

Organic Agriculture

clues for weed prevention
and control

International
Symposium

Vigo (Spain)
30-31 July, 2014

BOOK OF ABSTRACTS

... you have a lot to say to weed management in Organic Agriculture

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Edited by

Nuria Pedrol
Carolina G. Puig
Pablo Souza-Alonso

OA

Book of Abstracts of the International Symposium

Organic Agriculture: clues for weed prevention and control

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Edited by Nuria Pedrol, Carolina G. Puig and Pablo Souza-Alonso

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Vice-Chair: Carolina G. Puig. University of Vigo, Spain. cgpuig@uvigo.es

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Chair: Nuria Pedrol. University of Vigo. pedrol@uvigo.es

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Welcome

Dear participants in the International Symposium ‘Organic Agriculture: clues for weed prevention and control’:

Organic Agriculture (OA) is to be congratulated for being 2014 the International Year of Family Farming (IYFF). The IYFF aims to raise the profile of family farming and smallholder farming by focusing world attention on its significant role in eradicating hunger and poverty, providing food security and nutrition, improving livelihoods, managing natural resources, protecting the environment, and achieving sustainable development, in particular rural areas.

OA is based on the same principles of health, ecology, fairness and care (<http://www.ifoam.org/en/organic-landmarks/principles-organic-agriculture>), thus embracing the Precautionary Principle (Wingspread Statement, 1998). OA bases on living ecological systems and cycles, works with them, emulates them and helps sustain them. OA should attain ecological balance through the design of farming systems, establishment of habitats and maintenance of genetic and agricultural diversity.

The International Symposium ‘OA: clues for weed prevention and control’ has achieved the goal of gathering a notable number of active voices, worldwide Plant Scientists and Agronomists working together to attend the demands of effective tools for weed management in OA. In OA systems, weed control is considered the major production-related problem. An effective weed management in organic systems relies on the use of “many little hammers”, i.e., a global strategy composed of multiple physical, biological and cultural practices that, when acting together, are strong enough to provide an efficient weed control. In non-organic sustainable agro-systems, this is actually the defining idea of the integrated weed management strategy that can be considered as part of the broader goal of the integrated pest management (IPM). Conventional or organic, the implementation of IPM-based cropping systems is necessary in order to afford the global challenge of reducing the overall pesticide use.

Welcome to you all having a lot to say to weed management in Organic Agriculture. **Thank you** researchers for choosing this frame of the International Symposium ‘OA: clues for weed prevention and control’ to share and discuss your achievements. Thanks for your useful contributions to weed management in OA. Sincerely thanks to all you attendees, authors, sponsors, collaborators, and members of the Scientific and Organizing Committees for making this event possible.

Nuria Pedrol

ECOAGRICULTURE, A COMMITMENT TO THE FUTURE

by Esther Vivas*

“The opening of the International Congress ‘Organic Agriculture: Clues for Weed Prevention and Control’ being so near, it is an honour to address a few words to all those persons who, like you, are silently working in defence of agroagriculture and food sovereignty, that is, in defence of life and our collective future.

Ecological Agriculture has proved to be an answer and a solution to change a model of industrial, intensive, transgenic agriculture in the hands of a few multinationals, as many scientific studies show. In view of hunger, environmental degradation, the loss of farmhands and the increase of illnesses connected with the food we eat, ecoagriculture is a viable alternative, indeed, and a menace to the interests of agrobusiness. So the attempts at delegitimizing and undermining it have increased, often starting after speeches and presumable scientific and equidistant or impartial assertions, but actually plagued with lies and false statements.

Curiously enough, the staunch and out-and-out defenders of what might be called “neo-liberal agriculture” call us, the defenders of ecoagriculture, ‘ideologists’, as if defending industrial and transgenic agriculture should not follow a certain ideology, that of those who are in the field of agroalimentary and biotechnologic multinationals, and who often earn money out of this. To make a commitment to ecoagriculture is to have faith in Science, a Science at the service of social majorities, those who set persons and the planet in the centre, a Science that does not show weaknesses and is not sold. It is an indispensable Science, the one we need, and that you may make possible.

Thanks for your commitment, and for not flagging in this effort.

Esther Vivas”

*Esther Vivas is a member of the Centre of Studies about Social Movements (CEMS) at Universitat Pompeu Fabra (Barcelona, Spain). Her main research areas are the analysis of the social and environmental impacts of the dominant agro-industrial model, the alternatives to this model, as well as the study of social movements (<http://esthervivas.com/english/>)

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SESSION I: WEED PREVENTION STRATEGIES

Early vigour and allelopathy – two useful breeding traits for improved weed competitive ability in wheat

Nils-Ove Bertholdsson

Department of Plant Breeding, SLU, P.O.Box 101, 230 53 Alnarp, Sweden; e-mail: nils-ove.bertholdsson@slu.se

Most commercial breeding companies do not include improved weed competitive ability (WCA) as a specific breeding goal. One reason for this is that WCA is not tested for in the official testing and is therefore difficult to use as a sales argument; another is that the trait is very complex and is hence difficult to breed for. With increased organic production the interest in cultivars with high WCA has increased and so has the interest among breeders. Some 15-20 years ago I studied various traits that might explain the variance in WCA in the breeding pool of Swedish barley and wheat and came to the conclusion that the two most important ones were early vigour growth and allelopathy. During the following years I have confirmed the usefulness of these traits in practical breeding programs with a special interest in wheat. Wheat is more important than barley in organic production but unfortunately it has a lower WCA than barley. In Swedish spring wheat for instance the allelopathic properties are poor. A screening of 813 cultivars from a world collection revealed a few cultivars with a potential allelopathic activity similar to that in barley. One of these was used in a breeding program resulting in lines with twice the activity of the Swedish parent and giving only half the weed biomass in the field plots. Unfortunately, there was also a yield penalty of 20%. In winter wheat the source of both early vigour and allelopathy was introduced from rye. The work with these wheat-rye translocation and substitution lines is still ongoing with the introduction of rye genes in more modern gene backgrounds. Parts of the materials in spring wheat and winter wheat are now further evaluated in the CORE II organic project Cobra.

Keywords: Early vigour, allelopathy, cereals, weed competitive ability

Faba bean (*Vicia faba* L.) green manure as a tool for weed control in sustainable maize production

Álvarez-Iglesias L.¹, Puig C. G.¹, Revilla P.², Reigosa M. J.¹ and Pedrol N.²

¹Department of Plant Biology and Soil Science, Facultad de Biología, Universidade de Vigo, Campus Lagoas-Marcosende s/n, 36310 Vigo, Spain; e-mail: pedrol@uvigo.es

²Misión Biológica de Galicia, Consejo Superior de Investigaciones Científicas (CSIC), Apartado 28, 36080 Pontevedra, Spain; e-mail: previlla@mbg.csic.es

The legume faba bean (*Vicia faba* L.) has been widely grown as green manure in rotation with maize in temperate climates. Faba bean green manure offers multiple ecosystem services, but little information regarding its effects on weed control is available. Our previous laboratory and greenhouse studies suggested that faba bean green manure can contribute to early control of weeds commonly associated with maize production in temperate areas. This work aims to assess the potential of faba bean flowering aerial biomass incorporated into the soil as green manure for early weed control under field conditions. Field experiments were conducted at two locations and two consecutive growing seasons in weed-infested fields. Faba bean was sown in autumn, and incorporated into the soil at flowering stage in early spring. Weed species composition, weed density and total weed biomass were determined in late spring and early summer. When compared with plots left fallow, apparent residue-mediated reductions of weed density and biomass were observed in both locations and sampling times. Reductions ranged from -15 to -70% for weed density, and from -41 to -79% for weed biomass. Biomass reduction was stronger for grass weeds in late spring and for broadleaved weeds in early summer. Our results demonstrate that faba bean green manure provides an efficient weed control immediately after incorporation. This short-term weed control, together with the additional benefits associated with legume green manuring, makes faba bean a valuable tool in sustainable maize-based cropping systems, as a part of integrated weed management programs.

Keywords: *Vicia faba*, *Zea mays*, green manure, allelopathy, weed management.

Canola (*Brassica napus*) crop rotation reduce weed pressure

Md. Asaduzzaman¹, Shamima Sultana² and Saira Hussain³

¹School of Agricultural and Wine Sciences, Charles Sturt University, Wagga Wagga, NSW, Australia; e-mail: masaduzzamam@csu.edu.au

²School of Biomedical Science, Charles Sturt University, Wagga Wagga, NSW, Australia; e-mail: shussain@csu.edu.au

³College of Development Alternative, Dhaka-1207, Bangladesh; e-mail: shamima.agro@yahoo.com

Canola (*Brassica napus* L.) is an important rotational break crop and fairly easy to manage in farmer's production system. Nevertheless, weeds are still responding for major constraints and cost in canola due to herbicides inputs and reducing yields and quality. The modern herbicides, improved weed management and continued development of new and more herbicides has increased canola quantity and quality. However, the high frequency of herbicides and the criticisms about herbicides resistant canola, expanding demand the consideration of other non-chemical alternative such as allelopathy through canola crop rotation. Crop rotation is an ancient agronomic practice and a cornerstone of farm management. It provides the foundation for preventative weed management. Canola crop rotation encourages agronomic operational diversity that in turn can facilitate improve weed management with other benefits in including allelopathy. Alternate crops in canola rotation allow different herbicides use for overall weed control in the long term strategies. The rotate herbicides groups help to reduce the buildup of herbicide resistant weed biotypes. However, the full benefits to rotation (others crops following canola and canola following other crops) for weed management is still not fully understood. The long term experiments are needed to exclude short-term influence of weather, soil productively and management changes.

