and Dan Legard 4

1 University of California Santa Cruz, 95064, Santa Cruz, USA; 2 USDA-ARS Wenatchee, WA; 3 University of California Cooperative Extension; 4 California Strawberry Commission

Anaerobic soil disinfestation (ASD), a biological alternative to soil fumigation, has been shown to control a range of soil-borne pathogens and nematodes in numerous crop production systems. Current work is focusing on how to optimize ASD (in terms of carbon source used, temperature and degree of anaerobiosis attained) to control specific sets of pathogens, and to understand which mechanism(s) are responsible for disease control. Data will be presented from a series of on-going field and greenhouse trials that test the effect of soil temperature, carbon source (e.g. rice bran, grape pomace, molasses) and cumulative anaerobic conditions (Eh in mVhr below 200mV) on suppression of Verticillium dahliae, Macrophomina phaseolina and Fusarium oxysporum. Results indicate that microsclerotia of V. dahliae can be reduced by 80 to 100% providing soil temperatures are above 18oC and a cumulative Eh of 50,000mV hrs below 200mV is achieved. Shifts in soil microbial communities and associated production of organic acid and volatiles during the anaerobic phase may be associated with disease suppression. Further, microbial shifts associated with ASD using rice bran as a carbon source persist for at least 10 months, and enhanced V. dahliae suppression was observed two years after treatment. Temperature and Eh thresholds for other pathogens are being determined. When soil temperatures are high ASD with RB as a carbon source shows promise for reducing Fusarium and Macrophomina, but did not provide complete control. Trials are being repeated with refinements to see if greater pathogen control can be achieved. In 2014-15 404ha of commercial strawberry and raspberries in CA were planted using ASD, and in one field demonstration organic strawberry yields were almost doubled using ASD relative to grower standard practices.

Keywords: Anaerobic soil disinfestation, soil borne disease management, strawberry, organic acids
LED LIGHT TO IMPROVE STRAWBERRY FLAVOUR, QUALITY AND PRODUCTION

Maike Henanberg, J. Janse and W. Verkerke

Wageningen UR Greenhouse Horticulture, 2665 MV Bleiswijk, The Netherlands

A current demonstration in the greenhouses of Wageningen UR in Bleiswijk (the Netherlands) shows positive results of LED light on the quality and production of strawberries (Fragaria x ananassa). In this demonstration two strawberry cultivars, Elsanta and Sonata, are exposed to three different light treatments. The first treatment consists of top LED light only (90 µmol m-2 s-1), the second of top LED light with additional LED light on the leaves (200 µmol m-2 s-1) and the last of top LED light with additional LED lighting on the fruits (90 µmol m-2 s-1). Strawberries were harvested two times per week from October till December and each time total production was determined. Repeated measurements on refraction, titratable acid and vitamin C content were conducted in addition to flavour testing by a consumer panel and a sensory expert panel. Results point out that treatment with additional LED light on leaves and the treatment with LED light on fruits results in a significant increase in production, flavour, refraction, titratable acid and vitamin C content. Lighting on fruits causes an even higher increase in vitamin C content than lighting on leaves. The observed effect of additional LED lighting on the fruits is surprising, since only 90 µmol m-2 s-1 was available to the plant compared to 200 µmol m-2 s-1 in the other treatment. Our findings indicate that LED lighting is a promising technique in greenhouse horticulture to optimize flavour, nutritional value and production of strawberries.

Keywords: Fragaria x ananassa, greenhouse horticulture, light-emitting diode, ascorbic acid, refraction, acid level, aroma

EFFECT OF MINERAL AND ORGANIC FERTILIZATION ON CARBON FIXATION DURING A NECTARINE ORCHARD LIFETIME

Moreno Toselli1, Baldi E.1, Quartieri M.1, Sorrenti G.1, Marzadori C.2, Cavani L.1, Gioacchini P.1 and Innocenti A.2

1 Department of Agricultural Sciences, University of Bologna, 40127 Bologna, Italy; 2Experimental farm M. Marani, 246, Ravenna Italy

The objectives of the present experiment were to compare a mineral vs an organic fertilization in term of C sequestration in the orchard agro-ecosystem, by evaluating tree biomass and soil C fractions after the commercial orchard lifetime (13 years). Nectarine trees of cv Stark RedGold, grafted on GF677, were subjected, since their plantation (2001), to the following treatments, according to a complete randomized experimental design (4 replications): 1. unfertilized control, 2. mineral fertilization according to integrated management guidelines of the Emila-Romagna, Italian region, including P and K applied at planting and N (70 kg ha-1 for the first three years and then 120-140 kg ha-1 year-1) split in two applications at 40 days after full bloom (60%) and in September (40%) and repeated yearly; 3. compost supplied at a rate of 5 t dw ha-1 year-1, and 4. compost at a rate of 10 t dw ha-1 year-1, both treatments 3 and 4 were split as for treatment 2. In December 2014, 1 tree per plot (16 in total) was harvested, divided in roots, trunk, branches (age > 2 year) and current year shoots (1 year old) and weighted. A sub-sample of this material was weighted and oven dried and analyzed for C concentration. At the same time, soil samples were collected at different soil depth and distance from the tree row to evaluate the concentration and quality of C in the soil. Application of compost at high rate and mineral N increased tree biomass similarly (84 and 86 kg tree-1, respectively), compared to compost application rate of 5 t ha-1 (69 kg tree-1) and untreated control (65 kg tree-1). Trunk diameter of harvested trees was linearly related with tree total biomass (with a Pearson correlation coefficient, r of 0.82). Compost application increased soil organic matter concentration, compared to untreated control and mineral fertilization, contributing to sequestration of C.

Keywords: Prunus persica, root growth, yield, nitrogen, nutrients.

PRECISION APPLE FLOWER THINNING USING ORGANICALLY APPROVED CHEMICALS

Gregory Peck1, Candace DeLong1, Leon Combs1, Keith Yoder1 and Alson H. Smith, Jr.2

1Virginia Tech, Winchester, VA 22602 USA; 2Agricultural Research and Extension Center, Winchester, VA 22602 USA

Well-managed apple trees typically produce about ten times more blossoms than are needed to produce a full crop of acceptably-sized fruit. In order to minimize tree damage from over-cropping, improve fruit size, and ensure that trees produce an adequate number of fruiting buds for the following year, the flower and/ or fruit load must be reduced or “thinned”. The conventional practice of fruitlet thinning may also alleviate the risk from spring frost, but it does not carry the higher rewards of earlier bloom thinning, and the conventional practice involves chemicals that are not allowed in certified organic production. We have developed a temperature-based pollen tube growth model that accurately predicts the ideal application timing of bloom thinning chemicals. While growers in arid climates, such as Washington State, have successfully applied this model in their orchards, it has only been in the last couple years that growers in more humid climates, such as Virginia, have shown an interest in bloom thinning. This is largely because of concerns that spring frosts may further damage blossoms and result in too few fruit to harvest. However, we have shown that flower thinning is both a reliable and desirable technique for organic apple producers in Virginia. Additionally, our research has shown that combinations of several organically approved materials used for bloom thinning, namely liquid lime sulfur, JMS Stylet-Oil, and Regalia (a knotweed extract) can provide early season disease control of apple scab (Venturia inaequalis), cedar-apple rust (Gymnosporangium juniperi-virginianae), quince rust (Gymnosporangium clavipes), and powdery mildew (Podosphaera leucotricha). Among the many fungal diseases that need to be managed in Virginia, these are among the most formidable barriers to organic apple producers. Through the use of precision apple flower thinning, organic apple growers will be able to increase their production and be more competitive in the regional, national, and international marketplaces.

Keywords: blossom, crop load, lime sulfur, modelling, pollen tube, pollination
DESIGN OF A THINNING DEVICE FOR HORTICULTURAL FRUIT CROPS

Lutz Damerow 1, C. Seehuber 1 and M. Blanke 2
1 Institute of Agricultural Engineering, University of Bonn, Germany;
2 INRES - Horticultural Science, University of Bonn, Germany

Thinning is a pre-requisite in the majority of fruit crops worldwide in order to overcome or prevent alternate bearing (change of years with large and low yields) and to provide regular yields of high quality fruit in terms of size, taste, colour and constituents, as required by the market. The widely-used chemical thinning often uses compounds, commonly referred to as hormones, temperature-dependent and criticised by the consumer.

Hence, a new device was developed to achieve a wide variety of three-dimensional thinning motions in such biosystems, which consists of three variable horizontal rotors with rotating tines. The objective was to remove individual flowers out of the 5 flowers in a cluster; otherwise the large number of fruitlets within a cluster develops into small, hard, green and unripe fruit. Six-year-old apple cv. ‘Pinova’ trees on M9 rootstock 3.5 m x 1.5 m spacing near Bonn, Germany were mechanically blossomed-thinned in the periphery.

Overall, the success of the selective thinning depended on the interaction between branch angle and singlet portion. Branches facing (45°) the thinning device were more severely thinned. Selective thinning led to removal of individual flowers out of a flower cluster (rather than removing complete clusters) and increased the portion of the desired singlets from, i.e. flower bunches with one single flower with less fruit to fruit competition for photo-assimilates and subsequently better fruit quality.

Keywords: apple (Malus domestica Bork.), alternate bearing, crop load management, fruit quality, sustainability.

MANAGEMENT OF PEST INSECTS USING SEMIOCHEMICAL TRAPS

Catherine-Aryelle Baroffio 1, A.K. Berg-Karlsson 2, J. Cross 3, M. Fountain 1, V. Guibert 4, D. Hall 5, B. Ralle 1, P. Richoz 1, A. Rogivue 1, L. Sigsgaard 6, N. Tranrem 7, A. Wibe 8
1 Agroscope IPS, 1964, Conthey, Switzerland; 2 KTH Royal Inst. Of Tech., Stockholm, Sweden; 3 East Malling Research, Kent, UK; 4 Natural Resources Institute, Kent, UK; 5 Latvia Plant Prot Res Centre, Tiga, Latvia; 6 University of Copenhagen, Frederiksberg, Denmark; 7 Bioforsk, ås, Norway; 8 Bioforsk, Tingvoll, Norway.

The strawberry blossom weevil (Anthonomus rubi), the European tarnished plant bug (Lygus rugulipennis) and the raspberry beetle (Byturus tomentosus) cause large losses in yield and quality in organically grown strawberry and raspberry. A common trap was developed to attract in strawberry Anthonomus rubi and Lygus rugulipennis and in raspberry Anthonomus rubi and Byturus tomentosus. Attractive lures were combined into a single multitraps. This is one of the first approaches to pest management of non-lepidopteran insect pests of horticultural crops using semiochemicals in the EU, and probably the first to target multiple species from different insect orders. The aim is to develop optimized lures and cost effective trap designs for mass trapping and to determine the optimum density and spatial and temporal patterns of deployment of the optimized traps for controlling these pests by mass trapping.

Keywords: strawberry, raspberry, semiochemical trap, Lygus rugulipennis, Anthonomus rubi, Byturus tomentosus.

‘SUSTAINABLE FRUIT SYSTEM’: RESULTS AND EXPERIENCES OVER 6 YEARS ON THE POSSIBILITIES AND LIMITS OF A PESTICIDE FREE TABLE APPLE ORCHARD IN SWITZERLAND.

Franco Weibel, Claudia Daniel, Lukas Pfiffner, Hansjakob Schärer, Lucas Tamm, Ignazio Giordano, Eric Wyss
Research Institute of Organic Agriculture, FiBL, 5070 Frick, Switzerland

In most experimental studies carried out to enhance functional agricultural biodiversity (FAB) in apple production systems only single interaction effects were tested. However, before innovative self-regulating orchards can be recommended to commercial (organic) apple growers, more scientific data and practical experiences on the benefits of orchards designed for high FAB must be collected.

Since 2007, our experiment ‘Sustainable Fruit System’ (SFS) combines all known measures of indirect pest and disease control in a near-to-practice 1 ha model orchard without the use of any pesticide (not even organic ones). The measures comprise e.g. choice of scab (Venturia inaequalis) resistant cultivars (Topaz and Ariwa planted in alternate rows) on the vital rootstock Supporter 2; establishment of flowering plant strips enhancing beneficial arthropods in the alleys ways, in the tree rows and in the hedges; and low planting density for better canopy aeration (1666 trees/ha). The orchard is split into 4 blocks: 2 blocks are treated with biocontrol agents, e.g. application of Granulosis virus against codling moth (Cydia pomonella), in the other two blocks no biocontrol is applied. As reference orchards, we monitor 2 intensively managed commercial orchards (1 organic, 1 integrated production) with the highly scab susceptible cultivar Gala.

Our results reveal that the self-regulating orchard developed already in the 2nd and 3rd leaf a clearly higher flora and fauna biodiversity compared to the reference orchards. In addition, the populations of apple pest predators e.g. hoverflies, ladybirds and spiders increased to high levels. These antagonists were capable to prevent aphid damages although the pre-flower abundance of aphids (particularly Dysaphis plantaginea) was usually 5-12 times over the economic threshold value. Although the FAB of the model orchard worked satisfying well against pest insects, the obvious limitation of the system is the insufficient disease regulation of e.g. Sooty blotch (Schizotryium pomi), bitter rot (Gloeosporium sp.) and a breakthrough of Vf-scab resistance. In a follow-up new trial we will therefore consider beside new findings of FAB in orchards much more also issues of disease regulation.