Keywords: *Canola, weeds and herbicide*

Long-term weed dynamics and yield comparison of organic and conventional cropping systems in the Canadian prairies

Benaragama, D. and S. J. Shirliffe

Department of Plant Sciences, University of Saskatchewan, Saskatoon, SK, S7N 5A8, Canada

Organic systems generally thought to have low yields due to high weed abundance or due to low soil fertility. However, it has also being argued that in some organic systems despite high weed abundance grain yields are either similar or high in organic compared to conventional systems due to better soil properties in the organic systems. Still, the long-term effect of cropping systems on weed abundance, crop-weed competition, and grain yields were not well known. A long-term study was carried out (18 years) at Scott, Saskatchewan Canada by Agriculture Agri-Food Canada to study the effect of diverse cropping systems on weed dynamics and grain yields. The main experiment consisted of three input levels; High input (High), Reduced (RED) and organic (ORG), and three crop diversity levels; low (LOW), diversified annual grains (DAG), and diversified annual perennials (DAP). In order to assess the crop-weed competition, during the 17th and the 18th year, a micro-plot study was carried out within the main experiment with four weed control treatments applied to the common wheat phase of all the RED and ORG rotations. The treatments were 1. weed free treatment, 2. weedy treatment, 3. standard weed control, and 4. pseudo weed (tame oat) seeded at 1:1 ratio with the crop. Overall, when 18 years weed biomass and grain yield data were analysed for the wheat phase of the entire systems, grain yield was 15% low in ORG systems compared to RED systems. Diversified annual perennial system had the lowest yield and was 17% lower than LOW diversity rotation which had the highest yield. Weed biomass was 16 times high in ORG compared to RED systems. When the crop-weed competition was analysed at the end of the three cycles, grain yields were low in ORG under both weedy and weed-free conditions. Importantly, there was no difference between cropping systems for yield loss due to weed competition. Given the low productivity in ORG systems, the similar yield loss as RED systems suggests that ORG systems probably able to tolerate weed competition better than RED systems.

Keywords: *weed competition, organic systems, conventional systems, yield loss*

Ecological Services providing Crop introduction in organic vegetable systems: effects on weed community and competitive ability

Ciaccia, Corrado¹; Testani, Elena¹; Campanelli, Gabriele²; Leteo, Fabrizio¹; Canali, Stefano¹; Tittarelli, Fabio¹ and Trinchera, Alessandra¹

¹Consiglio per la Ricerca e la Sperimentazione in Agricoltura – CRA – RPS, Research Centre for the Soil-Plant System. via della Navicella 2-4 – 00184 Rome - Italy; e-mail: corrado.ciaccia@entecra.it

²Consiglio per la Ricerca e la Sperimentazione in Agricoltura – CRA-ORA, Research Unit for Vegetable Crops, via Salaria 1 – 63030 Monsampolo del Tronto (AP) - Italy

Cover crop introduction in agroecosystems provides several ecological services at field/farm level (i.e. weed, pest and diseases management, nutrient cycling, biodiversity conservation, etc.). Therefore, they can be defined as Ecological Service providing Crops (ESC). Thus, both the ESC species and management choices play a relevant role in weed control. In order to test this hypothesis, a randomized block experiment was set up in the CRA-ORA organic farm (Monsampolo del Tronto - AP, Italy), comparing the effect on weeds of autumn-winter cereal covers (wheat; barley; spelt; rye; a their mixture) preceding melon crop with a control (no ESC). The ESCs were flattened by a roller crimper, to obtain a mulch layer in which the melon was transplanted. Weeds were not controlled until the melon harvest. The weed community was evaluated both in cover crop and melon cycles throughout species identification, density and biomass determination. The competitive ability of melon towards weeds in function of ESC was also assessed through the competitive balance index (C_b). Preliminary results showed differences in weed density depending on species during the cover crop cycle. The melon biomass at harvest showed no significant differences; on the other hand the competitive ability (C_b) of the melon grown on different ESC mulch was significantly influenced by the ESC species. Our findings suggest that the weed community composition, as far as its effect on crop competitiveness, can be manipulated by the choice of the correct ESC.

Keywords: *cover cop, roller crimping, dead mulch*

On farm investigation of three cover crop mixtures in Hungarian vineyards

Ádám Donkó¹, Tamás Miglécz², Péter Török², Orsolya Valkó², Balázs Deák³, András Kelemen³, Gábor Zanathy⁴, Dóra Drexler¹

¹Hungarian Research Institute of Organic Agriculture (ÖMKi); e-mail: adam.donko@biokutatas.hu

²University of Debrecen, Faculty of Sciences, Department of Ecology; e-mail: tamas.miglecz@gmail.com

³MTA-DE Biodiversity and Ecosystem Services Research Group; e-mail: debalazs@gmail.com

⁴Corvinus University of Budapest Research Institute for Viticulture and Oenology; e-mail: gabor.zanathy@uni-corvinus.hu

Incorrect mechanical cultivation – especially on hill-valley planted, steep vineyard slopes – has negative effects on vineyards. Moreover, climate change scenarios predict heavier rainstorms, which can enhance soil degradation, and at most do not increase the water content of the soil significantly. There are alternative technologies to avoid these factors. Covering methods (mulching by straw, reed or sedge) are appropriate soil management techniques. The use of cover crops, however, has a special importance for providing environmentally friendly soil management: Sustainable species-rich cover crop mixtures help not only to prevent erosion and provide easier cultivation, but have also a positive effect on soil structure, soil fertility and ecosystem functions. These positive effects are of high importance especially in organic viticulture. Our aim was to develop cover-crop mixtures consisting ecotypes from local provenance which are properly adapted to the ecological conditions of Hungarian vineyards. The experiment was designed as a participative on-farm research, and was launched in the spring of 2012. Three cover crop seed mixtures (Biocont-Ecovin, mixture of legumes, mixture of grasses and forbs) were compared in vineyards of the Tokaj and Szekszárd wine regions of Hungary. Botanical and viticultural measurements (yield, must quality, and pruning weight) were taken. We used the usual cultivation practice of the vineyard inter-rows as control treatment. We found that cover crops suppressed weeds of the inter-rows effectively. Our results suggest that in the continental climate of Hungary every second inter-row sowing is likely more preferable than consecutive cover-crop application, in sites where erosion control is not essential.

Keywords: *cover crop, vineyard, erosion, organic*



Effect of interseeding cover crops and times of fertilization on weed suppression and maize

Rasoul Fakhari¹, Ahmad Tobeh², Mohammad Taghi Alebrahim²

¹Young Researcher, University of Mohaghegh Ardabili, Ardabil, Iran; e-mail:
rasoulfar100@gmail.com

²Department of Agronomy and Crop breeding, University of Mohaghegh Ardabili, Ardabil,
Iran; e-mail: ahmad_tobeh1340@yahoo.com

Interseeding cover crops are primarily used to provide surface cover as well as to improve soil fertility and suppress weeds. The objective of this study was to evaluate the effect times of nitrogen fertilization and interseeding cover crops on the growth of main crop (maize) in agricultural research station of Ardabil (Iran). Three cover crops, fall rye (*Secale cereale* L.), hairy vetch (*Vicia villosa* L.) and berseem clover (*Trifolium alexandrinum* L.), were interseeded in maize furrows (*Zea mays* L.) at simultaneous planting the main crop. Nitrogen fertilizer timing was consisting of two levels including, the first level ($N_1 = \frac{1}{2}$ at planting time + $\frac{1}{2}$ in the 8 to 10 leaf stage of maize) and the second level ($N_2 =$ at planting time + in the 8 to 10 leaf + a week before tasseling. The number and dry weight of weeds was measured at the maximum plant height stage of main crop and main crop yield was recorded at physiological maturity. The results indicated that all the cover crops produced more above-ground dry biomass than the weedy fallow. Hairy vetch and fall rye were the most efficient weed suppressors and had the least proportion of weed biomass (<1%) of the total produced by the cover, while they also reduced weed emergence. Weed growth was suppressed significantly by interseeding cover crops through increasing the vegetation cover ratio of main crop plus cover crops. In addition, times of fertilization had positive effects on the main crop yield and weed suppression. The yield of maize in second level (N_2) of nitrogen fertilization was more than the first level (N_1). It seems that in the second level nitrogen fertilization treatments (N_2), nitrogen use efficiency during vegetative growth, compared to first level (N_1) have some advantages. Over all, considering benefits of effective weeds control and much production, the treatment of hairy vetch and three times of nitrogen fertilization was introduced as a proper method.

Keywords: *Cover crop interseeding, maize, times of fertilization, weed suppression*

Weed control by sowing species rich cover crop seed mixtures in Hungarian organic vineyard farming

Tamás Miglécz¹, Ádám Donkó², Orsolya Valkó¹, Péter Török¹, Balázs Deák³, András Kelemen³, Gábor Zanathy⁴, Dóra Drexler², Béla Tóthmérész³

¹University of Debrecen, Faculty of Sciences, Department of Ecology; e-mail: tamas.miglecz@gmail.com

²Hungarian Research Institute of Organic Agriculture (ÖMKi); e-mail: adam.donko@biokutatas.hu

³MTA-DE Biodiversity and Ecosystem Services Research Group; e-mail: debalazs@gmail.com

⁴Corvinus University of Budapest Research Institute for Viticulture and Oneology; e-mail: gabor.zanathy@uni-corvinus.hu

In organic wine-growing, weed control and preserving soil fertility are crucial, because synthetic pesticides and herbicides are forbidden in organic agriculture. Thus, it is vital to test alternative management techniques to control weeds, sustain soil fertility and improve agro-biodiversity. To fulfil these issues, the use of species-rich cover crops became increasingly integrated in organic wine-growing. We evaluated the establishment of three species-rich cover crop seed mixtures in four vineyards of Tokaj region, East-Hungary. We asked the following questions: (i) How effective are the cover crop seed mixtures in weed control? (ii) Which species of seed mixtures establish successfully in the first year after sowing? (iii) Which sown species are present even in the second year? Percentage cover of vascular plant species was recorded in the inter-rows in five 1 m² permanent plots in late June, 2012 and 2013. All sown species established within the timeframe of the study, even some species were detected only with very low cover scores or were not present in every vineyard stands. We found that *Lotus corniculatus*, *Medicago lupulina*, *Plantago lanceolata*, *Trifolium repens* and *T. pratense* established well and had high cover scores in most vineyards even for the second year. We detected significant weed suppression for all sown mixtures, but the rate of weed suppression was different in case of different seed mixtures. The overall establishment of seed mixtures was successful, which suggest that species-rich, native cover crop mixtures offer a vital opportunity to control weeds and to improve the biodiversity of vineyards.

Keywords: *weed management, ecosystem services, Biocont-ECOWIN seed mixture, Legume seed mixture, Grass-medical forb seed mixture*



Can the atlantic shrubland control the invasion of *Ailanthus altissima* (Mill.) single? Allelopathic evidences

Tonio L. Nogueira¹, María Pardo¹, Lorena Álvarez-Iglesias¹, Carlos Cavaleiro² and Nuria Pedrol¹

¹Department of Plant Biology and Soil Science, Faculty of Biology, University of Vigo, 36310-Vigo, Spain; e-mail: tonionogueira@uvigo.es

²Department of Pharmacognosy, Faculty of Pharmacy/CEF, University of Coimbra, 3000-Coimbra, Portugal

The loss of biodiversity is the main problem caused by plant invasions in terrestrial ecosystems. One example is *Ailanthus altissima* that invades some areas of Galicia (NW Spain) being one of the main invasive tree species across Europe and other continents, except Antarctica.