Keywords: sustainable, apple, production, biodiversity, self-regulation.
DISEASE AND ARTHROPOD PEST INCIDENCE IN TWO ORGANIC APPLE ORCHARD SYSTEMS IN VERMONT, USA, 2008-2013

Terence Bradshaw, Lorraine P. Berkett, Heather M. Darby, Robert L. Parsons, Sarah L. Kingsley-Richards, Morgan C. Griffith, Sidney C. Bosworth, Josef H. Gorres, Renae E. Moran, and Elena Garcia

1University of Vermont, Burlington, VT 05405, USA; 2University of Maine Coop. Extension, Monmouth, ME 04259, USA; 3University of Arkansas, Fayetteville, AR 72701, USA

The results presented summarize six years of seasonal data of disease symptoms and arthropod infestations and/or damage on foliage and fruit on five organically-managed apple cultivars (‘Ginger Gold’, ‘Honeycrisp’, ‘Liberty’, ‘Macoun’, and ‘Zestar!’) grown in a newly planted orchard (Orchard 1) and a top-grafted established orchard (Orchard 2). Significant differences were found among cultivars for all assessed diseases in the study. ‘Ginger Gold’ and ‘Macoun’ had significantly greater foliar and fruit scab than ‘Honeycrisp’ and ‘Liberty’ in both orchard systems. The low incidence of scab on ‘Honeycrisp’ foliage and fruit and ‘Zestar!’ fruit was not statistically different than the scab-resistant cultivar ‘Liberty’ on which no scab was observed. Apple rusts were present on foliage, with ‘Ginger Gold’ and ‘Honeycrisp’ having the highest incidence and ‘Zestar!’ having the lowest in both orchards. ‘Macoun’ and ‘Liberty’ ranked the highest in the percentage of fruit without arthropod damage in both orchard systems but differences among the other cultivars were not distinct. Management of lepidopteran pests of fruit was a major challenge on all cultivars over the years of the study. European red mite incidence was high in both orchards, but only in Orchard 2 were there differences among cultivars, where ‘Ginger Gold’ and ‘Honeycrisp’ had greater incidence than ‘Macoun’ and ‘Zestar!’ and ‘Liberty’ not different from any other cultivar. These results combined with analyses of tree growth, crop yield, and economic performance comparing the five cultivars within each orchard system will aid growers in their decision-making to select cultivar(s) and orchard establishment methods for an organic production system.

Keywords: Malus x domestica, ‘Ginger Gold’, ‘Honeycrisp’, ‘Liberty’, ‘Macoun’, ‘Zestar!’; integrated pest management, apple scab, rust, fruit rots, mites, Lepidoptera pests

NON-TARGET IMPACTS OF AGRICULTURAL BIOSTIMULANTS COMPARED WITH SULFUR-BASED FUNGICIDES ON PHYTOPHAGOUS MITES IN A CERTIFIED ORGANIC APPLE ORCHARD IN VERMONT, USA

Ann Hazelrigg, L.P. Berkett, H.M. Darby, J. Gorres, and R.L. Parsons

1Department of Plant and Soil Science, University of Vermont, Burlington, VT 05405, USA; 2Department of Community Development and Applied Economics, University of Vermont, Burlington, VT 05405, USA

Disease management in organic apple orchards in Vermont is focused on controlling diseases with sulfur fungicides. The objective of this two year study was to evaluate the non-target effects of an organic disease management system containing agricultural biostimulants compared to two sulfur-based systems on phytophagous mite populations of the European red mite, Panonychus ulmi and two-spotted spider mite, Tetranychus urticae. Trees were arranged in a completely randomized design of five three-tree replications in a certified organic orchard. The two sulfur-based systems differed in the number of applications; in the third system, sulfur was replaced with biostimulants including pure neem oil, liquid fish, an activated microbial inoculant, and equisetum and stinging nettle teas. Each biostimulant application also included kelp meal, unsulfured organic molasses and yucca extract emulsifier. Organically-approved insecticides were applied uniformly to the whole orchard. Leaf samples were evaluated for the number of motile phytophagous mites approximately every 14 days from 1 July through 26 August each year. Although not always significantly different from the sulfur-based systems, when there were differences, the biostimulant system had fewer mites per leaf than one or both of the sulfur-based systems in both years. The difference in the number of sulfur sprays did not have a major effect on the mite populations. This research documents that the biostimulant system, which represents a novel management system for Vermont organic apple orchards, did not result in increased phytophagous mite populations and potentially may offer beneficial suppression compared to sulfur-based management systems. Before further adoption in commercial orchards, the targeted effects of the agricultural biostimulants on apple scab and other important diseases, in addition to the non-target effects on insects, tree growth, yield, and fruit quality, must be considered.

Keywords: integrated pest management, ‘Zestar’, European red mite, two-spotted spider mite.

NON-TARGET IMPACTS OF AGRICULTURAL BIOSTIMULANTS COMPARED WITH SULFUR-BASED FUNGICIDES ON PEST AND BENEFICIAL ARTHROPODS IN A CERTIFIED ORGANIC APPLE ORCHARD IN VERMONT, USA

Ann Hazelrigg, L.P. Berkett, H.M. Darby, J. Gorres, and R.L. Parsons

1Department of Plant and Soil Science, University of Vermont, Burlington, VT 05405, USA; 2Department of Community Development and Applied Economics, University of Vermont, Burlington, VT 05405, USA

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meal, unsulfured organic molasses and yucca extract emulsifier. Organically-approved insecticides were applied uniformly to the whole orchard. The use of the agricultural biostimulators had very limited non-target effects and when present, they were beneficial in suppressing insect pest incidence and/or damage on foliage compared to one or both of the sulfur-based fungicide systems. However, many insect pests or their damage were not observed on the foliage or had incidence of less than 1% in any of the systems. The biostimulator system suppressed European red mites (Panonychus ulmi) in both years compared to both sulfur-based systems when data were averaged across cultivars. On fruit, no differences in non-target impacts among any of the three systems were observed except for surface-feeding Lepidoptera and San Jose scale (Quadraspidiotus perniciosus) damage. In summary, the organic disease management system containing biostimulants did not have different non-target impacts for almost all of the pest and beneficial arthropods evaluated in this study compared to the sulfur-based systems. Before this novel disease management approach in commercial orchards is adopted, the effects of the biostimulants on important diseases, in addition to the effects on tree growth and yield must be considered.

Keywords: integrated pest management, ‘Ginger Gold’, ‘Honeycrisp’, ‘Liberty’.

IMPACT OF FLOWERING STRIPS ON PESTS, PEST ENEMIES AND PEST PREDATION AND PARASITISM IN THREE EXPERIMENTAL APPLE ORCHARDS

Marlice Botelho-Costa 1, Elise Thenoux 12, Armin Bischoff 2, Jean-François Toubon 1, Claire Lavigne 1, Pierre Franck 1

1 INRA, UR1115 PSH Plantes et Systèmes de culture Horticoles, 84000 Avignon, France; 2 Institut Universitaire de Technologie d'ignon, UMR CNRS-IRD 7263 IMBE Institut Méditerranéen de Biodiversité et Biologie, Avignon, France.

Conservation biological control aims to increase the abundance of natural enemies of insect pests by reducing mortality and creating habitat that provides food, a favorable microclimate, alternative hosts, and shelter for overwintering. At the local scale, the introduction of sown flower strips may increase habitat diversity and richness of both ground-dwelling and flying predators and parasitoids, thereby enhancing biological pest control. However, studies demonstrating a significant improvement of pest control are still rare because pest insect population dynamics depend on many other factors and flower strips may also contain resources for pests. We compared the effect of different plant mixtures (20m long strips of species-rich wildflowers, species-poor grass or spontaneous vegetation) planted in orchard margins on the biological control of two insect pests in three non-treated experimental apple orchards. Targeted pests were the coding moth (Cydia pomonella, Lepidoptera) and the rosy apple aphid (Dysaphis plantagnae, Hemiptera). We estimated the abundance of insect pests and pest enemies and pest damage along the growing season using visual inspections of trees and fruits, and sampling with pitfall traps and band traps of corrugated cardboard. Pest predation was estimated using sentinel organisms (coding moth eggs, aphids) and parasitism was assessed directly on pest populations. In parallel, we assessed the plant species diversity of the plant mixtures and observed with transects their arthropod diversity. Overall we collected approx. 2800 codling moth larvae, among which approx. 20% were parasitized by one of three main parasitoid species. Predation rates of sentinel preys averaged 41% for coding moth eggs and 22% for aphids in spring. We also collected a large number of potential predators among which approx. 3500 spiders and 300 carabids which have been determined to family or species level. Results are being analyzed to assess the potential effect of the planted plant mixtures on these variables.

Keywords: conservation biological control, flowering strips, predation, parasitism, biodiversity

BIOLOGICAL CONTROL OF TETRANYCHUS URTICAЕ (Koch) IN TOMATO GREENHOUSES

Vincent Gigon 1, Josiane Le Corff 2, Cédric Camps 3

1 Hepla, 1254, Jussy, Switzerland; 2 Agrocampus ouest, UMR 1099 BIO3P, 49045 Angers, France; 3 Agroscope, Research Centre Conthey (VS), 1964 Conthey / Switzerland

Biological control against phytophagous arthropods has been widely used in IPM programs mostly under greenhouse conditions. Its success is dependent on a number of factors related to the interactions between the pest and the predator (or the parasitoid) and to the environmental conditions. Interactions (including intraguild predation- IGP) among different biological control agents might also have a negative impact on the success of biological control programs. In tomato crops, the spider mite Tetranychus urticae (Koch) is a phytophagous mite that is very problematic. In a production greenhouse, we asked whether a new predator Phytoseiulus macrocarpilis (Banks) could control T. urticae populations, alone and with Macrolophus pygmaeus (Rambur). M. pygmaeus is a polyphagous mirid released against greenhouse whiteflies. It is supposed to predate on P. macrocarpilis. Our experiment took place during the summer of 2013 (June 15-August 15). To test the efficacy of the two predators alone or together on T. urticae populations, four cages per treatment with three tomato plants each, were used to compare the evolution of the arthropod populations in the four treatments (T. urticae alone, T. urticae + P. macrocarpilis, T. urticae + M. pygmaeus, T. urticae + P. macrocarpilis + M. pygmaeus). Comparisons of the areas under the curve calculated by counting the number of arthropods by plants over time indicated that P. macrocarpilis controlled the population of T. urticae, while M. pygmaeus had a very limited impact. Furthermore, there was no evidence of IGP between the two predators. P. macrocarpilis could develop under the dry environmental conditions observed in the greenhouse (Temperature = 24.4 ± 2.3 °C, Relative Humidity = 51.4 ± 7.2%). As its efficacy was estimated to be app. 60%, further studies should clarify the number and location of the release points to optimize the control of T. urticae by P. macrocarpilis.

Keywords: Biological control, Tetranychus urticae Phytoseiulus macrocarpilis, intraguild predation, tomato.
A HOLISTIC APPROACH FOR THE BIOLOGICAL CONTROL OF WHITE GRUBS (MELOLONTHA MELOLONTHA) IN ORGANIC STRAWBERRY PLANTATIONS

Eliogio Malusa 1, Tartanus M. 1, Łabonowska B.H. 1, Canfora L. 3, Pinzari F. 2 and C. Tkaczuk 2

1 Research Institute of Horticulture, Skiermnickie, Poland; 2 Siedlce University of Natural Sciences and Humanities, Siedlce, Poland; 3 CRA-Center for Plant Soil System, Rome, Italy

Organic production of strawberry fruits has been increasing in the last years in Poland, mainly due to the increased interest for processing. In the last decade, the damage caused by soil pests which include, inter alia, the white grubs Melolontha melolontha (European cockchafer), Phyllopertha horticola (Garden chafer), Otiorhynchus ovatus (Strawberry root weevil) and Otiorhynchus sulcatus (Black vine weevil) increased drastically. Currently, no specific biological products for control of these pests are registered in Poland. Considering the difficulty in controlling the pests, we have established laboratory and field trials to develop a strategy based on the coordinated use of physical (soil steaming and tillage) and biological methods (use of entomopathogenic nematodes of the species Heterorhabditis bacteriophora or entomopathogenic fungi of the species Metarhizium anisopliae, Beauveria bassiana and Beauveria brongniartii) of pest control. These were coupled with agronomical practices (pre-planting of Fagopyrum esculentum or treatment with plant extracts functioning as attractants or repellents for the larvae) before the plantation is established and during its exploitation. Both physical and agronomical practices reduced the soil population density of the insect and appear to improve the establishment of a strong entomopathogenic fungal population, which should have a long term impact on the pest. The application of biological agents to control the white grubs larvae showed a fairly good performance, although the effect was not immediate - entomopathogenic fungi and nematodes were also observed in subsequent developmental stages of the pest (e.g. in pupae) and in soil samples collected at the end of the growing season, thus assuring a sufficient persistence in soil. Different plant extracts are showing promising results in laboratory tests. The results show that only a comprehensive approach could be feasible to assure an effective control of these soil-born pests.

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Keywords: biological control, soil steaming, entomopathogenic fungi and nematodes.

ANTIOXIDANT ACTIVITY AND PHENOLIC CONTENT IN PEACH FRUITS FROM ORGANIC AND INTEGRATED MANAGEMENT

Danilo Cecarelli, C. Talento, E. Caboni, D. Neri

Council for Agricultural Research and Economics, Fruit Tree Research Center - Rome, Italy

Consumers are paying an increasing attention to antioxidants and their beneficial effects on human health. In particular high interest has been focused on phenolic compounds in fruit and vegetables since their consumption was shown to be associated with a reduction of incidence of cardiovascular and neoplastic diseases. Several studies have demonstrated that the level of phenolic compounds in fruits, including peaches and nectarines, is highly related to genetic factors, stage of maturity, environmental and cultivation methods. In this work soluble solids content (SSC), titratable acidity (TA), pH, total phenolic content (TPC), total anthocyanin content (TAC) and antioxidant activity (AA) were evaluated in fruits of 8 peach (Prunus persica L.) cultivars grown in organic and integrated orchards. The AA was measured with the DPPH radical assay at 513 nm. Differences in TPC, TAC and AA between the two cultivation systems were found only in some cultivars, while an overall difference due to the orchard management was not found. In all cultivars, the nutraceutical parameters investigated were found significantly higher in skin, respect to flesh, and genotype dependent.

Keywords: cultivation systems, Prunus persica (L.) Batsch, total phenols, total anthocyanin content.

POLYPHENOLS AND ORCHARD MANAGEMENT: THE CASE STUDY OF APPLE IN BIORECO EXPERIMENT

Carine Le Bourvellec 1,2, Sylvie Bureau 1,2, Renard Catherine 1,2, Plénét Daniel 3, Girard Thierry 4, Simon Sylvaine 4

1 INRA, UMR408 Sécurité et Qualité des Produits d’Origine Végétale, F-84000 Avignon, France; 2 Université d’Avignon et des Pays de Vaucluse, UMR408 Sécurité et Qualité des Produits d’Origine Végétale, F-84000 Avignon; 3 INRA, UR1115 Plantes et Systèmes de culture Horticoles, F-84000 Avignon, France; 4 INRA, UE695 Recherches Intégrées, Domaine de Gotheron, F-84320 Saint-Marsel-lès-Valence, France

The present study was performed to evaluate phenolic content of apples (cultivars ‘Ariane’, ‘Melrose’ and ‘Smoother’) managed under organic, low input and conventional systems. Apples were harvested in the orchards of the system experiment BioReco at INRA Gotheron (Drôme, 26) over the course of three years (2011, 2012 and 2013). Multivariate analyses highlighted that the management system had a smaller impact on the variation of phenolic content than the cultivar and the yearly climate. When considering the Ariane cultivar and year 2011 to investigate the effect of the management system per se, the total polyphenol content of either the flesh or the peel of apples was not significantly different between systems. Procyanidins, the main compound, were also similar among systems. Some compounds of the peel ((-)-epicatechin and 5’-caffeoylquinic acid) showed higher concentrations in organic apples, but the opposite was observed for (+)-catechin in the flesh. Phloridzin content of peel significantly decreased in apples from organic to low-input then conventional systems. Cyanidin-3-O-galactoside in the peel was the lowest in low-input apples. As far as the same metabolic processes are involved in the elaboration of phenolic compounds in the fruit, this indicates that mechanisms underlying polyphenol content in the plant are complex. Finally, when considering a range of management systems combined with three cultivars instead of the usual organic vs. conventional comparison, polyphenol content of
apple appeared more determined by the cultivar and the year of cropping than the orchard practices.

**Keywords:** Malus x domestica. Borkh., cultivar, orchard practices, fruit quality, secondary metabolites.

**NON-DESTRUCTIVE DETERMINATION OF SURFACE FEATURES ON POMEGRANATE FRUIT**

Ruth Spielmanns, Judith Spielmanns, Lutz Damerow and Michael Blanke

Institute of Agriculture Engineering, University of Bonn, Germany

Pomegranates change their appearance with age: while freshly picked fruit exhibit a shiny-glossy and smooth peel, this becomes wringly during shrinkage and shelf life. It would be helpful to have a sensor, which could measure this parameter of fruit quality or fruit freshness. A new sensor technology is becoming available for the detection of surface features based on a combination of glossiness, colour and contrast. Hence, the overall objective of the present preliminary study was to examine pomegranate during the utmost shelf life for any changes using these sensor systems. Red and yellow pomegranate fruit from med countries obtained on the local market in Bonn were examined by three means, luster sensor, and 3 D microscope for fine-structure and peel roughness. The 3D colour microscope (HX 5000) showed the change in microstructure of both the yellow and red pomegranate fruit with its progressive shrinkage during shelf-life of 3 weeks with a concomitant increase in peel roughness.by ca. 1mm. The new luster sensor (CZ H75) could significantly distinguish between stored and fresh yellow pomegranate, while this change was not detected with by the luster sensor with red pomegranate fruit. The results are discussed with respect to the properties of the sensor and interpretation of its ‘luster level’ output.

**Keywords:** sensor technology, pomegranate, fruit quality

**EFFECT OF APPLICATION OF CHOSEN PRODUCTS ON REDUCTION OF CHERRY FRUITS CRACKING (PRUNUS AVIUM) INDUCED BY RAIN**

Radek Vávra, Suran, P., Zelený, L., Skřivanová, A., Blažková, J.

1 Research and Breeding Institute of Pomology, 508 01, Horice, Czech Republic

Application of 5 products against cracking caused by rain before the cherry harvest was evaluated in 2013 and 2014 in the Research and Breeding Institute of Pomology Holovousy Ltd (Czech Republic). Following products were used: Actisil, Boronia, Borosan, Gibb 3 and Platina which act on the physiology of the plant, increase the strength and elasticity of the cell walls and product Agrovitai which forms the polymer protective layer on the skin and prevents water absorption to cherries. Products were sprayed on cherry cultivars ‘Amid’, ‘Burlat’, ‘Justyna’, ‘Kasandra’, ‘Kordia’, ‘Regina’, ‘Sweet Early’, ‘Tamara’, ‘Těchlovan’ and new hybrid ‘HL 13 577’. Actisil was applied in 4 replications and other products were applied once - 10 to 12 days before harvest or in case of the imminent rain. Evaluated traits were: percentage of cracked fruits, fruit weight, fruit width, soluble solid and firmness of the flesh. The most perspective applicant is Gibb 3 decreased cracked fruits for cultivar ‘Justyna’ by 11 %, for ‘Tamara’ by 10 % and for ‘Regina’ by 9 % compared to none treated control sample. Positive impact on fruit weight had products Boronia + Actisil with recorded weight gain on cultivars ‘Amid’ by 4,1g, ‘Kasandra’ 3,2 g, ‘Justyna’ 2,4 g, HL 13 577 , ‘Kordia’ 1,8 g and ‘Tamara’ 1,4 g. Differences between tested cultivars were recorded. On cultivars with lower flesh firmness (‘Sweet Early’, ‘Burlat’) were not recorded differences between tested products. On cultivars with higher flesh firmness was product Gibb 3 evaluated as the most effective in protection against cracking induced by rain on tested trees in orchards as well in laboratory test with dipping cherry fruits in tap water.

**Keywords:** induced rain cracking, cherry cultivars, fruit firmness, soluble solid content, gibberelins.

**HEAT TREATMENTS COMBINED WITH HIGH CO2 OR N2 ATMOSPHERES TO KILL CHESTNUT FRUIT TORTRIX LARVAE**

Sébastien Lurol, C. Belaen, P. Landry, F. Verpont and B. Hennion

Ctifl - Technical Institute for Fruit and Vegetables - 13210 Saint-Rémy-de-Provence, France

Postharvest losses are a major brake on the economic growth of the fruit sector and on the development of the production of certain fruit species in organic farming. Chestnut (Castanea sativa Miller) is a very sensitive commodity with high losses due to insect infestation and diseases. In 2014, the first trials were carried out to evaluate the efficacy of postharvest heat treatments combined with high CO2 or N2 atmospheres to kill insects. Different treatments at 45°C and 100% CO2 or 100% N2 were applied on chestnut fruit tortrix larvae (Cydia splendana) and showed a complete effectiveness on larvae mortality. A higher temperature (50°C) with a 40% CO2 concentration gave similar results. These preliminary results must be validated in vivo to confirm the potential of this technique for killing chestnut fruit tortrix.

**Keywords:** Castanea sativa, insect disinfection, controlled atmosphere, fruit losses, physical treatments, postharvest
Beyond plant selection or technology and inputs management, other approaches are possible to overcome production and protection challenges. In this session, design and redesign issues will be addressed, including site selection, new orchard patterns and diversified cropping systems (with multiple layers, combining various species or activities). Organisation in time and space will be tackled through orchard trajectories and farm or regional transition processes. Economic risk factors and assets will also be addressed to support the feasibility of suggested options.

TOPIC 4
Design and evaluation of integrated and organic horticultural systems: innovative cropping patterns and management methods

Coordinators: D. Granatstein & E. Malezieux

TOPIC 4, SESSION 1 (Parallel, 9th of June, pm)

Oral Presentations

FRUITS OR VEGETABLES: WE DON'T NEED TO CHOOSE: HORTICULTURAL AGROFORESTRY AS AN ECOLOGICAL INTENSIFICATION PATHWAY
Dayaleth Alfonzo-López, S. Bellon, Marc Tchamitchian
INRA PACA, UMR767, ÉcoDéveloppement, 84914 Avignon, France

The necessary ecologization of agriculture in the developed countries has recently resulted in the research of innovative systems that are both economically viable and environmentally friendly, with sustainable objectives at mid and long terms. The agroforestry systems, mixing trees and crops on the same plot, are ecologically intensive systems that allow a better use of natural resources, hence increase production on the same land area. The vegetable orchard is an agroforestry system mixing fruit trees and vegetable crops that disappeared in the 1950’s for economic reasons. Its reintroduction becomes a new research topic for ecological purposes, with agronomic bases to ensure its viability.

This presentation focuses on the ecological changes introduced by mixing these two productions. We review the current knowledge on agroforestry in general and discuss its application to horticulture. The analysis is structured according to the classification of the ecosystem services, detailing provisions, regulations (for pest control, nutrient recycling and water quality). Top-down effects (because of natural enemies) and bottom-up effects (because of resource competition) can regulate the population dynamics of insect pests. The efficient use of the nutrients as the nitrate, the changes in the transpiration and the soil water retention leads to the reduction of the ground water pollution in these systems. This pollution reduction is controlled by these factors: the decrease of the nitrates loss by lixiviation process, the decrease of the runoff waters and the infiltration increase. The accumulation of greater amounts of soil organic matter, the large storage of nutrients on the biomass, a higher root density related to a vertical stratification of the root system, helps to maintain the nutrient reserves, to reduce the lixiviation and to trigger the nutrients transfer from the ground to the surface soil layers. We conclude on the potential of such mixed systems to provide diversified and quality fruits and vegetables and on their adaptation to peri-urban agriculture.

Keywords: fruits, vegetables, mixed systems, agroforestry, ecosystem services, organic farming.

APPLICATION OF AGRO-ECOLOGY CONCEPTS TO ORANGE CULTIVATION IN SOUTHERN EUROPE
Giancarlo Roccuzzo 1, Filippo Ferlito 1, Biagio Torrisi 1, Maria Allegra 1, Elena Testani 2, Fabio Tittarelli 2, Stefano Canali 2 and Corrado Ciaccia 2

1Consiglio per la Ricerca in Agricoltura e l’analisi dell’economia agraria, Centro di ricerca per l’Agrumicoltura e le Colture Mediterranee. Corso Savoia 190, 95124 Acireale (CT), Italy ;
2Consiglio per la Ricerca in Agricoltura e l’analisi dell’economia agraria, Centro di ricerca per lo studio delle Relazioni tra Pianta e Suolo Via della Navicella, 200184 Roma, Italy

Recent studies carried out in Southern Italy demonstrated the technical feasibility of organic farming management in citrus systems. In a field study started in 1995, the effects of poultry manure, farmyard manure and compost from “pastazzo” (a residue of citrus juice industry) were compared to a control (mineral fertilizer) after yearly application at the same N input level on ‘Valencia late’ orange [Citrus sinensis (L.) Osbeck] trees, grafted on sour orange (C. aurantium L.). The system comparison showed an increase of soil organic C stock for compost treatment, allowing the recycle of organic residues available in citrus agro ecosystem, fostering nutrient
insecticide use, while many growers even get very good results with only one insecticide spraying. These changes bring about new balances within the fruit production system, with some secondary pests decreasing while others increase their economic importance. This has set new challenges for managing certain pests and developing alternative tactics to replace conventional insecticides. Current results, changes in the program design, and future projections are presented and discussed.

Keywords: apple, pear, mating disruption, codling moth, oriental fruit moth.

ABUNDANCE OF PREDATORY BUGS ON TEN FLOWERING PLANT SPECIES WITH POTENTIAL USE IN HABITAT MANAGEMENT TO CONTROL HORTICULTURAL INSECT PESTS

Josée Boisclair, Geneviève Richard, Elisabeth Lefrançois, Maryse Leblanc, Michèlè Grenier

Organic Agriculture Innovation Platform, Research and Development Institute for the Agri-Environment (IRDA), Saint-Bruno-de-Montarville, QC, J3V 0G7, Canada

Curative strategies to control insect pests are quite limited in organic crop production. Therefore, insect pest management efforts in organic cropping systems should be focused on preventative approaches. Conservation biological control involving the management of the agroecosystem is one of these approaches. The use of flowering strips adjacent to crops may provide food source (pollen and nectar, alternate hosts and/or prey) and shelter for natural enemies of insect pests. Some flowering plant species may encourage the presence of predatory bugs which may contribute to biological control of pests such as thrips, mites and aphids. Supported by Agriculture and Agri-Food Canada, this 3-year study aimed at determining the abundance of some predatory bug species, among which Orius spp., on ten flowering plant species: alfalfa (Medicago sativa), alyssum (Lobularia maritima ‘Easter white bonnet’), coriander (Coriandrum sativum ‘Santo monogerm’), cosmos (Cosmos bipinnatus ‘Sensation mix’), French marigold (Tagetes patula ‘Bonanza mix’), mustard (Sinapis alba), nasturtium (Tropaeolum majus ‘California giant’), petunia (Petunia grandiflora ‘Ultra mix’), phacelia (Phacelia tanacetifolia) and yarrow (Achillea millefolium ‘Colorado’). The experimentation was conducted at the Organic Agriculture Innovation Platform managed by the Research and Development Institute for the Agri-Environment (IRDA) and located in Saint-Bruno-de-Montarville (Québec, Canada). The experimental design consisted of a randomized complete block design and three replicates. Strips of single plant species were planted in 2010, 2011 and 2012. Strip size was 2.4 m x 3 m. Sweep net and yellow sticky traps were used weekly to monitor insect abundance and diversity in each plot. Data collection included plant stage, abundance of predatory bugs and pests. The captures with yellow sticky traps suggest a greater abundance of predatory bugs in cosmos and nasturtium while sweep net sampling indicates greater abundance in alfalfa.