Usually, research in biological invasions deals on the invasive competition effects against the native plants. On the contrary, we focus on the effects of the native dominant species against the invasive species. Our field observations suggest that the mature native shrubland is able to stop the invasion of *A. altissima*, acting as a natural barrier. Both dominant species of the Atlantic shrubland: *Ulex europaeus* and *Cytisus scoparius* have a great competitive ability; in fact, they are top invasive plant species in other parts of the world.

Under the hypothesis that competition by passive interference (allelopathy) may underlie the resistance to invasion, we tested the phytotoxicity of volatiles emitted by *U. europaeus* and *C. scoparius* on the *in vitro* early growth of *A. altissima*, by using the method of hermetic chambers (Barney *et al.* 2005). Moreover, for the first time in literature, we determined the composition of the volatile extracts of both shrub species by GC-MS.

The volatile compounds emitted by the native shrub species produced a significant phytotoxic effect on *A. altissima*, by inhibiting drastically seedling growth. The volatile profile of *U. europaeus* and *C. scoparius* revealed the presence of some allelochemicals previously described as phytotoxic in other species. From our results, we conclude that Allelopathy can, at least in part, underlie the competitive ability of the Atlantic shrubland against the invasion of *A. altissima* by seed setting.

Keywords: *native species, invasive species, phytotoxicity, volatile compounds, Ulex europaeus, Cytisus scoparius*



Winter cover crops and growth of weeds in no-tillage organic corn system

Steliane Pereira Coelho, Emerson Trogello, Luis Paulo Leis Pereira, Silvane de Almeida Campos and João Carlos Cardoso Galvão

Universidade Federal de Viçosa, Brazil; e-mail: steagroecologia@yahoo.com.br; luis.pereira@ufv.br; etrogello@yahoo.com.br; silvanecampos@yahoo.com.br; jgalvao@ufv.br

The greater difficulty the tillage performed under organic management faces is the control of weeds. Because of that, it is imperative to investigate and implement efficient and viable alternatives to their control. In this way, the objective of this study was to evaluate the development of weeds in no-tillage organic corn system in different winter cover crops under two cropping systems. The experimental design was a randomized complete block factorial (5 x 2) scheme with four replicates, comprising 40 experimental units. The treatments were composed of five seeded covers (recommended bulk-seeded, UFV bulk, oat, sunflower and control) and two cropping systems (single and intercropped maize with *Canavalia ensiformis*). The bulk system originated from seven crops: oat, maize, sorghum, sunflower, soybean, pigeon pea and pig bean, differing only in the amount of seed used. It was evaluated the dry mass of weeds in physiological stages V2, V5 and corn flowering. Coverage of oat caused a reduction of 93.7; 94.2 and 80.8 % of dry mass of weeds, compared to control, at the different stages, respectively. The sunflower showed low suppression of the weeds mainly in corn flowering. UFV bulk system and recommended bulk showed similar effects on the dry mass of weeds, but lower than the oat. The intercropping with *Canavalia ensiformis* did not influence the reduction of the dry mass of the weeds. Coverage of oat showed to be an alternative for suppressing weeds in no-tillage organic corn.

Keywords: *Organic agriculture, Zea mays, consortium*

Cover crop competition as a control method for *Elytrigia repens*

B. Ringselle¹, L. Andersson¹, H. Aronsson¹ and G. Bergkvist¹

¹ Swedish University of Agricultural Sciences, Faculty of Natural Resources and Agricultural Sciences, Department of Crop Production Ecology, 750 07 Uppsala, Sweden; e-mail: bjorn.ringselle@slu.se

Elymus repens is a problematic rhizomatous grass weed in the northern temperate zone. In organic agriculture it is usually controlled with intensive tillage during autumn, which drastically increases nitrogen leaching. Cover crops can be used for a variety of functions, among them weed suppression and reducing nitrogen leaching. As such they are a very appealing potential control method for *Elymus*, but effectiveness varies greatly between studies. Very little focus has been put on the type of cover crop or mixture being used, the level of cover crop biomass that was achieved, nor what type of competition mechanism is actually effective against *Elymus*. In field trials we noted that perennial ryegrass (*Lolium perenne*) could reduce *Elymus* aboveground biomass during autumn but that it did not translate into a lower amount of above- or belowground biomass in the following year. Red clover (*Trifolium pratense*) instead increased the amount of rhizomes in the subsequent year. The mixture of the two cover crops had the reductive effect of the ryegrass without the negative aspect of the clover, had a more consistent level of cover crop biomass and increased subsequent yield by 5%. We will present these results as well as a greenhouse experiment looking more closely at the mechanisms of light and nutrient competition on *Elymus* by cover crops.

Keywords: *Elymus repens*, cover crops, nitrogen leaching, perennial weed

Use of permanent cover crops for weed control in apple orchard

Batoul Samedani¹ and Mohsen Rivand²

¹Plant Protection Institute of Iran, Weed Research Department, Tehran, Iran; e-mail:bsamedani@yahoo.com

²Plant Protection Institute of Iran, Weed Research Department, Tehran, Iran; e-mail:mo_rivand@yahoo.com

Planting permanent cover crops is an eco-friendly approach for reducing weed problems through nonchemical methods. Permanent cover crop effects, in comparison with annual cover crops, on weed control and weed community structure have been studied in orchards interrows. Treatments were *Festuca ovina*, *F. arundinacea*, *Lolium perenne*, *Bromus inermis*, *Secale cereale* and control (without any treatment). Treatments were carried out for 2 yr in the interrows of apple in Tehran. *S. cereale* as permanent cover crops impacted weed density, biomass and weed community structure. *B. inermis* and *F. ovina* were more effective than other permanent cover crops on weed density (70-80%) and weed biomass (60-80%). Results revealed treatments effects on weed community structure. Grasses and *Rumex acetosa* in *L. perenne* and grasses in *F. ovina* were dominated in middle of spring in second year. However, other treatments favored grasses and *Descurainia sophia* as the dominant species.

Keywords: weeds, permanent cover crop, apple

Effectiveness of cover crop species in oil palm weeds management

Batoul Samedani^{1,2} and Abdul Shukor Juraimi²

¹Plant Protection Institute of Iran, Weed Research Department, Tehran, Iran; e-mail: bsamedani@yahoo.com

²Department of Crop Science, Universiti Putra Malaysia, Serdang, Selangor DE, Malaysia; e-mail: ashukorjuraimi@gmail.com

Sustainable oil palm cultivation is gaining popularity in Malaysia. Currently alternative strategies to chemical herbicides for weed control have received widespread attention. Hence field experiments were designed to compare the effect of cover crops on the response of oil palms and weeds. Six ground cover treatments viz. *Axonopus compressus*, *Calopogonium caeruleum* + *Centrosema pubescens*, *Mucuna bracteata*, *Pueraria javanica* + *Centrosema pubescens*, weeded and un-weeded were evaluated for 2 years. Initial weed composition revealed two dominant weed species viz. *Borreria latifolia* and *A. compressus*. *A. compressus*, *M. bracteata* and other legume cover crops achieved 100% coverage at 3, 6 and 9 months after planting, respectively. Cover crops were found to be effective in controlling weeds dry weight and density in comparison to the un-weeded treatment ranged between 97.3 - 99.9% and 94.77 - 99.73%, respectively. The un-weeded treatment favored *Paspalum conjugatum* and *A. compressus* as the dominant species. In the *A. compressus* and *C. caeruleum* + *C. pubescens* the associated weed species with highest dominance was *Asystasia gangetica*, while the weeds *A. compressus* and *A. gangetica* were associated with *M. bracteata* and *P. javanica* + *C. pubescens*. In the weeded treatment *B. latifolia* was dominant. The *A. compressus* treatment had the lowest species richness and diversity. The *A. compressus* treatment showed yield difference with weeded plot at between 18 to 24 months after planting. The cover crops did not influence nutrient levels or photosynthesis rate of oil palm relative to the un-weeded and weeded. Phenolic compounds in the soil increased over time and cover crops produced much more than in the un-weeded treatment. The absence of significant yield or nutritional effects compared to un-weeded plots suggest that cover crop management systems are unlikely to have negative impacts on oil palm health.

Keywords: weeds, cover crop, yield, soil, photosynthesis, oil palm

SESSION II: WEED CONTROL

Weed management in organic crop production from a European perspective

Bo Melander

Aarhus University, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark; e-mail:
bo.melander@agrsci.dk

Physical and cultural methods for weed control play an important role for the management of weeds in organic cropping systems in Europe. With the expansion of the organic area in recent years, more research has been conducted to develop new methods and improve management strategies. Currently, weed harrows, rotary cultivators and inter-row cultivators are the principal methods used for full-width treatments in large agricultural crops, such as cereals, oil seed rape, maize and pulses. The mechanical methods are often combined with cultural measures, e.g. stale seedbeds, delayed sowing, placement of fertilizers etc., to benefit from the additive - and sometimes even synergistic - effects of combining direct and cultural methods. In row crops, such as sugar beets and horticultural crops, thermal and mechanical methods are mostly combined to remove as many weeds in the rows as possible in order to minimize the need for manual weeding. Weeds growing between the rows are easily controlled by inter-row cultivation. These physical methods work without any intelligence in terms of cameras with the ability to discriminate crop plants from weed plants. Currently, they have wide application in organic row crops but new solutions with intelligence have emerged lately. Robotic weeding for row crops with abundant spacing between individual crop plants is now available for automatic intra-row weed removal. Although not equipped with intelligence, band-steaming for row crops developing dense crop stands is another intra-row weed control concept that has been developed recently. The concept aims at complete destruction of seed propagules in the soil of the treated intra-row zone prior to crop sowing, usually resulting in long-lasting weed control.

A new EU directive for the implementation of IPM based crop protection is expected to accentuate the need for non-chemical methods in the conventional sector also. Most recently, manufactures have introduced new high-tech solutions to provide large scale agriculture with rational and high-capacity solutions. Inter-row hoes have been equipped with GPS-systems and cameras for optimizing precision and steering. And new GPS technology is currently being developed with the ability to create parallel or diamond crop establishment patterns, which enable inter-row hoeing to be conducted in different directions.

Please visit the web-site http://www.ewrs.org/physical_and_cultural_weed_control.asp for more information about physical and cultural weed control activities within the European Weed Research Society.

Keywords: *Mechanical weed control, thermal weed control, cultural weed control, new technologies*

Weed control with essential oils in organic farming

Mehmet Arslan¹ and Ilhan Uremis²

¹Erciyes University, Agriculture Faculty, Department of Agricultural Biotechnology;
Rektörlüğü 38039 Kayseri, Turkey; e-mail: mehmetarslan@erciyes.edu.tr

²Mustafa Kemal University, Agriculture Faculty, Department of Plant Protection; e-mail:
iuremis@mku.edu.tr

Thymus vulgaris L. essential oil with high thymol content and *Origanum onites* L. essential oil with high carvacrol content and their equal mixture were tested for controlling of common purslane, (*Portulaca oleracea* L.), redroot pigweed, (*Amaranthus retroflexus* L.) black nightshade (*Solanum nigrum* L.) and ground cherry (*Physalis angustifolia* L.). Each essential oil was applied at the rate of 0, 40, 80, 160 and 320 L/ha in the micro-plots. The experimental design was 3 x 5 factorial with 3 replications in the micro-plots. *O.* essential oil was found more effective on the germination inhibition of redroot pigweed, black nightshade and ground cherry than those of *T. vulgaris* and equal mixture of both essential oils. However, *O. onites* and *T. vulgaris* essential oils had similar effects on the germination inhibition of common purslane. Germination inhibition of weed seeds seriously decreased with the application of essential oils higher than 80 L/ha. The results of the current study showed that oregano essential oil could be used against weeds of the cultivated areas especially in the high value organic crop growing areas.

Keywords: *Black nightshade, common purslane, essential oil, germination inhibition, ground cherry, redroot pigweed.*

Contact effects of essential oils on weeds growing in organic farm lands

Mehmet Arslan¹ and Ilhan Uremis²

¹Erciyes University, Agriculture Faculty, Department of Agricultural Biotechnology;
Rektörlüğü 38039 Kayseri, Turkey; e-mail: mehmetarslan@erciyes.edu.tr

²Mustafa Kemal University, Agriculture Faculty, Department of Plant Protection; e-mail:
iuremis@mku.edu.tr

Thymus vulgaris L. essential oil with high thymol content and *Origanum onites* L. essential oil with high carvacrol content, vinegar mixture of both *O. onites* and *T. vulgaris* were tested in an organic crop land. Each essential oil and their mixture with vinegar were applied at the rate of 0, 40, 80, 160 and 320 L/ha on the weeds growing in the organically growing crops. The experimental design was randomized complete block with 3 replications. *O. onites* essential oil was found more effective on all of the weeds growing in organic farm land than that of *T. vulgaris*. Vinegar mixtures with essential oils were found more effective on controlling weeds compared with essential oil application alone. Weed killing percentage of essential oil and their mixture with vinegar increased with the increasing essential oil doses. The results of the current study showed that oregano essential oil with vinegar mixture could be used as a contact organic herbicide against problem weeds in the organic crop growing areas.

Keywords: *Bio-herbicide, essential oil, oregano, thyme, organic weed control*

Weed management in maize through allelopathic water extracts

Shahzad M.A. Basra

Department of Crop Physiology, University of Agriculture, Faisalabad, Pakistan; e-mail:
shehzadbasra@gmail.com

Non-judicious use of herbicides could cause environmental, health and herbicides resistance problems. Allelopathy is an eco-friendly and organic weed management is emerging as organic as a tool in controlling weeds. In this study, allelopathic water extracts of sorghum, sunflower, brassica and mulberry were applied at 18 L ha⁻¹ alone or in combination with half dose of Primextra Gold as pre-emergence spray, for weed management in maize. *Trianthema portulacastrum*, *Cyperus rotundis*, *Digera arvensis* and *Eleusine indica* were the dominating weeds in the experimental field. All the weed control methods significantly reduced total weed density and dry weight recorded at 40 and 60 days after sowing (DAS). Hand weeding employed at 15 and 30 DAS reduced the total weed density and total weed dry weight by 75 and 67.17%, 80.07 and 79.66% recorded at 40 and 60 DAS, respectively than weedy check. Sorghum + sunflower + brassica + mulberry water extract each applied at 18 L ha⁻¹ combined with half dose of Primextra Gold as pre-emergence spray provided 68.71 and 65.51% reduction in total weed density and 73.77 and 71.88% reduction in total weed dry weight as compared to control recorded at 40 and 60 DAS, respectively. All 4 plants water extract each at 18 L ha⁻¹ combined with half dose of Primextra Gold applied as pre-emergence spray gave significantly higher cob length, number of grain rows per cob and 1000-grain weight over control but statistically at par with full dose of herbicide. Allelopathic plant water extracts tank mixed with half dose of Primextra Gold gave maximum grain yield, which was 45.07% higher than weedy check (vs 31.47% increase over control from label dose of herbicide). In conclusion, allelopathic crop water extracts reduced the dry weight of weeds by 63%. Application of sorghum, sunflower brassica and mulberry water extract in combination with half dose of Primextra Gold 720 SC (360 g a.i. ha⁻¹) provided as affective weed control as was achieved from standard herbicide dose. This study suggests that allelopathy offers an attractive and environmental friendly method of weed control.

Keywords: Allelopathy, maize, water extract, weed control

Search of new ecoherbicides: the phytotoxic effect of the hydrolate of *Cistus ladanifer* for organic weed management

José Bondía¹, Carolina G. Puig², Pedro P. Pellín³ and Nuria Pedrol²

¹Universidad Autónoma de Madrid, Spain; e-mail: jose.bondia@estudiante.uam.es

²Department of Plant Physiology and Soil Science, Faculty of Biology, University of Vigo, Spain; e-mail: pedrol@uvigo.es

³El Jarpil - Essential Oils and Natural Products. C/ Sierra de Gredos, 23 Almería, Spain.

Due to overexploitation and poor management of agrosystems, ecological agriculture and new sustainable and environmentally friendly techniques have to be considered as alternative tools for weed control. Previous studies have pointed out the phytotoxic effect of *Cistus ladanifer* in several manners, such as essential oils or aqueous extract. In this study, we used the hydrolate of *C. ladanifer* (or hydrosol or essential water), a co-product of the distillation of the essential oil, as a potential herbicide for weed management in organic agriculture. From our results of *in vitro* bioassays, the hydrolate inhibited the germination and primary growth at low concentrations (10- 20% in distilled water) of the weeds *Amaranthus retroflexus*, *Portulaca oleracea*, *Digitaria sanguinalis* and *Parietaria judaica*, being the radicle growth the most affected parameter. Otherwise, the crops *Zea mays* and *Glycine max*, were not inhibited at these concentrations. Further greenhouse assays and field trials are required to appraise the use of this product as a promising bio- herbicide for organic agriculture.

Keywords: *Cistus ladanifer*, hydrolate, allelopathy, weed management, organic agriculture.

Application of allelopathy in organic agriculture

Zahid Ata Cheema, Muhammad Farooq and Sardar Alam Cheema

Allelopathy Lab, Department of Agronomy, University of Agriculture, Faisalabad-38040,
Pakistan; e-mail: cheemaza@gmail.com

Continuous and indiscriminate use of agro-pesticides is posing severe environmental threats and health hazards for human being. This is also causing changes of weed flora and development of pesticide resistant weed and insect-pest biotypes in field crops. Evolution of new pest biotypes demands innovative tools of their management. Organic agriculture is being promoted worldwide for the production of safe and quality food and protecting the global environment. Allelopathy, a naturally occurring phenomenon in agricultural ecosystems, has been evaluated as a possible alternative for chemical pest (pathogens, insect-pest and weeds) management and growth promotion in organic agriculture during recent years. We have extensively explored the potential allelopathic plants including sunflower, sorghum, mulberry, rice, maize, brassica, eucalyptus and moringa for organic pest management and growth enhancement in field crops in a series of studies. Allelopathy has been employed through intercropping, crop rotations, mulching and plant water extracts for pest management and plant water extracts for growth promotion. We have proved that, if wisely planned, allelopathy offers a pragmatic option for pest management and growth promotion in field crops. Thus the phenomenon of allelopathy may be opted for producing organic food products and protecting the environment on the planet.

Keywords: *Biopesticide, growth promotion*

Combined use of *Azolla* and loach suppressed weed *Monochoria vaginalis* and increased organically farmed rice yield

Weiguo Cheng, Yuka Okamoto, Shuhei Sato, Katsuya Kasahara, Keitaro Tawaraya and Hironori Yasuda

Faculty of Agriculture, Yamagata University, 1-23 Wakaba-machi, Tsuruoka, Yamagata, 997-8555 Japan; e-mail: cheng@tds1.tr.yamagata-u.ac.jp

Organic farming uses alternatives to agricultural chemicals such as synthetic fertilizers and pesticides. The primary challenge in organic rice farming is controlling weeds without using herbicides. *Monochoria vaginalis* is one of the most common and troublesome annual broadleaved weeds in rice paddies, where it competes with rice for N uptake. *Azolla* is a genus of floating aquatic ferns, used for many centuries as a green manure in traditional rice production. Loach is a freshwater fish that was once widely spread in Asian rice paddies, but has disappeared in modern conventional rice paddies due to use of synthetic agricultural chemicals. We performed an in situ container experiment to study the effects of individual and combined use of *Azolla filiculoides* and loach (*Misgurnus anguillicaudatus*) to suppress *M. vaginalis* emergence and increase organically farmed rice yield. This study was designed with 4 treatments—control (with neither *Azolla* nor loach), *Azolla* (*Azolla* alone), loach (loach alone), and Az+Lo (combined *Azolla* and loach)—with 3 replications each. The results show that use of *Azolla* alone and loach alone partially suppressed *M. vaginalis* emergence and improved rice yield due to the effects of both shading and N-fixation by *Azolla*, and aquatic bioturbation by loach. The combined use of *Azolla* and loach had a stronger effect, totally suppressing weed emergence and increasing rice yield to 131% that of control treatment, indicating that combined use of *Azolla* and loach may be a valuable approach in organic rice farming, especially in organically farmed rice paddies with high densities of *M. vaginalis* seeds. Thus the combined use *Azolla* and loach meets 2 of the greatest challenges in organic rice production: providing effective weed control and ensuring adequate N fertilization without use of synthetic chemical inputs.

Keywords: *Azolla*, loach, *Monochoria vaginalis*, organic farming, rice yield.