Keywords: conservation biological control, preventative pest management, predatory bug, Orius, insectary plants.
NEW AGRONOMIC TECHNIQUES FOR HIGH QUALITY ORGANIC SWEET CORN IN MARITIME CANADA

Josée Owen and S. Leblanc

Potato Research Centre, Agriculture and Agri-Food Canada, Fredericton, New Brunswick, Canada

In eastern Canada, sweet corn is a high input, high value, seasonal table vegetable crop. In maritime Canada, where the season is later and briefer than other parts of eastern Canada, sweet corn is commonly sold for $6 per dozen ears, and demand for organic sweet corn results in prices as high as $12 per dozen, or even more if pre-shucked. Acme is limited, however, because of the challenges of bringing organic sweet corn to successful harvest. The crop requires high levels of fertility, as well as intensive pest management techniques to control weeds and insects which cause reductions in crop quality and yield. Methods for high quality sweet corn production were examined in the context of a long term organic rotations experiment in New Brunswick. Innovative techniques were developed including: 1) using transplants instead of direct seeding; 2) planting into zone-tilled established red clover living mulch; 3) use of narrow over-zone biodegradable organic “mini-mulches”; 4) drip irrigation; 5) fertility regime using pre-plant banded organic compost and soluble organic fertilization; and 6) insect pest scouting and control using organic pesticides. This resultant system was extremely intensive, but comparison of input costs and revenues from this organic system with those from conventional sweet corn systems proved it to be highly profitable, more so even than conventional systems. The caveat was that the risk profile differed vastly between systems with the organic system requiring considerably higher investment in the early part of the season. This high-performance system will likely yield well for growers across eastern Canada, and is the first reliable system for producing organic sweet corn for this region.

Keywords: Zea mays; zone-tillage; living mulch; integrated production; cropping systems.

PERFORMANCE OF ORGANIC VEGETABLE ROTATIONS UNDER MEDITERRANEAN EXPERIMENTAL AND ON-FARM CONDITIONS

Emre Bilen 1, N. Özsöy 1, C. A. Nazik Bayram 1, M. Unal 1, B. Aslan 2, L. Al Bitar 1, S. Kaya 2, I. Duman 1, U. Aksoy 1

1 CIHEAM Mediterranean Agronomic Institute of Bari, 70010 Bari, Italy; 2 Ege University, Faculty of Agriculture, Dept. of Horticulture, 35100 Bornova, Izmir, Turkey

Vegetables are generally grown as intensive systems on smaller plots and their economic significance is of utmost importance in the Mediterranean countries. Even if organic management became widespread around the Mediterranean starting from 1980s, long-term rotations based mainly on vegetables are rather rare. Performance of organic farming systems relies on the economic, technical and ecological outputs. A four year experiment was carried out between 2006 and 2010 at Ege University experimental site (İzmir/Turkey) in cooperation with CIHEAM Mediterranean Institute of Bari. The best practices were transferred to the farmer conditions in the fifth year. The 4-year rotation program was designed as follows: in winter months experimental plots had broccoli, broad bean, vetch or fallow (natural vegetation) followed by a main crop that changed yearly in the order of tomato, zucchini, pepper and eggplant. Broccoli represented the farmers' choice as a winter vegetable and vetch and broad bean as green manure. Additionally, organic-certified commercial compost was added during the summer cycles as a standard amendment. Effect of pre crops and main crops on soil organic matter, primary nutrients, weed abundance and yield were assessed for each main crop cycle. Soil N, P and K contents of the experimental plot were kept at rich or sufficient levels for four years, and yields obtained for the summer vegetables were within the regional averages. Based on the economic and technical outputs, best practices (vetch or broccoli + zucchini and vetch or broccoli + tomato) were tested under farmer conditions. The paper summarizes the major results on soil fertility and yield and quality of tested crops obtained under experimental and on-farm conditions. Based on five-year results, broccoli and vetch are recommended as the two successful pre-crops for winter where summer vegetables are the main crops.

Key words: broccoli, eggplant, pepper, quality, tomato, vetch, yield, zucchini.

ECOSYSTEM SERVICES FROM COVER CROP-BASED ORGANIC VEGETABLE SYSTEMS

Kathleen Delate 1 and Cynthia Cambardella 2

1 Iowa State University, Ames, Iowa, USA; 2 USDA-ARS, Ames, Iowa, USA

A four-year multi-disciplinary, multi-state project was established to address critical stakeholder needs for improving organic vegetable farming practices to optimize pest management, crop quality, and profitability, while enhancing soil quality, fostering carbon sequestration, and minimizing nutrient loss through cover crops, composting, and reduced tillage to help mitigate global climate change. Treatments included six cropping system: four treatments using cover crops (CC) and two without CC. Of the four CC treatments, two were organic no-till and two were tilled prior to vegetable crop planting/transplanting. Composted animal manure and straw mulches were applied to a sub-set to test the effect of these soil amendments on yields and weed management. Fall cover crops were planted each year in October, at a rate of 28 kg/ha hairy vetch and 101 kg/ha rye. Cover crops were disked or terminated with a roller/crimper at anthesis in May, with vegetable planting two to four weeks later, weather-dependent. Compost was applied pre-planting in April, at 112 kg N/ha, and organic fertilizer (2-5-4 N-P-K; MBA, Blue Mounds, WI) was side-dressed at 56 kg N/ha approximately six weeks after planting. Results indicate that higher tomato, pepper, sweet corn and onion yields were associated with tillage, although no-till vegetables with side-dressed organic fertilizer produced equivalent yields to tilled plots in four of eight comparisons. Cover crops enhanced overall soil quality by improving storage of soil organic C, total N, and biologically active soil C and N; and improved soil structure under reduced tillage. With compost, higher soil organic C, total N, biologically active soil N, and higher plant nutrient concentrations were observed compared to when no compost was applied. Lysimeter data has been showing that the concentration of leached N has been consistently lower under vegetables grown with a cover crop and in no-till.
Keywords: organic no-till, lysimeters, soil quality.

FROM ORCHARD TO AGRI-FOOD SYSTEM REDESIGN TO REDUCE PESTICIDE USE
Servane Penvern\textsuperscript{1}, Coline Kouchner\textsuperscript{1}, Laure Ruynat\textsuperscript{2}, Sylvaine Simon\textsuperscript{1}, and Claire Lamine\textsuperscript{1}
\textsuperscript{1} UR Ecodéveloppement, INRA PACA, Avignon, France; \textsuperscript{2} UE Recherche Intégrée, INRA PACA, St Marcel les Valence, France

Decreasing pesticide use in orchards is a major challenge. The study of pest management strategies and their determining factors is important to evaluate possible reductions in pesticide use. Decision-making in orchards is constrained by a high risk of fruit damage and yield loss due to permanent hosting of pests in a perennial system and market standards of ‘zero default’ fresh fruits. In this context, we focused on the middle Rhone Valley in South-Eastern France, where many producers have switched from peach to apricot production in the last two decades due to an economic and sanitary crisis. We investigated the following questions: Is new orchard planting an opportunity to rethink pest management strategies? How do technical constraints and socio-economic aspects (e.g., commercial outlets, information network, technical support) influence decision-making? A survey was conducted with 35 apricot and peach producers. The interviews focused on pest management strategies and alternative methods adoption, recent farm pathways, commercial outlets and information and technical networks. Drivers, bottlenecks and opportunities to adopt alternative methods and design more ‘ecologized’ pest management strategies were identified. Orchard planting was not so much a prerequisite for orchard redesign as was the progressive integration of various alternative methods. Our results also emphasized the interdependences between farmers’ pest management strategies and pesticide regulations, food chain constraints and information systems: farmers advised by input sellers used more pesticides than those with no or independent advisors; farmers selling through short distribution channels used fewer pesticides than those selling through farmers’ organizations, brokers or wholesalers. Promising levers have thus been identified to reduce pesticide use, but their application and diffusion often fail due to their low adequacy to the agri-food, regulation and/or technical support systems. Therefore, orchard transition towards ecologization and pesticide reduction should be facilitated through a deeper redesign at the scale of the agri-food system.

Keywords: pest management strategies, technology adoption, socio-technical lock-in, drivers, food chain.

Poster Presentations

INTEGRATED COVER CROPPING PRACTICES TO REDUCE EROSION IN INTENSIVE, STEEP-SLOPED POTATO PRODUCTION
Josée Owen
Potato Research Centre, Agriculture and Agri-Food Canada, Fredericton, New Brunswick, Canada

New Brunswick is one of Canada’s top potato producing provinces, with the bulk of the production area concentrated in the upper Saint John River Valley, on steep slopes of 2-15\%. Rotations are usually just 2-3 years long, and on some farms, continuous potato production continues to be practiced. The region is known for frequent, intense rain events, which has led to 20 t/ha or more sediment erosion annually over the past 5 decades. Best management practices, such as diversion terraces and grassed waterways are increasingly being used in the area, but soil continues to be tilled in the fall, lie bare over winter, through spring planting, up until potato emergence and vine growth. In the fall, once potato harvest is complete, soil is left bare until planting the following spring. New trials are underway at the Potato Research Centre to look at innovative techniques for covering bare soil in the potato year with the aim of reducing soil erosion. One technique being studied is the establishment of a spring cover crop. At potato planting, winter rye seed or buckwheat is planted, germinates quickly and forms a cover to protect soil during the 40 or so days between planting and hilling. Trials are looking at a second technique, which involves the broadcast seeding of a cover crop at vine killing prior to harvest. Crops such as winter rye are able to establish, withstand the soil disturbance of harvesting and continue to grow, forming a cover which can remain in place and over winter. Other crops are being tested for their potential for fall seeding, including winter rape, winter canola, and rape/radish mixtures. A third technique is being investigated for the first time, involving tillage and formation of raised beds in the fall prior to the potato year; the beds are planted with winter rye, which forms a cover that remains in place over winter. The potatoes are planted directly into the bed in spring using a modified planting method. This technique, if successful, combined with a fall seeding at potato vine kill would result in vegetative cover over the entire potato growing season. Data collection focuses on yield performance of the potato crop, biomass production of the various cover crops, soil moisture monitoring and water infiltrometry, and assessment of soil cover by vegetation using digital image analysis.

Keywords: nurse crop, vegetative cover, cover crops, soil erosion.

DESIGN AND ASSESSMENT OF PROTECTED MARKET GARDENING CROPPING SYSTEMS SUITED TO CONTRASTED FOOD SYSTEMS
Perrin Benjamin\textsuperscript{1}, Salembier Cléo\textsuperscript{1}, Lefèvre Amélie\textsuperscript{1}, Lesur-Dumoulin Claire\textsuperscript{1}, Meynard Jean-Marc\textsuperscript{2}
\textsuperscript{1} INRA SAD (Sciences pour l’Action et le Développement), UE0411
\textsuperscript{2} Domaine Expérimental Alénya Roussillon, 66200 Alénya, France

INRA SAD, UMR SAD-APT, 16, rue Claude Bernard 75231 Paris cedex, France

Reduction of pesticides use in agriculture is a great challenge, especially in market gardening where producers have to deal with a large range of crop species, pests and diseases. Under greenhouse conditions, pest populations and disease outbreaks evolve very quickly and can directly cause commercial yield losses forcing producers to build efficient pest management strategies to secure their incomes. In market gardening, farmers manage pests and diseases through different strategies. This diversity is related to the specific objectives and resources of each farm, which are directly impacted by the supply chains (long or short) and the certification schemes (organic or conventional), i.e. to the food systems to whom the farm belongs. The 4SYSLEG project aims to design, experiment and assess protected market gardening cropping systems to reduce pesticide use, while taking into consideration specific constraints of production related to diverse food systems. Following a diagnosis, four productive frameworks were built to guide the design process. Then relevant IPM practices (biocontrol tools, crop rotation, intercropping and surroundings management) were identified in order to design a global strategy suited to each framework. The prototypes (resulting from a coherent combination of these practices) were tested on-station to assess their performances, produce knowledge on the biological processes at work and formalize guidelines to manage these systems. The poster focuses on two cropping systems within the four tested, to present, how food system features (long supply chain in conventional farming and short supply chain in organic farming) are taken into account at field scale to design suited agroecological pest management strategies. We illustrate in particular how we built a set of decision rules to manage a specific summer pest issue and we present first results of the multi-criteria assessment.

Keywords: design, multi-criteria assessment, protected market gardening, system experiment.

CAN AN ORGANIC MARKET GARDEN WITHOUT MOTORIZATION BE VIABLE THROUGH HOLISTIC THINKING? THE CASE OF A PERMACULTURE FARM

Kevin Morel 1, C. Guégan 2, F. Léger 3
1 INRA SAD-APT, INRA Paris, France ; 2 Ferme du Bec Hellouin, Bec Hellouin, France ; 3 UMR SAD-APT, AgroParisTech, Paris, France

In industrialized countries, innovative farmers inspired by permaculture holistic principles claim to design market gardens only based on manual labor. We carried out a case study on one of these farms to assess in which extent this approach could make it possible for a commercial organic market garden to be viable without motorization. Our work showed that these market gardeners implemented a wide range of strategies embracing ecological, technical and commercial dimensions to increase their production on a small cultivated area and the added value of such production. On a surface area of 1061m², they were able to create a monthly net income between 882€ and 2058€, depending on sales and investment levels. Theses incomes were generated with an average working time of 43h per week. Such economic performances demonstrated that these initiatives can be viable. However, the studied approach excluded growing manually conservation crops such as potatoes. Further investigation should be carried out about the way manual and motorized market gardeners can collaborate to build together a satisfying commercial offer.