Phytotoxic potential of rosmarinic acid on *Arabidopsis* seedlings

Aitana Costas-Gil, David López-González, Carla Díaz-Tielas, Manuel J. Reigosa, Adela Sánchez-Moreiras

Department of Plant Biology and Soil Science Faculty of Biology. University of Vigo Campus Lagoas-Marcosende s/n E-36310, Vigo, Spain; e-mail: aitana@uvigo.es

Rosmarinic acid is a natural phenolic compound commonly found in plants of the families Boraginaceae and Lamiaceae, and in aquatic monocots of the families Zosteraceae and Potamogetonaceae.¹ Although the antibacterial, antiinflammatory, antimutagenic, fungicide, bactericide and antioxidant activity of rosmarinic has been demonstrated,² its phytotoxic activity has been poorly investigated.

The phytotoxicity of this compound was tested on *Arabidopsis thaliana* (L.) Col-0 and *Lactuca sativa* (L.) cv. Great Lakes seedlings with concentrations of 0, 50, 100, 200, 400, 800 and 1200 μM . In general, the results showed a higher inhibitory effect on *Arabidopsis* than on *Lactuca* growth. Rosmarinic treatment caused a strong effect on the root growth of *Arabidopsis* with a low IC_{50} of 175 μM .

The root structure, thickness and presence of root hairs in *Arabidopsis* roots were studied under a magnifier. Rosmarinic-treated roots showed a strong tissue disorganization, which resulted in necrotic areas. Ultra-structural analysis (by electron microscopy; TEM) of rosmarinic-treated roots showed higher bigger intercellular spaces and increased secretion of Golgi complexes, which could be the consequence of detoxification processes. As well, rosmarinic treatment resulted in an increased number of vacuoles and broken and condensed mitochondria, which could be related to energy deficit conditions. Measurements of mitochondrial membrane potential with JC-1 fluorochrome (confocal microscopy) confirmed the energy deficit signals. The necrotic areas, confirmed by Trypan Blue staining, together with the decrease of mitochondrial membrane potential suggest that cell death processes are present in rosmarinic treated-roots.³ The strong root growth inhibition, the changes at cellular level and the cell death processes confirmed the strong phytotoxicity of rosmarinic acid, a promising candidate for weed management.

Keywords: *rosmarinic acid, Arabidopsis thaliana, phytotoxicity, energy deficit, cell death*

Dynamic of release of allelochemicals from *Eucalyptus globulus* leaves incorporated into the soil and their potential phytotoxicity for weed control

Carolina G. Puig¹, Paula B. Andrade², Manuel J. Reigosa¹ and Nuria Pedrol¹

¹Department of Plant Biology and Soil Science, laboratory of Plant Ecophysiology, University of Vigo. Campus Lagoas-Marcosende, 36310-Vigo, Spain; e-mail: cgpuig@uvigo.es

²REQUIMTE/laboratory of Pharmacognosy, Department of Chemistry, University of Porto, 4050-313 Porto, Portugal; e-mail: pandrade@ff.up.pt

In order to minimize the reliance of chemical herbicides for a sustainable agriculture, alternatives strategies based on natural products, such as the use of allelopathic plants as cover crops or applied to the soil as green manure for weed control, have been reported. It is well known the allelopathic nature of *Eucalyptus globulus* Labill., its herbicidal activity and its chemical composition, especially of the essential oil. But studies on the use of eucalyptus leaves incorporated into the soil as green manure for weed control in sustainable agriculture are very recent in literature (Puig *et al.* 2013). Based on the temporal phytotoxic effects of eucalyptus leaves observed on the germination and growth of *Amaranthus retroflexus* L. and *Echinochloa crus-galli* (L.) P. Beauv., high-performance liquid chromatography coupled with diode array detection was performed to identify and quantify the phenolic composition of eucalyptus leaves incorporated into the soil throughout time.

Phytochemical analysis showed the presence of polyphenols such as flavonoids (hyperoside and rutin) and phenolic acids (chlorogenic acid and ellagic acid) in eucalyptus leaves. The phenolic quantification of leaf litter along time showed a continuous reduction of each compound concentration, according to the phytotoxic effects observed on weeds. The continuous release of allelochemical compounds from leaves may be partially responsible for the observed phytotoxic activity, which could explain the durability of the bioherbicide effect of *E. globulus* green manure.

Keywords: *Tasmanian blue-gum, phenolic compounds, phytotoxicity, weed control, sustainable agriculture*

Allelopathic potential of *Mentha suaveolens*: Volatile Bioassay

Carolina G. Puig, Manuel J. Reigosa and Nuria Pedrol

Department of Plant Biology and Soil Science, laboratory of Plant Ecophysiology, University of Vigo. Campus Lagoas-Marcosende, 36310-Vigo, Spain; e-mail: cgpuig@uvigo.es

Mentha is a genus of the Labiatae family, which is known to produce large quantities of volatile compounds. Essential oils have been studied for their chemical composition and biological activities. At the present work, the potential herbicidal activity of the volatile compounds released from *M. suaveolens* Ehrh. aerial parts was studied for the first time. Different amounts of freshly-harvested leaves and flowers were evaluated for herbicidal activity in a manner that only atmospheric contact was allowed between the test species and the mint tissues, following the methodology of Barney *et al.* (2005). The phytotoxic effects were tested on the germination and growth of *Lactuca sativa* L. and *Agrostis stolonifera* L. as dicot and monocot model target species, *Zea mays* L. as crop species, and *Amaranthus retroflexus* L. as one of its representative accompanying weeds. Results show that the volatile cocktail released from mint aerial tissues delayed the germination and reduced significantly the radicle length of lettuce. Although germination of weed species was not affected, growth was significantly inhibited by mint volatile cocktail. On the other hand, no effects on crop were observed. This selectivity and capability of controlling weeds without damaging the crop is a key factor when considering a potential herbicide for its use in the field. Our results indicate that *M. suaveolens* produce and release a cocktail of volatile compounds that could be used as natural herbicides for weed control.

Keywords: *mint, volatile compounds, phytotoxicity, weed control*



Phytotoxicity of the essential oil component Citral detected by chlorophyll *a* fluorescence imaging

Elisa Graña, Carla Díaz-Tielas, Adela M. Sánchez-Moreiras and Manuel J. Reigosa

Faculty of Biology, University of Vigo, Campus Lagoas-Marcosende s/n E-36310, Spain; e-mail: eli-grana@uvigo.es

Citral (3,7-dimethyl-2,6-octadienal) is a monoterpene commonly found as volatile component of essential oils in different aromatic plants. Although it has a demonstrated phytotoxic activity on seedling metabolism, nothing is known to date about its effects on adult plant metabolism.

In order to establish its phytotoxic potential, adult *Arabidopsis thaliana* plants were treated for 21 days (spraying or watering) with 0, 300, 600 and 1200 μM citral concentrations. Chlorophyll *a* fluorescence was monitored every 2 days for the 21 days of treatment and post-harvest analyses were done on the citral-treated and untreated leaves at the end of the treatment.

Clear morphological differences were observed among concentrations and among application ways. Results showed a decrease in effective PSII quantum yield for the two treatments, which was confirmed by an increase in $\phi(\text{NO})$ (quantum yield of non-regulated energy dissipation). Spraying treatment affected also F_v/F_m (maximal PSII quantum yield) and electron transport rate (ETR) in a very significant way, suggesting a damage at the antenna complex.

The results of photosynthetic activity, decrease of growth rate and pigment content and increase of total proteins suggests a general reduction of metabolism in citral watered-plants, while the results obtained for spraying could be suggesting more direct by-contact damage, likely causing alterations in the plant oxidative status.

In conclusion, citral appears as a promising plant growth regulator and a potential bioherbicide.

Keywords: *citral, weed control, chlorophyll a fluorescence, phytotoxicity*

Use of geese for weed control in orchards

Anaïs Lavigne¹ and Christian Lavigne²

¹FREDON, Croix Rivail, 97224 Ducos, Martinique; e-mail: a.lavigne@fredon972.fr

²CIRAD-CAEC, Petit-Morne, 97285 Le Lamentin, Martinique; e-mail: christian.lavigne@cirad.fr

Because of humid tropical conditions, weed control is a permanent concern in the outlay of a fruit producer in Martinique, in the French West Indies. The practice of chemical weed control is to date the cheapest, but the recurring use of herbicides in the orchards leads to soil erosion and water pollution. The aim of this experiment was to evaluate an association of geese with a productive orchard of guavas in order to control the weeds.

The system was installed on a plot of 1440 m² divided into four plots of 360 m². One plot was the control treatment and was mowed with a lawn mower. Seven geese grazed each of the other three plots, for one or two weeks. The experiment lasted five months. A legume cover crop (*Desmodium heterophyllum*) was installed one year before on the four plots. Biomass production was measured after each rotation on the grazed plot and every three weeks on the control plot. Pre- and post-grazing herbaceous layer heights were also measured.

The total biomass, along with the height of the herbaceous layer, remained stable on grazed plots during grazing. The need of controlling weeds has been half divided on grazed plots compared to the control plot.

Integration of grazing geese in perennial crops reduces the need for weed control. However, as geese are mainly true grasses feeders, the proportion of unpalatable species in the herbaceous layer may increase. In this case, other weed control methods should be combined.

Keywords: Martinique, weeds, perennials, integrated control, poultry, cover crops, agroforestry



Trans-cinnamaldehyde, a phenolic compound with phytotoxic activity

David López-González, Aitana Costas-Gil, Elisa Graña, Carla Díaz-Tielas, Ana Martínez-Peñalver, Manuel J Reigosa, Adela M Sánchez-Moreiras

Faculty of Biology University of Vigo, Campus Lagoas-Marcosende s/n, E-36310, Vigo, Spain;
email: davidlopez@uvigo.es

Trans-cinnamaldehyde is a phenolic compound which is naturally synthesized as secondary metabolite in species of the family Lauraceae, like *Cinnamomum osmophloeum* and *C. zeylanicum*. It is used as flavouring in foods and has demonstrated cytotoxic, fungicide and antimicrobial activities, but its phytotoxic activity was not deeply investigated.

Thereby, this work is aimed to establish the phytotoxic potential of this compound on the model species *Arabidopsis thaliana* (L.) Col-0 by treating *Arabidopsis* seedlings with different trans-cinnamaldehyde concentrations (from 0 to 1250 μM) to establish its phytotoxic potential. *Arabidopsis* root growth was highly affected by trans-cinnamaldehyde treatment showing a so low IC_{50} concentration of 46 μM , while the germination process was completely inhibited starting from 800 μM . Trans-cinnamaldehyde-treated roots showed increased number of root hairs, loosening of root dominance and a high proliferation with a batch of several roots, which made difficult to distinguish the main and the secondary roots. This high proliferation of roots could be due to an alteration in the auxins/cytokinins balance. Structural analysis by light and transmission electron microscopy of 5 and 10 days-old trans-cinnamaldehyde-treated *Arabidopsis* roots showed important disturbances compared to the control, as abnormal nucleus shape, fragmented chromatin and increased number of mitochondria, which could be related to programmed cell death processes.

Auxin quantification by ELISA, measurements of mitochondrial membrane potential with JC-1 and cell death staining with Trypan Blue were done in order to better know the effects and the mode of action of this secondary metabolite on plant metabolism.

The strong phytotoxicity of trans-cinnamaldehyde on *Arabidopsis* suggests the potential of this molecule for weed management.

Searching potential uses for the phytotoxicity of *Acacia dealbata* Link

**Paula Lorenzo¹, Jonatan Reborado², Luís Muñoz³, Luís González², Helena Freitas¹
and Susana Rodríguez-Echeverría¹**

¹Centre for Functional Ecology, Department of Life Sciences, University of Coimbra, 3000-455 Coimbra, Portugal; e-mail: paulalorenzo@uc.pt

²Departamento de Biología Vexetal e Ciencia do Solo, Universidade de Vigo, E-36310 Vigo, Spain

³Departamento de Química Orgánica, Universidade de Vigo, E-36310 Vigo, Spain

Many agrochemicals used for decades have been banned recently due to the development of herbicide-resistant weeds and impacts on human health and ecosystems. For this reason much attention is being focused on alternative, easily degradable and environmentally-friendly methodologies based on natural products. Allelopathy, the impact of one plant on another by releasing chemical compounds, can offer new tools for management of undesirable weeds in crops. *Acacia dealbata* is an invasive-perennial plant worldwide that showed allelopathic effects on neighborhood species in non-natives ranges. Leaves, the most abundant part of *A. dealbata*, are available through the year and could be greatly responsible for the allelopathic effect observed.

This work aims at studying the potential herbicidal activity of compounds obtained from *A. dealbata* leaves.

Chemicals of fresh leaves were extracted in methanol for ten weeks and sequentially fractionated with hexane, ethyl acetate and water. The dry fractions were re-dissolved in DMSO-MES. The phytotoxic effect of each fraction on the germination and seedling growth of *Lactuca sativa* was bioassayed at 0, 50, 100, 250 and 500 ppm.

Seed germination was not affected by any of the tested fractions. The radical growth of *L. sativa* was significantly stimulated by the compounds in the hexanic fraction and inhibited by chemicals in the aqueous fraction. Compounds present in ethyl acetate stimulated the radical growth at low concentrations but reduced it at high ones. Stem length was generally increased by all chemical fractions tested.

Although field experiments are necessary, our results show that hydrosoluble compounds from *A. dealbata* leaves might have a potential herbicidal activity.

Keywords: natural compounds, herbicidal activity, DMSO (Dimethyl sulfoxide), MES (2-[N-morpholino]ethanesulfonic acid)



Volatile profile of *Cytisus scoparius* and phytotoxic effects of isolated compounds on the germination of two weed species

María Pardo-Muras¹, Antonio L. Nogueira¹, Carlos M. F. Cavaleiro² and Nuria Pedrol¹

¹Department of Plant Biology and Soil Science, University of Vigo, 36310 Vigo, Spain;
e-mail: mpardomuras@uvigo.es

²Center for Pharmaceutical Studies, University of Coimbra, 3000-548 Coimbra,
Portugal

The intensive use of synthetic herbicides may threaten sustainable agricultural production and has resulted in serious environmental problems. So, other techniques based on natural products to control weeds are being developed, looking for safety for environment and human health. In the search of natural herbicides, in this study we determined the chemical composition of *Cytisus scoparius* (L.) Link and test its phytotoxic activity on the germination of two weed species.

The chemical composition of the volatile extract of *C. scoparius* (collected in SW Galicia) was analyzed by means of GC and GC-MS. Fourteen compounds were identified from the flower extract and ten from the extract of vegetative parts, representing more than 90 and 70 % of total extract, respectively.

We compared the phytotoxicity of eleven volatile compounds by estimating their effects on the seed germination of *Amaranthus retroflexus* and *Digitaria sanguinalis* under laboratory conditions. The results showed that most of the tested oxygenated monoterpenes significantly inhibited seed germination of the tested plants, whereas hydrocarbons did not.

Keywords: *Scotch broom, essential oil, GC-MS, redroot pigweed, large crabgrass, bioherbicide*

Allelopathic effect of Ecological Services providing Crops on weed control in organic vegetable systems

Testani, Elena¹; Ciaccia, Corrado¹; Campanelli, Gabriele²; Leteo, Fabrizio¹; Canali, Stefano¹; Tittarelli, Fabio¹ and Trinchera, Alessandra¹

¹Consiglio per la Ricerca e la sperimentazione in Agricoltura – CRA – RPS, Research Centre for the Soil-Plant System. via della Navicella 2-4 – 00184 Rome - Italy; e-mail: elena.testani@entecra.it

²Consiglio per la Ricerca e la Sperimentazione in Agricoltura – CRA-ORA, Research Unit for Vegetable Crops, via Salaria 1 – 63030 Monsampolo del Tronto (AP) - Italy

The allelopathic properties of some cover crops and their proper management could represent an important tool for weed control in agroecosystems. Several crops, better defined as Ecological Services providing Corps (ESC) for the different ecological benefits provided at field/farm level, demonstrate strong weed suppression ability, either by releasing allelochemicals from living plant parts or from decomposing residues.

In order to compare the effect of autumn-winter cereal ESCs (wheat, barley, spelt, rye and a mix of them) on weeds, a randomized block experiment was set up in the CRA-ORA organic farm (Monsampolo del Tronto - AP, Italy). The ESCs were flattened by a roller crimper in order to obtain a dead mulch layer slowly degrading. Weeds were monitored during the ESC living cycle and after flattening throughout total weed density and biomass samplings. Bioassay tests, performed with ESC leaf water extracts on seeds of a target plant (curly dock, seeds collected in field), were carried out in order to verify the allelopathic potential of the species in weed germination inhibition, under laboratory condition. Water extracts were also analyzed by DI-SPME/GC/MS for the identification of the principal active compounds.

Field and laboratory results were compared showing statistically significant differences in the ESC effect against weeds.

Keywords: *allelopathy, cover cop, bioassay, DI-SPME*

Effect of blue gum, silver wattle and common gum cistus extracts on seed germination and seedlings development of *Parietaria judaica* L.

Torres, L.¹; Díaz-Vizcaíno, E.A.¹; Rigueiro, A.²

^{1,2}Dpto. Botánica. Escuela Politécnica Superior. Universidad de Santiago de Compostela. España; e-mail: lucia.torres@usc.es, elvira.diaz@usc.es

²Dpto. Producción Vegetal. Escuela Politécnica Superior. Universidad de Santiago de Compostela. España; e-mail: antonio.rigueiro@usc.es

Blue gum (*Eucalyptus globulus* Labill.), silver wattle (*Acacia dealbata* Link) and common gum cistus (*Cistus ladanifer* L.) are species present in our environment which show allelopathic activity. These species have been selected to evaluate the effect of aqueous extracts of the three species, obtained by maceration, on germination and early development of parietaria (*Parietaria judaica* L.), a ruderal and parietal plant. A test was performed with four replicates of 25 seeds of *P. judaica* each, placed in Petri dishes (4 ml extract per replicate and control), under controlled environment conditions (16 h light at 22 °C; 8 h dark at 18°C) for one month. Daily germination percentage and length of five-day old seedlings were recorded. The effect of extracts on final germination percentage and length of seedlings was compared by ANOVA and *a posteriori* LSD test. The results show that inhibition of germination by extracts was very low (silver wattle and blue gum extracts) or low (common gum cistus extract). Five-day old seedlings growing on blue gum extract were very similar in length to those of control, whereas length of seedlings growing on silver wattle and common gum cistus extracts differed significantly from control. These initial results show little phytotoxic effect of the three extracts analyzed on *P. judaica* seed germination, and a noticeable effect of extracts of silver wattle and common gum cistus on seedling growth.

Keywords: bioherbicides, weed control, *Acacia dealbata*, *Cistus ladanifer*, *Eucalyptus globulus*

SESSION III: BIODIVERSITY IN ORGANIC AGRICULTURE

Biodiversity conservation in dry land cereal fields: Unravelling the effects of agricultural intensification in the Mediterranean region

F. Xavier Sans

Grup de Recerca Ecologia dels Sistemes Agrícoles. Universitat de Barcelona, Departament de Biologia Vegetal, Av. Diagonal 643, 08028 Barcelona; e-mail: fsans@ub.edu

The role of weeds in arable farming systems has been largely debated because of both their potential delivery of ecosystem goods and services and the competition between weeds and crops. Weeds are essentials in farmland biodiversity because they are at the basis of the food web of these systems. However, agricultural intensification, at the field and landscape scales, has caused a decrease in weed species richness and changes in species composition. In recent years the Agroecology research group at the University of Barcelona has conducted several studies to understand how both aspects of intensification affect diversity of dry land cereal fields in the Mediterranean region to prevent this loss of diversity and develop efficient management regimes.

Effects of agricultural intensification on plant diversity.

The review of several studies conducted by the research team shows that agricultural intensification negatively affects the abundance and richness of the flora and, in turn, the entire community of arthropods. The comparison of weed communities from the 50s to the present reflects the reduction of weed flora, especially characteristic and rare arable weeds that thrive almost exclusively in arable habitats and the decline in abundance of functional groups such as legumes and insect-pollinated species. The recent study of the abundance and frequency of characteristic and rare weed species in more than 300 crop edges of organic cereal fields denotes the delicate status of these weeds, which are very scarce even in those areas found to be a more appropriate habitat for them. Results suggest that policies reinforcing some specific practices (e.g. autumn-sown cereal crops, periodic soil disturbances and low-input fertilisation - i.e. no slurry fertilisation use-) should be considered to reinforce populations of characteristic arable species and to palliate the decline of the rare arable ones.

The comparison of plant diversity at the centre, edges and boundaries between cereal fields that differ in farming intensity (i.e., conventional and organic farming systems) distributed in 15 localities differing in landscape complexity of the Central Catalonia (NE of Iberian Peninsula) shows that both scales of agricultural intensification have a similar negative effect on the total plant species and characteristic arable weed richness, and they also affect plant assemblages. Thus, the relative importance of farming intensity and landscape varies depending on the location within the field, which can be

attributed to differences in the agricultural impact and limited seed dispersal from adjacent habitats. Management is the main factor in explaining differences among field centres, whereas changes at boundaries are mainly due to landscape characteristics, and at edges both factors are relevant.