Keywords: organic horticulture, Permaculture, Holistic approach, Energetic autonomy, Agroecology, Post-oil agriculture

INNOVATIVE DESIGN AND MANAGEMENT TO BOOST FUNCTIONAL BIODIVERSITY OF ORGANIC ORCHARDS. A NEW CORE ORGANIC PROJECT: ECOORCHARD

François Warlop 1, Penvern S. 2, Weibel F. 3, Herz A. 4, Porcel M. 5, Tchamitchian M. 5, Sigsgaard L. 6
1 Research Group for Organic Farming (GRAB, F) ; 2 National Institute for Agronomic Research (INRA, F) ; 3 Research Institute of Organic Agriculture (FiBL, CH) ; 4 Julius Kuhn-Institut (IKI, DE) ; 5 Sveriges lantbruksuniversitet (SLU, SE) ; 6 University of Copenhagen (UCPH, DK)

Orchards are perennial cultures, and, especially in organic fruit production it is essential to design and manage orchards in a way which favours beneficials such as insect predators and parasitoids over pests and diseases. As landscape dominating crops their management affects overall biodiversity in the agricultural landscape. Increasing plant biodiversity and habitats in such a way that beneficials are favoured is called Functional Agro-Biodiversity (FAB). The value of FAB for reducing pesticide use in fruit production is generally acknowledged, and many growers try to increase it. However, they lack situation-specific information about how to drive and assess biodiversity to optimize FAB.

ECOORCHARD is therefore combining several approaches: (i) identifying and sharing innovative methods already implemented by fruit growers to increase FAB in EU countries; (ii) assessing simple methods for farmers to monitor FAB ; (iii) quantifying the effect of FAB-boosting flower strips. The different on-farm sites, scientific trials and a web-based stakeholder platform to collect and share information are important elements to bring the collected experiences and scientific results very directly to the organic fruit growers. Interviews already started in 2015 with advisors and growers will provide useful information on original practices and methods used in orchard, to be shared during workshops with farmers for empowerment. ECOORCHARD aims to develop appropriate functional biodiversity practices for users’ needs and thus will identify and assess innovative techniques in terms of effectiveness and implementation conditions, carry out classical field experiments, on-farm and multi-site trials and collective workshops involving farmers, researchers and advisory services. More on: http://coreorganicplus.org/research-projects/ecoorchard

Keywords: functional biodiversity, insect pest management, plant pathogen management, apple.
PARTICIPATORY DESIGN OF INNOVATIVE HORTICULTURAL INTERCROPPING SYSTEMS IN PROTECTED MARKET GARDENING PRODUCTION

Salemier Chloé¹, Lefèvre Amélie¹, Lesur-Dumolin Claire¹, Perrin Benjamin¹, Meynard Jean-Marc²

¹INRA, Sciences pour l’Action et le Développement, UED411 Domaine Expérimental Alénya Roussillon, 66200 Alénya, France ; ²INRA, Sciences pour l’Action et le Développement, UMR SAD-APT, 75231 Paris cedex, France

In different agroecosystems, intercropping has proved to be a promising way to reduce pesticide use, as it can reduce risks of pests or diseases damages (i) by limiting their dispersal (physical or chemical processes) and (ii) by diversifying resources for natural enemies. However, up to now, intercropping in protected market gardening is poorly referenced. Biological processes operating in specific crop combinations are only partially understood and guidelines to design and manage these complex agro ecosystems are scarce. However, few market gardeners already develop intercropping under shelter on diversified farming systems. In order to design innovative cropping systems, we developed a participatory research program involving producers, extension agents and researchers. This research combined: (i) the organization of design workshops gathering these stakeholders. During these workshops, we collectively explored hitherto unseen ways, to design prototypes of innovative intercropping systems aiming at reducing pesticide reduction; (ii) the tracking of on-farm systems based on intercropping. We looked out for the rare cropping systems developed by farmers to analyze their agronomical logics (practices, objectives inherent to their development) and their performances; (iii) the on-station experiment of innovative intercropping systems. System experiments allowed us to analyze biological processes operating in intercropping and to assess the performances of such systems. Combining these different resources allowed us to explore the complexity and diversity of intercropping systems as well as the diversity of motivations driving farmers to develop them, in order to discuss their benefits and drawbacks. This communication aims to present results of this method which led (i) to design prototypes which were tested and assessed on station, and (ii) to identify guidelines to design, assess and manage intercropping systems suited to contrasted farming systems.

Keywords: design workshop, intercropping, market gardening under shelter, participatory research, system experiment, tracking on-farm innovations.

TOPIC 4, SESSION 2 (Plenary, 11th of June, pm)

Oral Presentations

MULTIDISCIPLINARY AND MULTIAGENT INTERACTIONS FOR INNOVATIONS IN HORTICULTURE – PARADIGMS BEYOND THE WORDS

Pierre-Eric Lauri¹, S. Simon², M. Navarrete³, L. Parro⁴, F. Normand⁵, M. Lesueur-Jannoyer⁶, J.P. Deguine⁷

¹INRA, UMRA AGAP, AFEF team, Montpellier, France ; ²INRA, U. 6065 Gotheron, 26320 Saint-Marcel-lès-Valence, France ; ³INRA, U. R. Écodéveloppement, 84914 Avignon cedex 9, France ; ⁴CIRAD, UPR HORTSYS, 34398 Montpellier cedex 5 ; ⁵CIRAD, UPR HORTSYS, 97455 Saint-Pierre cedex, France ; ⁶CIRAD, UPR HORTSYS, 97285 Le Lamentin cedex 2, France ; ⁷CIRAD, UMR PVBM, 97410 Saint-Pierre, France

The progression towards sustainable horticulture is usually associated with scientific and methodological breakthroughs. As a consequence, the innovation processes in the fields of biology and ecology and their agronomical implementation are increasingly recognized as main drivers to improve horticultural systems. At the same time, a horticultural system cannot be conceived without a good knowledge of the social and economic contexts in which it is embedded. It has to be considered as an integrated social-ecological system. This strong intertwining of the different research fields, as well as among agents along the horticultural chain from the grower to the consumer, poses new landmarks. There is a need for interdisciplinary researches combining the scientific fields usually involved in the studies of agricultural systems: biology, agronomy, environmental sciences and socioeconomy. Designing new horticultural systems in such a systemic framework is also relevant to develop and better implement exchanges of knowledge among agents. For example, this cross-knowledge constitutes the back-bone for building crop ideotypes and cropping systems well fitted to ecologically-based horticultural systems including genetics, agronomy and social-environmental levers and constraints. There is also a need in more participatory research and scaling-up to achieve adoption of innovations along the horticultural chain. Thus, the former linear and top-down scheme, i.e., from basic science to applied science and field work, is now reconsidered and the design of innovative agricultural production systems is viewed as an integrated, interactive and participative organization where agents are dynamically interacting. The new challenge is to better combine the detailed knowledge typical of the dominant reductionist paradigm mostly oriented towards the “one-size-fits-all” objective and the paradigm of complexity where the “custom-fit” approach predominates. Progressing towards these frameworks of knowledge and relationships among agents poses epistemological questions about multidisciplinarity and hybridization between scientific and expert knowledge.

Keywords: agroecology, innovation, integrated sciences, multiagent approach, participative organization, social-ecological-agrosystem, systemic approach.

COGNITIVE MAPPING OF ORGANIC VEGETABLE PRODUCTION IN FLANDERS TO SUPPORT FARMERS STRATEGY DESIGN
Organic farmers inherently have to cope with complex farming system processes. Next to pursuing economic performance, farm management also encompasses optimization of the farm’s ecological and social performance. For considering multiple criteria, the farmer needs a thorough knowledge on the highly interactive aspects of his production system. Furthermore, successful strategy design includes decisions at different levels -from field to market- within the farming system. To support strategic decisions, this study aims at modelling the key aspects and their inter-relations for successful organic vegetable production in Flanders. We used the qualitative cognitive mapping approach to represent and visualize the expert knowledge from different stakeholder groups (advisors, farm networks, research and educational institutions). Through in-depth interviews, experts were questioned on the key aspects of a successful organic farm management and how these aspects relate to each other. Next, the individual cognitive maps from the different interviewees were merged to build a social cognitive map. The strength of the relations between aspects reveals hot spots within the organic vegetable production. Preliminary results show that weed control, crop rotation and marketing channel are examples of central aspects. At sector level, the results will clarify strengths and weaknesses of organic vegetable production in Flanders. At farm level, focusing on one or more of the hot spots, while respecting its position in the organic farming system, can be helpful towards more adequate strategy design. The cognitive maps might serve as a communication tool for farmers and their advisors, or as a first step towards prospective or scenario evaluations when implementing new strategies.

Keywords: cognitive mapping, system analysis, strategy design.

SOCIAL ANCHORING IN THE COMMUNITY AND THE DESIGN OF VIABLE ORGANIC MARKET GARDENING MICROFARMS.

François Léger¹ and K. Morel ²

¹AgroParisTech, UMR SADAPT, INRA-AgroParisTech, Paris, France ; ²INRA, UMR SADAPT, INRA-AgroParisTech, Paris, France

Increasingly strong social movements built upon concrete experiences as organic market gardening microfarms to promote alternative food systems. These microfarms share some main characteristics: cultivated acreage smaller than official recommendations for market gardening set up; marketing in short distribution chains; high diversity of cultivated plants; low level of motorization and investment, agroecological practices. The study of 12 French microfarms, based on semi-structured interviews and cross-disciplinary analysis, pointed that alternative microfarms stands upon the access to immaterial or material resources, available in their social environment. Involvement in the community is thus a necessity, and at the same time the way to concretize ecological and social aspirations which are essential in the farmers’ projects. Because they hardly take into account these kinds of no-merchant inputs, classical techno-economic frameworks are thus not adapted to analyze and assess their strategic choices. A larger conceptual framework, nourished by the inputs of concepts as multifunctionality of agriculture, ecosystems services, “double” sustainability seems indispensable in this purpose.

Keywords: France, organic market gardening, alternative farming systems, microfarms, social aspirations, environmental aspirations, community involvement, short distribution chains, material and immaterial resources.

INTEGRATING KNOWLEDGE AND INFORMATION FOR A COMPETITIVE AND INNOVATIVE ORGANIC HORTICULTURE IN FLANDERS

Lieve De Cock, N. Taragola and M. Crivits

Institute for Agriculture and Fisheries Research, 9820 Merelbeke, Belgium

Networks are considered having a lot of potential in innovation as their members learn with and from each other by sharing information and knowledge, acting as one negotiation unit, investing collectively and/or involving relevant partners. Based on a study of innovation characteristics by Kanter (1988) our research used a novel conceptual framework to understand how networks can maximally support the farmer’s innovation process. The framework comprised five components: (i) vision, (ii) knowledge capturing and exchange, (iii) communication, (iv) coalition formation and (v) institutional innovation. Conversion to organic horticulture needs a radical change in the production system. The complexity of the system, the importance of precaution more than using problem solving practices make that organic horticulture is knowledge intensive. This knowledge is not always found in existing conventional networks. This paper explores three recently established networks for creating and exchange of knowledge in organic horticulture in Flanders and evaluates how these networks can contribute to the innovation capacity of the organic horticultural community. The analysis of the networks shows that networks, separately and together, have a high potential in assisting its members, the organic farmer in Flanders and the organic agricultural sector as a whole, directly or indirectly, in its innovation process. As important as the goals and tasks of the network, the actors and management of the networks are crucial to create trust, ownership and the necessary institutional support.

Keywords: innovation, networks, vision, knowledge exchange, communication, coalition building, institutional innovation.

CAN WE DEFINE A TYPOLOGY OF CROP PROTECTION WITHIN THE DIVERSITY OF ORGANIC PRODUCTION? WHAT ARE THE CONSEQUENCES ON THE NATURAL ENEMY ABUNDANCE AND DIVERSITY?

Gaëlle Marliaize, Servane Penvern², Françoise Lescourret¹, Yvan Capowiez¹

1Institute for Agriculture and Fisheries Research, Social Sciences Unit, 9820 Merelbeke, Belgium ; 2University of Antwerp, Ecosystem Management Research Group and IMDO, 2610 Wilrijk, Belgium ; 3Ghent University, Department of Agricultural Economics, 9000 Ghent, Belgium

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Organic agriculture is assumed to achieve more sustainable practices by reducing the negative environmental impacts of intensive agriculture, such as biodiversity decline. This conclusion is based on the results of numerous studies comparing conventional and organic agriculture. However, these studies barely consider the wide range of practices existing within organic agriculture. This could result in a diversity of organic pest management strategies with different potential effects on the natural enemy community. In this study, we first characterized the diversity of pest management strategies implemented by organic apple fruit growers. Then, we investigated whether these strategies have an impact on the natural enemy abundance and diversity in their orchards and on their ecological function (pest predation). The study was carried out around Avignon, in South-east France. We selected and surveyed 24 organic apple orchards. A multivariate analysis enabled to identify four crop protection strategies, which were characterized by specific combination of practices. The « Ecologically intensive strategy » promotes natural enemy by managing their habitat. The « Substitution strategy » is mainly based on pesticide usage. The « Technologically intensive strategy » uses innovative technological methods such as exclusion nets. The « Integrated strategy » mobilizes a wide range of different practices. Natural enemy communities and their function of predation were monitored in a subset of 20 orchards chosen randomly among the strategies identified. We showed that natural enemy communities are influenced by these strategies. For example, Forficula pubescens was higher in ecologically intensive strategy. In the light of these findings, it would be important to consider organic systems not as a unique system but as a combination of different practices. The classical dichotomy of conventional versus organic agriculture must be revisited.

Keywords: organic agriculture, natural enemies, intensification

**A TOOL TO HELP DETERMINE THE FEASIBILITY OF ORGANIC APPLE PRODUCTION IN THE SOUTHERN UNITED STATES**

Jennie Popp ¹, Héctor Germán Rodríguez ¹, Curt Rom ², Heather Friedrich ² and Jason McAfee ²

¹ Department of Agricultural Economics and Agribusiness, University of Arkansas, University of Arkansas, Fayetteville, AR 72701, USA ; ² Department of Horticulture, University of Arkansas, University of Arkansas, Fayetteville, AR 72701, USA.

Apple (Malus × domestica) is one of the most preferred fresh fruits in the U.S. in terms of fresh fruit production and value of production. Organic apple production is concentrated in five states: Washington, California, Arizona, Michigan, and Oregon. The southern U.S. climate conditions allow producers to grow high-quality fruit. Nonetheless, limited experience and lack of information available on the economic impacts of different regional organic production practices and the potential returns available from organic apple production have prevented a broader organic agriculture development. A new user friendly interactive decision support tool for organic apple production was recently developed to assist organic apple producers, researchers and educators in making economically sound decisions that can contribute to the growth of organic apple production acreage across southern U.S. This tool allows producers to focus on the economic impact of production decisions by estimating expected operating costs, fixed costs, total costs and total returns. However, this unique tool encompasses not only budgeting, but also the further analyses associated with breakeven, sensitivity and risk assessment. Organic apple costs and returns are often difficult to estimate in budget preparation because they are numerous and variable. Consequently, this computer based application was preloaded with production practice, cost and price information. So, it needs minimal information from a user to run but yet it is flexibility enough to allow appropriate adjustments to reflect specific production and a specific resource situation. All these features are important because it allows an organic apple producer to make more informed production, marketing and financial decisions about an actual or potential production operation if yield, price and cost values are actually different than expected.

Keywords: Malus × domestica, economic analysis, breakeven points, sensitivity analysis, risk analysis

**THE IMPACT OF LANDSCAPE COMPOSITION ON THE ABUNDANCE OF A CANOPY DWELLING SPIDER DEPENDS ON ORCHARD MANAGEMENT**

Manon Lefebvre, Pierre Franck, Jean-François Toubon, Jean-Charles Bouvier, Jérôme Olivares, Claire Lavigne

INRA, UR1115 Plantes et Systèmes de culture Horticoles, F-84000 Avignon, France

Pest control by naturally occurring generalist predators may be influenced by farming practices at both the local and landscape scales, by the amount of certain specific landscape elements or by landscape complexity. In orchards, major actors of pest control are canopy-dwelling species because it is there that pests attack fruits or growing shoots. *Cheiracanthium mildei* is a large nocturnal wandering arboreal spider that is a predator of several important insect pests (larvae and eggs of moths, leafhoppers, aphids). It is native of the Mediterranean region and is invasive in Northern America. We assessed its autumnal abundance (occurrence frequency) in a set of 61 commercial apple orchards of south-eastern France over three consecutive years (2010-2012). We determined the impact on its abundance of agronomic and land-cover characteristics at both the local and landscape levels using a random forest analysis and a regression tree. This approach highlighted the differential effect of landscape variables according to local orchard pest management. First, the presence of exclusion nets against the codling moth (*Cydia pomonella*) increased *C. mildei* abundance by 59%. Second, increasing areas of semi-natural landscape elements increased *C. mildei* abundance only in orchards that were not covered by nets and not surrounded by organic orchards. Third, overall, hedgerows and woods increased the abundance of *C. mildei*, which is consistent with the arboreal habitat of the species. Lastly, the abundances of *C. mildei* and of *C. pomonella* were not...
related, thus indicating that the enhancement of C. mildei does not preclude a control of this major pest.

**Keywords:** Cheiracanthium mildei; Perennial crops; Exclusion nets; Organic; Semi-natural habitat.

### CAL-COLLABORATIVE ORGANIC RESEARCH AND EXTENSION NETWORK: ON-FARM RESEARCH TO IMPROVE STRAWBERRY/VEGETABLE ROTATION SYSTEMS IN COASTAL CALIFORNIA.

Carol Shennan 1, J. Muramoto 1, G. Baird 1, M. Zavatta 1, L. Toyama 3, D. Nieto 4, J. Bryer 1, Gershenson A 2, Los Huertos M 1, Kortman S 3, Klonsky K 4, Gaskell M 5, Koike S 6, Smith R 6, Bolda M 7

1 Department of Environmental Studies, University of California Santa Cruz, CA 95064, Santa Cruz, USA; 2 Department of Environmental Studies, California State University San Jose, USA; 3 Department of Science & Environmental Policy, California State University Monterey Bay, USA; 4 Department of Agriculture and Resource Economics, University of California, Davis, CA, USA; 5 University of California, Cooperative Extension, Santa Maria, CA, USA; 6 University of California, Cooperative Extension, Salinas, CA, USA; 7 University of California, Cooperative Extension, Watsonville, CA, USA.

CAL-CORE is a network of researchers, farmers, extension professionals, industry and non-profit organizations dedicated to furthering research into organic strawberry and vegetable production in coastal California. Formed 9 years ago, we have worked on a variety of fertility, pest and disease management issues facing organic growers. Currently, our main effort centers on vegetable/strawberry rotations and different options for fertility and disease management. In a replicated field trial we compare treatments across a range of sustainability criteria: crop yield, nitrogen cycling and losses, greenhouse gas emissions, disease incidence, biocontrol of insect pests, soil carbon pools, and economics. Ultimately a full life cycle analysis for each rotation system will be developed to assess their overall environmental footprint. Main treatments are 2 versus 4 year rotations with different crop combinations believed to be either suppressive of a major soil borne disease (Verticillium wilt), or more profitable but more conducive to disease. Superimposed on the rotations are fertility treatments (legume/cereal cover crop only, legume/cereal cover crop + compost + additional fertility amendments, cereal cover crop + mustard seed meal, or untreated control) and in the two legume/cereal cover cropped treatments Anaerobic Soil Disinfection (ASD, a promising option for controlling a range of soil borne diseases) is used for disease management prior to planting strawberries. Six network farmers also chose a sub-set of these treatments to test on their farms and compare to their own management practices. The study is in year 4 and all treatments at all locations are now planted to strawberries. Preliminary data on system productivity, nitrogen cycling, soil carbon, and plant disease are presented. This project will provide farmers with tools to improve their production systems, meet water quality regulations, and quantify climate-related impacts of these intensive organic systems.

**Keywords:** nitrogen cycling, fertility management, soilborne disease, soil carbon, anaerobic soil disinfection, mustard seed meal.

### THE CIAA (CARROT IMPROVEMENT FOR ORGANIC AGRICULTURE) PROJECT: LOCATION, CROPPING SYSTEM, AND GENETIC BACKGROUND INFLUENCE CARROT PERFORMANCE INCLUDING TOP HEIGHT AND FLAVOR.


1 Department of Plant Pathology, University of Wisconsin-Madison, WI 53706, USA; 2 Vegetable Crops Research Unit, USDA, Agric. Research Service, Madison, WI, USA; 3 Organic Seed Alliance, Port Townsend, WA, USA; 4 Organic Seed Alliance, Arcata, CA, USA; 5 Dept. Horticulture and Landscape Architecture, Purdue University, West Lafayette, IN, USA; 6 Department of Nematology, University of California, Riverside, CA, USA; 7 Mount Vernon NWREC, Washington State University, Mount Vernon, WA, USA; 8 Washington State University, Cooperative Extension, Pasco, WA, USA; 9 Department of Horticulture, University of Wisconsin, Madison, WI, USA; 10 University of California, Cooperative Extension, Bakersfield, CA, USA.

Organic breeding and trialing efforts in the United States have emphasized participatory methods to effectively and efficiently identify and adapt germplasm to the organic production environment. U.S. organic farmers have listed a number of traits as priorities for breeding and trialing in organic systems; in a survey of Wisconsin (U.S.) organic vegetable farmers conducted in 2012, farmers listed disease tolerance, insect tolerance, yield, and germination as their top priorities. Additionally, farmers are eager to identify vegetable varieties that perform stably across the diverse production approaches and inputs used in organic vegetable management. To address these needs of organic vegetable farmers, we evaluated diverse carrot germplasm varying in traits important for successful organic production and marketing (germination and early seedling growth, disease and pest resistance, root shape and color, flavor, and nutritional value) under diverse organic production environments in four states in the U.S. (California, Indiana, Washington, and Wisconsin). With each of these sites, data was also obtained from a corresponding conventional production environment. Best linear unbiased prediction (BLUP)-based means and Spearman’s rank order correlations for all of the sites combined were calculated for top height and width at harvest, top weight, root weight, sweetness and harshness. Significant entry effects and significant interactions were found between entry and year and entry and region, with many region-year combinations not showing rank correlation with each other. Stability of variety performance was also estimated using the Shukula stability statistic. Significant differences were found in that stability of the varieties across production regions, with some varieties exhibiting significant change in rank between environments (i.e. year-region-system combinations). The results of this project provide information to both organic vegetable farmers and breeders seeking to identify germplasm most appropriate for organic production environments.

**Keywords:** breeding, carrot, top height, flavor.
POSSIBILITY OF STRAWBERRY GROWING IN INTERCROP WITH LEGUMES. A REVIEW.

Sandra Dane 1,2, Valda Laugale 1, Dace Sterne 2 and Liga Lepse 1

1 Pure Horticultural Research centre, Latvia; 2 Latvia University of Agriculture, Latvia

The aim of this literature survey was to look into newest researches about strawberry growing and intercropping systems to estimate possibility of growing strawberries in intercrop with legumes. Strawberries (Fragaria × ananassa Duch.) are one of the most popular berries worldwide. Growing strawberries traditionally in rows with rather wide distance between rows makes significant area of soil surface unused. According to today’s demands for sustainability it is great loss to maintain unused soil surface. Intercropping gives a new approach in crop growing. This unused soil surface between strawberry rows is main area in which intercropping can be used. As leguminous plants make an important part of food and feed, growing them as intercrop allows optimize land use and ensures protein outcome for consumption. Legumes also are used to improve soil quality. It is important due to decreasing of soil fertility caused by intensive and inappropriate land use. Main focus in the survey is on using beans (Vicia faba L.), peas (Pisum sativum L.) and clover (Trifolium hybridum L.) as intercrop in strawberries to maintain strawberry quality and possibly improve it. Legumes can provide co-plants with nitrogen, biological and physical barrier for pests and diseases. Maintaining of intercropping systems decreases pesticide usage so diminishing environmental load and ensuring consumers demand on healthy food. Thus this cultural system can be useful for organic and integrated farming. As main disadvantages of intercropping are more complicated maintaining of plantation and harvesting of both cultivated plants. An interplant (in this case – legumes) also provides fewer yields than in monocrop. According to this literature survey there is a possibility that strawberry and legume intercrop can be profitable. Field experiments needs to be carried out to evaluate this growing system in horticulture.

Keywords: sustainability, Fragaria × ananassa Duch., peas, beans, clover

REDESIGNING AGROECOLOGICAL STONE FRUIT ORCHARDS

Alain García 1, Muriel Millan 1 and Alosia-Louise Relachon 2

1 Cffl, 751, chemin de Balandran, 30127, Bellegarde, France; 2 Cffl-SupAgro Dijon, France

Stone fruit production in France is currently confronted with economic and environmental challenges. Organic stone fruit production is very limited because of the constraints of specifications and important technical obstacles, whereas the demand in organic fruits is high. The transition of orchards towards agroecology will not be possible without redesigning current farming systems. An approach of co-construction of stone fruit farming systems, ex-ante, based on expert knowledge, took place in three meetings at each of the three stages of the project: determination of the specifications; elaboration of the prototypes; evaluation, ex-ante, with expert knowledge, of farming system prototypes. This design method allowed three prototypes of stone fruit farming systems to be created prototypes 1 and 2, neighborhood orchard and the low input orchard, with results superior to those obtained by the reference systems, whether they are cultivated in an organic system or not. It would seem that these prototypes address current issues and allow the technical and economic obstacles faced by stone fruit producers to be overcome. But a more thorough evaluation ex-ante of these prototypes is necessary to confirm these results. This work must therefore be studied further before being able to select one or several prototypes which could be tested in orchards and then proposed to fruit growers.

Keywords: organic farming, agroecology, stone fruit, innovation, redesign, prototyping.

VERTICAL PROJECT: DESIGNING FRUIT AGROFORESTRY SYSTEMS FOR A RENEWED HORTICULTURE

Francois Warlop 1, Laurie Castel 2, Laetitia Fourrie 3, Julien Ronzon 4, Vianney Le Pichon 1, André Sieffert 4, Marc Tchamitchian 5, Stéphane Bellon 6

1 GRAB, Maison de la Bio, BP 11283, 84911 Avignon, France; 2 Chambre d’Agriculture de la Drôme, 26800 Etoile sur Rhône, France; 3 ITAB, Ferme Expérimentale, 26 800 Etoile sur Rhône, France; 4 Consultant for temperate agroforestry, Drôme, France; 5 INRA PACA, UR0767, Ecodéveloppement, 84914 Avignon, France

Although it addresses multiple issues for modern farming, agroforestry mixing fruit trees and annual crops (mainly vegetables) has not been well documented under temperate climate. One expected amenity of agroforestry is to increase biodiversity within the plot, and natural pest regulation. While fruit trees are among the crops that rely most on plant protection products, we made the hypothesis that introduction of annual crops in the perennial system can lead to effective biocontrol and to input reduction, while developing other synergies between crops (shadow beneficial effects, increase water use efficiency, ...) or social amenities. On each of the two locations (Durette/TAB) in southern France, with different characteristics (crop rotation, marketing, area...), the partners of a 6-years funded project called Vertical, designed in 2012 and 2013 innovative cropping systems addressing those specific constraints, in order to optimize their global performance. These systems have been implemented in 2013 and 2014. Sustainability indicators have been discussed and selected to (i) monitor and (ii) to assess these systems. An ex ante assessment tool has been developed under a participatory approach, to
stimulate the co-design of new performant plots. This tool will shortly be adapted to ex-post assessment, so that advisors but also farmers dealing with fruit agroforestry systems can identify their main bottlenecks and assets. A link to the national bottom-up network of fruit agroforestry systems (called Smart) will be achieved this way. This presentation focuses on the innovative cropping systems presentation, their rationale to achieve the desired pest regulations, and on tools to estimate cropping system performances.