Implications of the conservation of arable weeds.

To preserve agricultural plant diversity it is equally important to prevent agricultural intensification at the field and landscape scales. At the landscape scale, policies should limit the reduction and simplification of field margins while promoting recovery of natural habitats. To preserve the diversity of field margins it is important to limit negative management actions, such as direct removal of boundaries or herbicide spraying, as well as to prevent indirect effects of farming in the cropped field. In this context, the promotion of low-intensity farming practices or appropriate Agri-environment schemes would be effective measures in Mediterranean farmland.

At the field scale, policies enhancing low-intensity management techniques, such as organic farming, are the main ways to promote diversity in the fields and will be equally beneficial in simple and complex landscapes. However, the weed seed bank must be managed properly to avoid large infestations that may affect negatively crop yields. In this regard, the analysis of the effects of specific management practices on weed diversity highlights the importance of cleaning crop seeds properly to reduce the seed bank size and using complex rotations, especially as this tends to conserve species richness while reducing seed abundance. The goal should not be the complete removal of the weed flora, as it is a key element of biodiversity in farmland, but look for alternatives to the use of herbicides that maintain populations of weed species, especially the more competitive, below the thresholds of infestation to limit crop–weed competition but maintaining plant diversity. Several experiments analysing the effects of weed control practices on weed flora and crop yield in the centre and edges of organic and conventional cereal fields show that weed harrowing is an effective weed control method in organic cereal fields, which prevents weeds from being a limiting factor of crop productivity in organic cereal fields. A similar trend was observed by using herbicides in conventional fields. However, herbicides diminished weed species richness and changed the species composition, whereas harrowing allowed the maintenance of high levels of weed diversity in the organic fields.

To maintain diversity within agricultural areas, it is also important to reduce the farming intensity at the crop edges, which would favour characteristic arable weeds and margins' overall plant diversity. Hence, several schemes in which farmers receive compensation to modify their farming practices have been promoted across Europe with the goal of maintaining and restoring farmland biodiversity. Many of these conservation programmes focus on crop edges, that is, the first few metres of cultivated area adjacent to the uncultivated boundary.

Accordingly, Agri-environment schemes limiting the intensity of management (prohibiting the use of pesticides and/or fertilizers) at the edges become crucial to preserving them.

Keywords: *agricultural intensification, arable weeds, crop edges, field boundaries, landscape, organic farming*

Reducing sowing density for conservation of rare arable species at crop edges

Laura Armengot, Laura José-María, F. Xavier Sans

Universitat de Barcelona, Departament de Biologia Vegetal, Av. Diagonal 643, 08028
Barcelona; e-mail: larmengot@ub.edu

Organic farming should contribute to biodiversity conservation. However, organic farming *per se* is not sufficient to counteract the critical conservation status of many arable weeds and thus new management strategies should be implemented. In this study, we tested the effect of the fertilisation and the sowing density on the growth of three rare arable species (*Agrostemma githago*, *Vaccaria pyramidata* and *Centaurea cyanus*), but also on crop yields.

In an organically managed field, four 3 m × 18 m blocks were delimited along one crop edge. Blocks were split in four 3 m × 3 m plots. Two of them were fertilised with composted manure whereas the other two remained unfertilised. Within each fertilisation level, one plot was sowed with barley at the normal sowing density (220 kg ha⁻¹), whereas the other was sowed with the half rate. In each plot, seeds were sowed to obtain 16 individuals of each rare species. Their biomass and the biomass of the crop were measured before harvest in each plot.

Overall, the results showed an increase in the biomass of the three rare species in plots with reduced sowing density. However, no effect of the fertilisation was found, but for the exception of *A. githago*, with higher grow in fertilised plots. Fertilisation also increased crop yields.

Thus, reducing the sowing density at crop edges may help to maintain populations of rare species. However, it is not necessary to limit the fertilisation, since it does not affect weed species but benefits the crop production.

Keywords: *fertilisation rate, Agrostemma githago, Vaccaria pyramidata, Centaurea cyanus, crop yields*

Modeling rotations including temporary grasslands using the FlorSys model

Doisy D.^{1,2}, Colbach N.³, Roger-Estrade J.^{2,1} and Médiène S.^{2,1}

¹INRA, UMR211 Agronomie, F-78850 Thiverval-Grignon, France; e-mail:
Diana.Zafrani@grignon.inra.fr

²AgroParisTech, UMR211 Agronomie, F-78850 Thiverval-Grignon, France

³INRA, UMR1347 Agroécologie, EcolDur, BP 86510, F-21000 Dijon, France

Insertion of temporary grasslands to diversify the rotation could represent an agro-ecological way for weeds management, especially in biological systems. Initially used to predict the effects of cropping systems on the weed community dynamics in annual crops (Colbach *et al.* 2014, Gardarin *et al.* 2012), the multispecies model FlorSys could be used to simulate low input systems including temporary grasslands. The aim of this work is to parameterize the existing model FlorSys to consider the effect of a permanent cover (such as a grassland) in order to simulate the effect of low input cropping systems including temporary grasslands and investigate its impact on weed community changes and management.

We assumed that weed seed interception by the grass cover contribute to reduce the seed bank replenishment. Based on a weed seed rain simulation in controlled conditions, we measured this seed interception rate according to grass cover height and seed traits (Doisy *et al.*, 2013). Then we developed and integrated a new sub model, named "interception model", into the FlorSys model to adapt it to temporary grassland in arable crop rotations. The comparison of the results obtained from the model with and without the sub model lead us to estimate the impact of the interception process. To analyze the sensitivity of the modified model we simulated a six-year-old managed grassland.

Finally, to evaluate the final FlorSys model, we will compare the model simulations with the observations of weed dynamics in the long-term experiment SOERE-ACBB (Observatory and Experimental System for Environmental Research - Agroecosystems, Biogeochemical Cycles, and Biodiversity) at the INRA research centre of Lusignan.

Keywords: *crop rotation, temporary grasslands, modeling, FlorSys, weed community dynamics*

Weed seed bank dynamic in rotation including temporary grasslands

Doisy D.^{1,2}, Roger-Estrade J.², Gosme M.¹, Charrier X.³, and Médiène S.²

¹ INRA, UMR211 Agronomy, F-78850 Thiverval-Grignon, France; email:
Diana.Zafrani@grignon.inra.fr

² AgroParisTech, UMR 211 Agronomy, F-78850 Thiverval-Grignon, France

³ INRA, UEFE, France

Diversifying the crop rotation by temporary grasslands represent an agro-ecological way to manage weeds especially in biological systems where alternatives to chemical control are limited. Weed population management also need a better understand of the seed bank dynamic which represent a potential source of weeds (Bellinder *et al.* 2004). The aim of this work is to analyze the weed seed bank dynamic according to different rotation which including temporary grassland.

The analyze was conducted in the long-term experiment SOERE-ACBB (Observatory and Experimental System for Environmental Research - Agroecosystems, Biogeochemical Cycles, and Biodiversity) at the INRA research centre of Lusignan in western France (Lemaire *et al.*, 2005). This experimental set up allows to compare three rotations (i) a crop rotation maize/wheat/barley (ii) a crop rotation including three years of grassland and (iii) a 6-year-old grassland. To characterize the diversity of the weed communities we calculated four indexes (i) seed abundance (number of seeds/m²) (ii) species richness (number of species/m²), (iii) the diversity index of Shannon-Weaver, and (iv) Pielou evenness index.

In this study we highlighted a change in the structure of the weed seed bank communities following the insertion of temporary grassland (in terms of abundance and species composition) with an effect of the duration of the prairie. A three to six years grassland have a similar effect on weed abundance than crops using herbicides.

The next step is to analyze changes in species composition of the seed bank and to determine which functional traits are involved.

Keywords: *crop rotation, temporary grasslands, seed bank, weed community dynamics*



Cover crops alter the dynamics of weeds in no-tillage organic system

Steliane Pereira Coelho; Luis Paulo Lelis Pereira, Emerson Trogello, Silvane de Almeida Campos and João Carlos Cardoso Galvão

Universidade Federal de Viçosa, Brazil; e-mail: steagroecologia@yahoo.com.br; luis.pereira@ufv.br; etrogello@yahoo.com.br; silvanecampos@yahoo.com.br; jgalvao@ufv.br

The knowledge of the modification of weeds over time is important to define more efficient management in organic production. Since the population of weeds changes according the management and the use of cover crops in no-tillage organic modifies the dynamics of weeds, the aim of this work was to study the dynamics of weeds in no-tillage organic corn in different winter cover crops in two cropping systems. The experimental design was a randomized block factorial (5 x 2) scheme with four replicates, totaling 40 experimental units. The treatments were composed of five covers (recommended bulk-seeded, UFV bulk, black oat, sunflower and control) and two cropping systems (single and intercropped maize with *Canavalia ensiformis*). The bulk system were composed of seven crops: oat, maize, sorghum, sunflower, soybean, pigeon pea and pig bean, differing only in the amount of seed used. It was evaluated the relative frequency, relative dominance and relative importance of the weeds in physiological stages V2, V5 and maize flowering. The *Corcovadensis phyllanthus*, *Digitaria sanguinalis* and *Cyperus rotundus* species showed the highest frequency in the area. The culture system did not affect the dynamics of the weeds. The *Cyperus rotundus* specie showed higher relative importance among all the treatments. Oat and UFV bulk cover crops provided an efficient control over *Digitaria sanguinalis* and *Phyllanthus corcovadensis*. *Cyperus rotundus* showed the highest level of difficulty to control in no-tillage organic corn system.

Keywords: *phytosociology of weeds, organic agriculture, corn, cover crops*

SESSION IV: ORGANIC AGRICULTURE GENERAL

Organic rice farming increasing soil carbon stocks and nitrogen mineralization potentials in Japanese Andosols

Weiguo Cheng¹, Valensi Kauysar¹, Keitaro Tawaraya¹, Kazunobu Toriyama² and Kazuhiko Kobayashi³

¹Faculty of Agriculture, Yamagata University, Japan; e-mail: cheng@tds1.tr.yamagata-u.ac.jp

²Japan International Research Center for Agricultural Sciences, Japan

³Graduate School of Agricultural and Life Sciences, The University of Tokyo, Japan

Soils contain nearly 3 times the amount of carbon (C) as the atmosphere and about 2 times as terrestrial plant biomass and the ratios of soil organic C (SOC) and total nitrogen (TN) in rice paddies are stable. Increasing soil organic matter (both SOC and TN) not only helps to mitigate climate change, but also improves soil N fertility for crop growth. Some results showed organic farming enhanced top soil carbon stocks under in uplands, but no any report from submerged rice paddies. For understanding whether and how long organic rice farming affected SOC stocks and N fertilities in submerged rice paddies, we investigated an organic rice farmer fields in Japanese Andosols, located in Tochigi Prefecture Japan.