Keywords: agroecology, agroforestry, low-input farming, functional biodiversity, fruits, vegetables.

CO-DESIGN AND SET-UP OF INNOVATIVE FRUIT-BASED AGROFORESTRY CROPPING SYSTEM IN BELGIUM
Laurent James, Rondia A., Lateur M., Minnet L., Stilmant D.

Designing agroforestry systems combining pome fruit trees and vegetables contain multiple options. Proposals for different spatial arrangements and prototypes have been elaborated and evaluated through participative discussions involving scientists, advisors and farmers. Key challenges will be to optimize economic/technical constraints and ecological principles stimulating natural regulation processes against pests and diseases in temperate climate. This approach led to the set-up in 2014, of 1 ha-experimental agroforestry orchard at Gembloux, Belgium. It aimed to answer to three hypothesis: (i) the mixture of robust cultivars of fruit trees and vegetables includes a functional biodiversity with positive impact on the control of pests and diseases, (ii) tree canopies may have an impact on soil functioning, biological interactions and regulations, plant stress decrease and (iii) in our optimized ratio and distances between vegetables and trees in intensified and organized alley-cropping systems, the tree shading does not reduce light levels below the threshold of light saturation. Two other on-farm fruit-based agroforestry cropping prototypes are under process on two pilot farms in Belgium according to the farmer’s production objectives such as (i) adaptation to mechanization which may limit plant interactions with perennial and/or annual crops, (ii) need for a high income per surface unit allowing economic viability of farms in a capital intensive economic system.

Keywords: co-design, fruit-based agroforestry systems, impact assessment.

MULTIPLE ECOSYSTEM SERVICES ANALYSIS
PROCEDURE IN APPLE ORCHARD
Constance Destemtchian, Daniel Plénet, Michel Génard, Dominique Grassely, Jean-Michel Ricard, Françoise Lescoeurret, Sylvaine Simon, Marie Charreyron, Ichiki Garcia de Cortazar-Atau, Marie Launay, Nicolas Beaudoin, Marie-Hélène Robin

In order to meet market requirements, current fruit production has been strongly intensified, thus running fossil energy reserves dry in some cases. Sustainability has the dual task of providing acceptable food production level as well as preserving natural resources. This duality could be analyzed within the concept of ecosystem services (ES), from which humans draw potential benefits. Fruit production, besides providing primary goods to Humans such as food, can induce changes to, or receive benefits from the ecosystem it relies on. “Apple tree” agroecosystem services are various and present positive (synergies) or negative (trade-off) relations. These relations depend on the interactions that occur between the underlying ecosystem functions as well as the agricultural management. The study of these relations is necessary to adjust agroecosystem management towards specific ES profile goals. We therefore suggest describing the transformations occurring in the “apple tree” agroecosystem for a specific range of agricultural practices and pedoclimatic conditions. This poster presents the analysis procedure of the ES relations within an apple orchard, using indicators of ecosystem functions underlying ES. These indicators are quantitatively estimated by models simulating the functioning of an apple orchard managed by specific agricultural practices.

Keywords: multiple ecosystem services, apple orchard, synergies, trade-offs, agricultural practices.

GIS FRUITS – MEDIEVAL WORKING GROUP AN INITIATIVE DEDICATED TO THE PROSPECTIVE EVALUATION OF FRUIT SPECIES
Benoit Jeannequin, Marine Guadagnini-Palaia, Daniel Plénet, Yann Bintein, Jean-Marc Audergon

Fruit Industry is a significant and dynamic sector in Europe and more particularly in France. Up to 2012 its management was conducted by species and by product without global supervision and coordination between species except within thematic working groups organized by the Ministry with the different national representatives. In order to privilege the interrelations between the different species and products, a national initiative has been developed joining the different members from end-users (growers, retailers, consumers and fruit processing industry representative) to research-development and training sectors: the “GIS Fruits”. Among “GIS Fruits” 7 thematic axes presently are taken in consideration by the Fruit sector under specific working groups (WG). One of them is dedicated to the rational analysis of the actual system of evaluation of the agronomic performances of Fruit cultivars: Medieval WG. It deals with:

- The establishment of an actual state of the art of the experimental designs dedicated to fruit species agronomic evaluation,
- The identification of the new issues and methodologies able to be used to improve Fruit cultivar evaluation.
Both approaches will be synthesized and applied to improve, on prospective manner, fruit cultivar evaluation efficiency on both technical and economical aspects.

**Keywords**: fruit cultivar, agronomic evaluation, experimental design, prospective analyze, critical review.
TOPIC 5

Performances and their evaluation criteria:
from field to food (qualities and standards)

Coordinators: A. Allende & J-M. Codron

The range of expected performances in organic and integrated horticulture is extending. As a result, evaluation criteria have to be adapted accordingly. Characterization of and possible trade-offs among performances will be addressed in this session. Various standards, methods and tools are developed both on the production side and to meet demands in terms of consumer’s needs, expectations and safety. Their interactions with horticultural cropping systems and processing will be considered.

Oral presentations

DEXIFRUITS: AN EASY-TO-USE TOOL TO EVALUATE THE SUSTAINABILITY OF FRUIT PRODUCTION SYSTEMS
Aude Alaphilippe², Frédérique Angevin¹, Pascale Guillermín³, Alice Vélu¹, Franziska Zavagli³
¹INRA, UERI de Gotheron, 26320 St-Marcel-Lès-Valence, France ; ²INRA, UAR1240 Eco-innov, 78850 Thiverval-Grignon, France ; ³IFPC, Institut Français des Production Cidricoles, 61500 Sées, France ; ⁴Agrocampus, IRHS - AgroCampus Ouest, 49045 Angers, France ; ⁵CtitI, Centre de Lanxade, 24130 Prigonrieux, France

In the frame of the French National Action Plan for pesticide reduction, numerous networks of farms adopting less-pesticide dependent strategies have been created. Consequently, the need for a common tool to evaluate the sustainability of these production systems has raised. While for other crop many tools and indicators are available, for fruit crop, there is a lack of dedicated tool. DEXiFruits has been designed for stakeholders in order to make an ex post assessment of the sustainability of orchard systems within the farm and experimentation networks of the above mentioned plan (182 production systems for seven fruit crops). The objective of this tool is to facilitate the implementation of innovations by farmers thanks to an overview of their orchard performances. This model is based on a decision tree breaking the complex decisional problem of sustainability assessment into simpler attributes, referring to its economic, social and environmental dimensions. In the DEXi software, attributes are characterized by their name, a description and a scale, i.e., possible qualitative values for the attribute (discrete values described as words rather than numbers, e.g., ‘low, medium, high’). Even if scales are qualitative, some can be based on quantitative values (e.g. yield). The specifications of DEXiFruits are to be a stand-alone and easy-to-use tool, as well as to match with easy collected data describing the production system. To facilitate the use of such a tool, a referent system has been created for each fruit crop. It permits to the user to compare its production system to the referent one. Moreover, in each network, a specific referent system can be generated. The tool can also be used as a dashboard to identify strengths and weakness of the evaluated orchard systems and to identify possible improvements. Both the tool itself and its possible applications will be presented.

Keywords: fruit production, sustainability assessment, tool, dashboard.

A CLOUD MODEL FOR REAL-TIME FRESH PRODUCE TRANSPORTATION MANAGEMENT
Paul R.¹, Jubin Jacob-John¹, D’Souza D.², Hamilton, M.³
¹RMIT University, Melbourne, Australia ; ²La Trobe University, Melbourne, Australia

The increasing consumer demand for variety and the large number of small and medium providers within the organic fresh produce industry has resulted in a highly complicated fruit and vegetable supply chain network. Complexity has resulted in a reduction in the transparency and testability of the supply chain network and increased food wastage during the transportation process. This paper addresses such issues and proposes an intelligent model that improves the traceability and manageability of fresh produce during its transportation from the farmer to the retailer. The proposed real-time event controlled system incorporates the cloud and various messaging protocols to facilitate communication between the various stakeholders in the fresh produce industry. The model scrutinizes the physical and environmental characteristics pertaining to the transported fruit and vegetables using sensor systems. Thus, the model creates ‘big data’ that is analysed on a real-time basis. This elaborate analysis will effectively increase the traceability and testability of the product on a real time basis and decrease wastage during the transportation process. The improvisation of the traceability has a positive influence on the perception of the product quality and this in turn, improves the consumer’s confidence. With the enhancements and innovations in social media, the fresh
produce consumers can directly connect to this system, receive and update information pertaining to the status of the product. Although there is a plethora of data management systems existent within fresh produce supply chains, these systems analyse archival data and this model is an improvement due to the real-time data analysis component involved within the system.

Keywords: food supply chain, cloud integration, intelligent transport, real-time traceability

SIMULATING IMPACTS OF MARKETING STRATEGIES ON PINEAPPLE GROWERS AND GROWER ORGANIZATIONS’ PROFITS ON REUNION ISLAND

Solène Pissonnier, Elodie Dorey, Thierry Michels, Pierre-Yves Le Gal
CIRAD (French Agricultural Research Centre for International Development)

Fruit Grower Organizations (GO) may potentially sell growers’ fruits on different markets (local, export, industry, organic, etc.). Selecting markets combine (i) considerations regarding prices offered, required quantity, and quality specifications and (ii) growers’ abilities to supply required batches at a cost satisfying both GO and growers’ profits. This communication presents an approach aiming to support GO and growers designing marketing strategies fulfilling their economic objectives and fruit buyers’ requirements. This approach has been developed in the frame of the Queen Victoria pineapple production on Reunion Island, which amounts for 16 million tons dedicated to a steady local market but a growing demand from export and industry outlets. It is based on the coupling of two simulation tools, which assess economic impacts for a pineapple GO and its growers of a given marketing strategy. The first tool, named FRUITPLANT, calculates the profit gained by GO according to (i) the distribution of collected pineapple quantities between a range of outlets, (ii) the price offered by each outlet, (iii) the specific processing costs linked to each outlet, (iv) the price paid to each grower according to his delivered batches (quantity and quality). FRUITPLANT also calculates each grower’s gain according to his production area, his technical sequence, his yield, his production costs and his purchase price. Pineapple yields are estimated based on the use of a crop model SIMPİNĀ that can predict fruit weight and harvest dates according to the grower’s natural environment and practices. Fruits are oriented to different outlets according to their weight. The support approach was tested with a GO specialized in export. We illustrate its use with three scenarios: (i) decreasing pineapple quantities that growers dedicate to the GO, (ii) getting smaller fruits from poorer climatic conditions and, (iii) modifying the balance between export and processing industry outlets.

Keywords: pineapple, industry, export, fruit supply chain, simulation tool, scenario.

AN ANALYSIS OF YIELDs, REVENUES, AND PRICES FOR SELECT ORGANIC FRUITS AND VEGETABLES IN WASHINGTON STATE, USA

David Granatstein 1, E. Kirby 1, M. Brady 2
1 Center For Sustaining Agriculture & Nat. Resources, Washington State University, Wenatchee, WA 98801, USA; 2 School of Economic Sciences, Washington State University, Pullman, WA 99164, USA

As demand for organic fruits and vegetables continues to grow in the USA, growth in domestic supply has not kept up. This has led to an increase in the organic premium that is generating interest from potential new entrants into organic farming. However, many of them, particularly those that have no background in farming, lack the financial information to evaluate this production option. A study of actual sales and production by certified organic farms in Washington State, USA, showed a wide range in organic horticultural crop yield in comparison with conventional. Crops such as juice grapes and onions yielded as well as or better than the conventional benchmark, while raspberries, hops and snap beans yielded much less. Yield, price, and revenue varied by crop, grower size, market channel, and geographic region. For blueberry, organic yields in central Washington were higher than in western Washington and appeared comparable to conventional yields. Also, simple nonparametric methods were used to characterize yield and price distributions, in contrast with average values used in most published comparisons of organic and conventional yields. The study also estimated the statewide farmgate value of specific organic horticultural crops for the first time.

Keywords: organic yields, prices, revenue, blueberry, vegetable.

LONG-TERM ECONOMIC EVALUATION OF FIVE CULTIVARS IN TWO ORGANIC APPLE ORCHARD SYSTEMS IN VERMONT, USA, 2006-2013

Terence Bradshaw 3, Robert L. Parsons 1, Lorraine P. Berkett 1, Heather M. Darby 2, Sarah L. Kingsley-Richards 1, Morgan C. Griffith 3, Sidney C. Bosworth 1, Josef H. Gorres 1, Renae E. Moran 2 and Elena Garcia 3
1 University of Vermont, Burlington, VT 05405, USA; 2 University of Maine, Monmouth, ME 04259M, USA; 3 University of Arkansas, Fayetteville, AR 72701, USA

Apple growers may use several systems to establish orchards intended for organic management, including the planting of new nursery trees and top-grafting existing orchards to convert to selected cultivars. Long-term economic analysis of certified organic orchard systems is critical to evaluate potential profitability of the enterprise. The overall objective of this project was to evaluate long-term economic performance of five apple cultivars (‘Ginger Gold’, ‘Honeycrisp’, ‘Liberty’, ‘Macoun’, and ‘Zestar!’) grown in a newly planted orchard (Orchard 1) and in a top-grafted established orchard (Orchard 2). Actual management costs including labor, equipment, and inputs costs were recorded and commercial grades for fruit and projected net income per hectare for each cultivar for each system were assessed over the study period. There were few differences among cultivars for the percentage of fruit in each grade. Mean separation of fruit grade distribution within each cultivar was
variable, and in Orchard 2, three of the cultivars (i.e., ‘Ginger Gold’, ‘Liberty’, and ‘Macoun’) had the highest percentage of fruit in the US#1 Count grade, with ‘Honeycrisp’ fruit distributed equally into US#1 Count, Utility and Cull and with ‘Zestar!’ having no difference in % of fruit into US#1 Count and Utility grades. All cultivars in Orchard 1 had negative NPV after 20 years. In Orchard 2, ‘Ginger Gold’ attained positive NPV in Year 3, ‘Liberty’ in Year 5, and ‘Honeycrisp’ in Year 7, and ‘Macoun’ and ‘Zestar!’ in Year 8. Income calculations, which incorporate disease and arthropod impacts through fruit grade and horticultural performance through crop yield, and the long-term economic projections provide comprehensive information which apple growers can use to determine which cultivars and orchard system would be best for their organic enterprise.


FOOD SAFETY MANAGEMENT SYSTEM (FSMS) ADJUSTED TO CONTEXT CHARACTERISTICS IN THE FRESH PRODUCE CHAIN IN SPAIN

Irene Castro-Ibañez 1,2, Liesbeth Jacksens 2, Klementina Kirezieva 1, Pietermel A. Luning 3, Maria I. Gil 1, Mieke Uyttendaele 2, Ana Allende 1
1Research Group on Quality, Safety and Bioactivity of Plant Foods, CEBAS-CSIC, Espinardo, Murcia, Spain; 2Department of Food Safety and Food Quality, Faculty of Bioscience Engineering, University of Ghent, Belgium; 3Food Quality and Design Group, Department of Agrotechnology and Food Sciences, Wageningen University. Wageningen, The Netherlands.

The shift from local to global food markets as well as other food safety concerns such as pressure of climate change has increased the demand on current horticultural production systems to guarantee microbiological (e.g. control of Salmonella and pathogenic E. coli) and chemical (e.g. pesticide residues) fresh produce safety. To deal with these concerns, food safety management systems (FSMS) are needed but they should be tailored to each specific company situation. However, the context of the production, processing and trade chains will influence the FSMS. The objective of this study was to gain insights on the context of production and processing companies of fresh produce located in the South East region of Spain, a leading European horticultural area. A diagnostic tool was applied in thirteen producer and seven processing companies focused on trade to other companies of fresh-cut leafy greens all around EU. The diagnostic tool consisted in a questionnaire focused on the context of the company and risk profile. Results showed that product and process riskiness were moderate to high for most of the involved producer and processing companies. All the companies included in this study also compiled with voluntary standards such as GLOBAL GAP, BRC and IFS. The multiple certification requirements are forcing the companies to elaborate a generic sector based FSMS adapted to their situations.

Keywords: fruits and vegetables, assessment tool, food safety, producers and processors.

QUALITATIVE AND NUTRITIONAL DIFFERENCES IN PROCESSING TOMATOES GROWN UNDER ORGANIC AND CONVENTIONAL SYSTEMS

Diane M. Barrett
University of California, Davis, USA

The impact of organic and conventional production systems on the quality and nutritional parameters of fruits and vegetables is still under discussion. In this presentation we will highlight two different studies on the postharvest quality of processing tomatoes grown under organic and conventional production systems. Each study was conducted on three to four different large-scale commercial grower fields located in the California Central Valley, and fields were matched in terms of soil type. The experimental designs used to control and statistically sample an appropriate number of locations will be discussed, as will the differences in cultural practices used by the growers.

In both studies, it was determined that soluble solids ("Brix) were higher in the organically produced tomatoes. One study determined that while the consistency of tomato juice prepared from organically grown tomatoes was higher, the red color, ascorbic acid and total phenolics content of conventionally grown tomatoes was higher than organic. Although organically grown products are often thought to have higher nutrient content, both studies found the ascorbic acid/Vitamin C content to be lower, as well as the lycopene and rutin (flavonol) content. Nineteen different amino acids were tested, and there was a significantly lower level of glutamine, glutamate and tyrosine in organic tomatoes. Nitrogen was significantly lower in organically grown tomatoes, and there was higher level of 15N isotope. Potassium and phosphorous content were significantly higher in organic tomatoes while extractable ammonium was significantly lower, most likely a reflection of the use of manure fertilizers. Results showed that nutritional and quality parameters varied greatly by grower, production system and year for the same tomato cultivar. Organic tomatoes appeared to mature slower, which may explain some of the results.

PERCEPTION OF FAIRNESS WITHIN ORGANIC FRESH PRODUCE SUPPLY CHAINS: THE CASE OF SMALL AND MEDIUM FRESH PRODUCE RETAILERS

Jubin Jacob-John, N.K. Veerapa
Latrobe University, Melbourne, Australia

Consumers and other stakeholders expect ethical business practices along the supply chain, making it imperative for business customers to have a ‘responsibility centred’ purchasing strategy. This paper analyses the influence of perception of responsibility and ethics by focussing on “fairness” within supply chain relationships. The research employs a multiple case study approach to analyse the relationship between fair and equitable business conduction and dyadic supply chain relationships from a business customer’s (retailer’s) perspective. The researchers conducted semi-structured interviews with an intent to determine fairness related factors that affect purchasing and vertical inter-organizational relationships. The results illustrates that within the organic fresh fruit and vegetable...
value chain, the vertical relationships between suppliers and business customers are heavily influenced by the perception of fairness and responsibility centric activities of the supplier organization. A major finding of fairness perception is that from a business customer’s perspective, fairness perception is possible only when there is fair behaviour to all stakeholders and thereby, the paper illustrates a succinct definition of fairness from a stakeholder perspective. Moreover, by dividing fairness into three components; distributive, procedural and interactive fairness, the paper illustrates that there is a difference in perceived fairness according to the focus on each component of fairness. With greater competition from both local and international suppliers, it is imperative that suppliers create and implement strategies that foster effective supply chain relationships and this research guides managers to achieve the same. Research analysing the interrelationships between the fresh fruit and vegetable supply chain actors’ fairness perception and stakeholder orientation, and propensity to repurchase within a business-to-business context is minimal and this paper contributes to this scant literature.

**Keywords:** fairness, ethics, retailers, supply chain, trust, B2B.
SIDE EVENTS

ISHS Meeting, Workshops, Practical session

MONDAY 8TH OF JUNE

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<tr>
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<th>Event</th>
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<tbody>
<tr>
<td>5:30 pm – 6:30 pm</td>
<td>Room1</td>
<td>Business meeting of the ISHS Organic Fruit Work Group (1h)</td>
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<tr>
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<td>Contact: David Granatstein</td>
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<tr>
<td>5:30 pm – 6:00 pm</td>
<td>Room2</td>
<td>Workshop (30 min): Ethylene absorbers along the food chain</td>
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<td>Contact: Michael Blanke</td>
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TUESDAY 9TH OF JUNE

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<tr>
<td>5:30 pm – 7:30 pm</td>
<td>Room1</td>
<td>Workshop (2h): Traditional Tomato cultivars in Europe: Traditom and beyond</td>
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<td>Contact: Antonio Granell</td>
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<tr>
<td>5:30 pm – 7:30 pm</td>
<td>Room2</td>
<td>Workshop (2h): Which design and support for robust transitions towards ecological horticulture?</td>
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<td>Contact: Servane Penvern</td>
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THURSDAY 11TH OF JUNE

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<tr>
<td>5:30 pm – 6:00 pm</td>
<td>Room1</td>
<td>Workshop (30min): Innovative approaches of crop load regulation (CLM) in horticultural fruit crops</td>
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<td>Contact: Lutz Damerow</td>
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<tr>
<td>6:00 pm – 7:30 pm</td>
<td>Info</td>
<td>Practical session (1h30): DEXiFruits, demonstration and test of an easy-to-use tool to evaluate the sustainability of fruit production systems (room equipped with computers)</td>
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<tr>
<td></td>
<td>Room</td>
<td>Contact: Aude Alaphilippe</td>
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ISHS Meeting

BUSINESS MEETING, ISHS ORGANIC FRUIT WORKING GROUP

Convenor: David Granatstein, Chair of Working Group
Contact: granats@wsu.edu
Discuss possible dates, locations, and foci for the next organic fruit symposium; elect a new Working Group chair.
ETHYLENE ABSORBERS ALONG THE FOOD CHAIN

Convener: Michael Blanke  
University of Bonn, Germany  
Contact: mmblanke@uni-bonn.de

The workshop presents a recent innovation in preserving packaged fruit and vegetables. The innovation lies in the both new absorber material, its formulation and sustainable concept including the whole food supply chain and waste reduction.

The new absorber strips contain clay minerals, which absorb volatiles like ethylene, as a ripening enhancing gas; they are placed into the footainers at the packing house and their capacity lasts up to the consumer home (e.g. fridge).

The absorber strips can be used for almost all horticultural commodities (except apples) and e.g. prevent uneven ripening e.g. of pears and enable a package of pears to contain fruit of the same degree of maturity. One of the striking, and so far, unresolved mode of action of the new generation of absorber strips, is their positive effect on strawberry and other soft fruit, which were traditionally classified as climacteric fruit and hence insensitive to ethylene – this will be discussed.

The absorber strips have found market access in both the US and the UK, while first experiments on the Continent including Germany, Belgium and France seem promising. The workshop is to open with an introductory talk before general discussion (or other talks/ comments on the topic); there will be samples of the absorber strips for examination by the participants.

TRADITIONAL TOMATO CULTIVARS IN EUROPE: TRADITOM AND BEYOND

Conveners: Antonio Granell, Antonio Monforte (IBMCP-CSIC), Jaime Prohens (COMAV-UPV), Mathilde Causse (INRA-Avignon)  
Contact: agranell@ibmcp.upv.es; +3496 3877873

Aims and scope: To get together with other scientists and horticulturists interested in traditional tomato cultivars in Europe. Increase communication between scientific groups and growers working in traditional tomato varieties, from germplasm curators and other scientists interested in different aspects of traditional tomatoes such as horticulturists, geneticists, plant physiologists or molecular biologists, to farmers and farmer associations. Build a network linking all groups and resources. Identify the sector problems and discuss science-based solutions.

WHICH DESIGN AND SUPPORT FOR ROBUST TRANSITIONS TOWARDS ECOLOGICAL HORTICULTURE?

Conveners: Servane Penvern (INRA), Claire Lamine (INRA), Sylvaine Simon (INRA), Marc Lateur (CRA-W),  
Contact: spenvern@avignon.inra.fr

This workshop aims to exchange on various experiences and approaches used to identify, integrate and develop promising concepts or techniques in new or existing horticultural systems. It targets researchers and stakeholders interested in the transformation of horticultural systems valuing ecological processes. The analysis of short contributions should enable participants to better identify the prerequisites for robust transitions towards ecological horticultural systems. Such transitions rely on the consideration of constraints and the combination of methods at multiple levels, including interactive processes within agroecosystem but also within agri-food system. For example, the integration of hardy cultivars makes it necessary to redesign the socio-technical system beyond orchards: farmers’ practices, governance of research and extension, food industry and retailers’ strategies, consumers’ patterns, etc. In this perspective, systemic approaches are also needed beyond the field and the farm in order to integrate necessary changes in the agri-food system. Additionally, robust transitions also rely on the continuous adaptation of the methods to the specificities of each horticultural system. For example, the management of flowering strips assume to product local references and operational monitoring-tools for on-farm adoption. This workshop may therefore help to identify prerequisites, determining factors and approaches useful to consider for further research and extension projects to design and support transitions towards more ecological horticulture.

NEW APPROACHES TO THINNING OF HORTICULTURAL FRUIT CROPS

Convener: Lutz Damerow, Michael Blanke (University of Bonn)  
Contact: damerow@uni-bonn.de

The Workshop includes the following research areas:  
- flower and fruit recognition  
- mechanical approaches  
- mechatronics: water, air pressure, nozzles  
- modelling June drop (Greene model)  
- image analysis and data processing for flower/fruit removal  
- crop load management (CLM)  
- integrative crop load regulation concepts

Presentation, overview and discussion of physiological background and new technologies and concepts of thinning flower buds (including flower bud extinction), flowers, fruitlets or fruits of apple, pear, plum, peach, apricot etc. in order to improve fruit quality (fruit size, sugar, taste, colouration) and overcome and/or prevent biennial or alternate bearing (change of years with high and low yield).

Practical session

DEXIFRUCTS, DEMONSTRATION AND TEST OF AN EASY-TO-USE TOOL TO EVALUATE THE SUSTAINABILITY OF FRUIT PRODUCTION SYSTEMS

Convener : Aude Alaphilippe (INRA UERI Gothen)  
Contact: aude.alaphilippe@avignon.inra.fr

Introduction and demonstration of the tool for self-testing on computer(s)
Visit 1

HORTICULTURAL AGROFORESTRY SYSTEMS (LOWER RHONE VALLEY). EXPERIMENTAL STATIONS AND ORGANIC VEGETABLE FARMS

The trip will start with the visit of a tomato collection trial at INRA- Genetics and Breeding of Fruit and Vegetables research unit. The trial is part of a European project « Traditom » on traditional tomato cultivars. It will continue at the GRAB. The GRAB is a non-profit research organization dedicated to organic farming, for fruits, vegetables and vineyard sectors. The 15-people staff carries out on-farm research in farmers plots directly, and spreads information and results at national and EU scale. See www.grab.fr for more information.

On GRAB’s experimental farm, you will be able to see various experiments dealing with agroforestry (mixing fruits and vegetables), functional biodiversity, behavioural assessment of cultivars for organic farming, adaptation to climate change, alternative methods for pest control...

Visit 2

ORCHARD’IN: THE INRA EXPERIMENTAL STATION OF GOTHERON (MIDDLE RHONE VALLEY) AND ORGANIC FRUIT FARMS

We will move Northwards to the middle Rhone valley in the Drôme department. The visits will start with the INRA experimental station of Gotheron where organic and IP orchards are experimented in apple and peach fruit production. The station of Gotheron develops research programs to design and manage orchards towards more sustainability; system experiments combining various levers to manage pests and diseases will be presented by the programs’ leaders in peach and apple. After lunch, two contrasted fruit farms in Loriol will be visited to highlight the diversity of production and marketing systems and to enable direct exchange with growers (Farm “Biotiful”; and society “Fauriel Fruits” in Loriol sur Drôme).
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