Soil samples were taken from the fields after rice harvested on October 2013. The fields were divided into 4 treatments based on the years after organic farming, which are conventional (0 years), organic 4~5 years, 8~9 years and 12 years. The soil samples were divided to 2 layers of 0-15 cm and 15-20 cm depth. Anaerobic incubation was performed for 2, 4, 6 and 8 weeks and 30 °C to measure decomposed C (CO₂ and CH₄ productions) and mineralized N.

The results showed that SOC and TN on topsoil increased 13.8% and 15.6% respectively, after 12 years of application organic farming. The decomposed C and mineralized N on topsoil significantly increased by 23.9% and 24.7% after 8~9 years organic farming. In contrast, on subsoil there is no significant difference between conventional and organic paddy fields. The percentages of decomposed C to SOC and mineralized N to TN were increased with the organic farming years. These results indicated that organic rice farming increasing both soil C and N stocks, and simultaneously increasing C decomposition N mineralization potentials with the years of organic practice.

Keywords: *andosols, mineralized N, organic farming, rice paddy, SOC*

Utilization of fish manure vermicompost in soil restoration

E.F. Covelo¹ and P. Marcet²

¹Departamento de Bioloxía Vexetal e Ciencia do Solo. Facultade de Bioloxía. Universidade de Vigo, Spain; e-mail: emmaf@uvigo.es

²Departamento de Bioloxía Vexetal e Ciencia do Solo. Facultade de Enxeñaría Forestal. Universidade de Vigo, Spain; e-mail: marcet@uvigo.es

It is well known that the fish wastes have been used as organic fertilizer and nutrients for both agricultural purposes and for rehabilitation of degraded areas. Vermicompost made from sludge from biofilter could provide an effective source of nutrient-rich organic matter. The aim of this work is to evaluate the influence of addition of a fish manure vermicompost (FV) in the degraded soil properties and its comparison with a commercial vermicompost (CV).

Two different processes were employed: composting (pile system) and vermicomposting (boxes). Composting requires bulking agents. Selected waste mixtures – *Ulex europaeus* + fish manure were composted during four months. At the end of this process *Eisenia andrei* and *E. fetida*, were added and the aerobic treated compost were vermicomposted for two months.

Degradated soil was sampled from Santa Mariña de Xeve (Pontevedra, Spain). Vermicomposted fish manure was applied at a rate of 40 Mg ha⁻¹. Samples of the mixtures were placed in 3 kg plastic pots and incubated aerobically at 25°C, 20% soil moisture for 90 days. At each sampling date (0, 15, 30, 45, 60, 90 days), three replicates of control and amended soils (with FV and CV) were randomly selected for pH, organic matter, inorganic N, and total N. Fish manure vermicompost application increased the organic matter content and inorganic-N of degraded soils. The results suggest that fish manure vermicompost have a potential use as fertilizers in soils, which could reduce the direct risks of water pollution from the fish farming industry.

Keywords: fish manure, vermicompost, soil reclamation

Emergy analysis of production systems for conventional and agroecological Southeastern Brazil caffeine

Fernandes, Alessandra Furtado¹; Freitas, Helena Maria de Oliveira² and Moreira, Bruno Ricardo Jesus³

¹Centro de Ecologia Funcional/ Departamento de Ciências da Vida/ Faculdade de Ciências e Tecnologia/ Universidade de Coimbra P.O. Box 3046, 3001-401 Coimbra, Portugal; e-mail: alessandra.fernandes@ifsudestemg.edu.br

²Prof^a. Catedrática da Faculdade de Ciências e Tecnologia da Universidade de Coimbra

³Faculdade de Ciências e Tecnologia da Universidade de Coimbra

The agrarian question in Brazil is a subject of great relevance in the context of political, economic, social and environmental affairs. The object of this study, coffee, represents a worldwide market in monetary value surpassed only by oil. Brazil is the world's largest producer for more than 150 years, and Minas Gerais is the most concentrated area in production (98.3%). Currently, coffee agribusiness involves directly and indirectly, approximately 10 million people in a chain that goes from farm to cup. The Brazilian domestic consumption of coffee is growing every year, and 9 out of 10 Brazilians over 15 years old consume coffee daily. However, coffee cultivation is the third in the nation and receives large amounts of pesticides which is second only to corn and soybeans. In addition, the coffee utilizes too much manpower which exposes workers to these pesticides. In this study, we applied quantitative methodology of energy evaluation in conventional production and agroecological (organic agriculture) of coffee, specifically in the region of Zona da Mata Mineira, in order to interpret, analyze, and compare the degree of sustainability of these systems. The results show that according to the energy analysis, the production model known as the traditional coffee growing agrochemical is less sustainable than organic production of coffee. Agroecology, where organic farming can be an environmental, social and economical alternative, is viable and essential to the construction of real sustainability because it ensures more permanent jobs, more profit to the producer, and the preservation of the environment.

Keywords: *coffee farming, agroecology, organic agriculture, emergy analysis, sustainability indicators*

Organic in Nepal

Ganesh Chalise, Bhart Bahadur Karki , Niraj Kumar Udash, Sunita Shrestha, Krishna Kumari Acharya, Anil Shrestha, Devendra Bahadur Chhetri and Sarita Pandit

Society of Rural Development Nepal, Kathmandu, Nepal; e-mail: sfrdnepal@gmail.com

In Nepal, organic farming seems to be more appropriate as it considers important aspects of sustainability. Agriculture is the most important sector for ensuring food security, alleviating poverty. It enables the conservation of natural resources on which present and future generations will be entirely dependent upon for their survival and well being. In the name of development, the environmental resources have been exploited beyond comprehension. Acid rain, deforestation, depletion, smog due to automobiles and discharge of industrial pollution, soil degradation, depletion of ozone layer and discharge of toxic wastage by industrial units into rivers and oceans are some environmental problematic issues. The intensive use of inorganic fertilizers and pesticides has driven for increased crop production.

In fact, increased fertilizers consumption is a good indicator of agricultural productivity, but depletion of soil fertility is commonly observed in soils. During the past few decades, the heavy use of chemical herbicides, pesticides and intensification of agricultural production has led to other harmful effects like nitrate in the ground water, contamination of food materials, eutrophication, stratospheric changes, etc. High agricultural inputs are unlikely to be sustainable for very long unless the inputs are correctly managed in terms of both their quality and quantity.

Agriecol, Spanish Research Network for Organic Food and Farming

F. Xavier Sans

Universitat de Barcelona, Departament de Biologia Vegetal, Av. Diagonal 643, 08028
Barcelona; e-mail: fsans@ub.edu

Agriecol is a scientific and technical network for research on organic food and farming. Agriecol aims to provide communication among research groups, companies and associations to enable them to identify and develop lines of research. The Agriecol network provides the framework and tools to enhance cooperation and optimise research efforts, as well as to disseminate knowledge and technology to the productive sector. Agriecol brings together 79 Spanish research groups and over 300 researchers. The research network is divided into 4 working groups (organic crop production systems, organic livestock production systems, organic food, and sustainability of organic systems) with several research lines within each. Each group has a coordinator and a person in charge for each of the lines of work (<http://www.agriecol.org>). In recent years, Agriecol has organised periodical meetings to discuss the needs of research and to stimulate collaboration among researchers. Agriecol also has coordinated the expressions of interest of research groups interested in participating in the Era-Net Core organic II. The Agriecol website provides updated information on research calls, conferences and seminars, and activities of the research groups. The website shows the links to the most important publications in the sector, as well as scientific papers related to organic food and farming. It also offers a list of links to documents on the European and national legislation on organic food and farming issues, and to other websites connected to organic food and agriculture. By using the search tools on the website, you can identify the research centers and activities and identify the key contacts.

Keywords: *spanish research network, organic food and farming stakeholders, research priorities, international cooperation, knowledge and technology innovation*

EPILOGUE

WHERE IS THE ORGANIC AGRICULTURE?

by **Mukundane. B. Albert***

*Planted among farmers
Moving in cargos of transporters
Sinking in composite turbulent water bodies
Defended by environmentalists
Hospitalized by non-government organizations
Where is the organic agriculture?*

*Is it at the alter
Sport kicked by sports personnel
Scrambled by land encroachers
Centered amidst mob justice
Accounted with financial statements
Where is the organic agriculture?*

*Is it established by public debates?
Inspected by extension workers
Managed in serious investments
Search lighted by planned professionals
Launched by the big honourables
Where is the organic agriculture?*

*Is it hidden in journalist records/equipments,
In education centers of higher learning and research,
Mushrooming in business units on the global world
In paddocks of rural/urban regions
Where is Organic agriculture?*

*Supermarkets of modern citizens
Decentralized units of environment and agriculture
In fragmented blocks of investments
In inherited lands of royal empires
Marginalized in hidden territories
Where is organic agriculture*

*Torn apart by degradation
Rebuilt by visionary leaders
Master minded by research units*

*Modernized by bio-technology
Kept in viable projects
Where is the organic agriculture?*

*Designed by Artists
Authorized by the force of nature
Valued like a food store
Memorized by routine activities
Protected like the environment
Where is the organic agriculture?*

WOH ORGANIC FARMING

by Mukundane. B. Albert*

*The challenger of poverty and disease
The nutritious meal provider
The government strategic implementer
Woh organic farming*

*The famine halter and checker of every family
The starvation intervener at all levels
The integrator of global strategies
Woh organic farming*

*The technologic booster of agricultural techniques
The facilitator of extension services
The continuous supplier of the food chain
The active campaigner against environment hazard
Woh organic farming*

*The action planner of food security
The investment booster of export development
The diversification link of food values
The generator of foreign exchange fund
Woh organic farming*

EPILOGUE

The modernizer of sustainable economy
The welfare hub for all creatures
The star performer of its members
The allocator of best resources
Woh organic farming

The sustainable unit of healthy food items
The income booster for rural populace
The institutional builder for emerging firms
The power house for women in development
Woh organic farming

*Mukundane. B. Albert (prophetic poet). Posted on April 2014.

National Organic Agriculture Movement of Uganda (NOGAMU)
P.O. Box 1340 Kampala-Uganda

Authors list

- Acharya, K. K. (Nepal).....p. 52
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