BOOK OF ABSTRACTS

Extracts: PREVENTIVE MEASURES

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The EU directives are currently oriented toward the concept of Sustainable Agriculture, requesting to consider all possible means to reduce the impact of pesticides on human health and on the environment and to consider. Several agricultural production systems advertise with labels their concepts and products, often with a strong “less pesticides” aspect. Most known examples are “Integrated production” IP and “biological (organic) production”. Consumers associate these labels with a more ecological production than label less products, with the bio label having the highest appreciation. Consumers (wherever affordable) can contribute therefor to a system of perceived ecological positive impact. The concept “S.A.” is centered on maintaining the production factors, environment and human/social system functioning. So the impact of any factor leading to degradation or depletion of resources or social strain has to be mitigated or substituted. The current increase of knowledge and technologies offers new possibilities and can be oriented to substitute factors little compatible with a S.A. The pesticide based disease and pest management are currently the most questioned production factors, having a high return rate if considered on the plot level, however not on a global level. The use of resistant cultivars has a high return rate on the ecological and economical side. However as the input costs for developing such cultivars can only be amortized through sale of seed or planting material and possibly an associated production factor (herbicide), only few species and traits are of interest to developers. So mostly it is left to the public hand to develop through breeding or/and genetic engineering disease/pest resistant plants. The beneficiaries (environment - consumers) are mostly unaware of the potential benefits and will therefore not actively contribute to the development and use of such products. Products obtained through genetic engineering have a great potential to contribute to sustainability as highly targeted amelioration are possible and can be done in a relative short time and low costs. But only under a holistic evaluation and holistic benefit/cost analysis, the public research sector will be charged to develop such plants. Ten years ago the first scab resistance (the same as used in classical apple breeding) gene originated from the wild Malus floribunda 821 was cloned and demonstrated to incite full scab resistance inserted into a Gala apple under the control of a 35S promoter. Since technology developed so that cisgenic (only genes & regulatory sequences from a crossable donor) scab resistant Gala trees were developed and are tested in field trials. Additional scab resistance and Fire blight resistance genes are described and functionality tested. The employment of such scab and Fire blight resistant cisgenic Gala (or any other cultivar) would be of relevant benefit to the environment, consumer and producers.
Tillage systems with tine or disc based cultivations and no inversion of the soil prior to crop establishment is the most common way of reducing tillage for arable cropping systems with small grain cereals, oilseed rape and maize in Europe. However, new regulations on pesticide use may hinder further expansion of non-inversion tillage systems. European agriculture is asked to become less dependent on pesticides and promote crop protection programmes based on integrated pest management (IPM) principles. Conventional non-inversion tillage systems rely entirely on the availability of glyphosate products, and herbicide consumption is mostly higher as compared to plough-based cropping systems. Annual grass weeds and cleavers often constitute the principal weed problems in non-inversion tillage systems in which crop rotations concurrently have very high proportions of winter cereals. There is a need to redesign cropping systems to allow for more diversification of the crop rotations to combat these weed problems with less herbicide input. Especially the inclusion of spring sown crops is an important component in this context but needs economic justification as the yield potential is usually lower than for winter cereals. Cover crops, stubble management strategies and tactics that strengthen crop growth relative to weed growth are also seen as important components in future IPM systems but their impact in non-inversion tillage systems needs validation. Direct mechanical weed control methods based on rotating weeding devices such as rotary hoes may become useful in reduced tillage systems where more crop residues and less workable soils are more prevalent but further development is needed for effective application. A new seeding technology based on GPS-technology that enables cross hoeing of row crops could mean a major step forward in omitting herbicide use in maize, sugar beets and many vegetables. Owing to the frequent use of glyphosate in reduced tillage systems, perennial weeds are not particularly problematic. However, results from organic cropping systems clearly reveal that desisting from glyphosate use inevitably leads to more problems with perennials, which need to be addressed in future research.
PARALLEL SESSION – ECOSYSTEM ENGINEERING AND ENVIRONMENTAL ASPECTS

OPTIMIZING ECOLOGICAL MECHANISMS OF PEST AND DISEASE CONTROL FOR SUSTAINABLE IMPROVEMENT OF AGROECOSYSTEM PRODUCTIVITY: MAJOR LESSONS DRAWN FROM CIRAD’S OMEGA3 PROJECT

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CIRAD’s Omega3 project, which operated from 2008–2012, aimed at (i) gaining knowledge on ecological pest and disease regulation processes that can be mobilized via plant species diversity (PSD) deployment in agroecosystems, as an alternative to conventional practices based on pesticide use, and (ii) generating tools and methods to design and evaluate innovative pest and disease-resilient cropping systems based on PSD. Some biological models (="pathosystems") representing a range of spatial scales of PSD deployment, across the pest/pathogen life history traits the most amenable to manipulation via by PSD (namely dispersal ability and host specificity), were selected, with a view to robustness and generality of expected results. At a metric scale, we studied the effects of sanitizing plants on soil borne white grubs and parasitic weed Striga affecting upland rice in Madagascar, and on tomato bacterial wilt (TBW) in Martinique. At the field level, we studied the luring effects of trap plants, combined (i) with barrier effects and conservation biological control on tomato fruitworms (TFW) and sap-feeding pests on vegetable crops in Martinique and Niger and, (ii) with a food attractant mixed with a biological insecticide on cucurbit fruit flies in Reunion. We also studied the effect on cocoa plant bugs and black pod rot (BPR) of intercropping cocoa trees with other perennial plants using different spatial designs in Cameroon. At the landscape scale, we studied the effects of the arrangement of various land uses on the incidence of coffee leaf rust (CLR) and the abundance of coffee berry borer (CBB) in Costa Rica. Our examples stressed the need for trade-offs to manage conflicts or exploit synergies in underlying PSD-based processes. For instance, against TBW or upland rice white grubs, the trade-off between high biomass production for indirect regulation via alteration of microbial communities vs low biomass production but direct regulation via biocidal/allelopathic effect. Or the trade-off between the prevention or encouragement of infestation of the main vegetable crop by early occurring/little damaging sap-feeding pests, in perspective with a positive or adverse effect on regulation of later occurring/highly damaging fruit pests (e.g. TFW), via top-down pathways. Or the trade-off to account for conflicting interactions between cocoa and plant bugs and BPR in relation with shade and natural enemies (entomopathogenic fungi and ants) on the one hand, and between CBB and CLR (and their
natural enemies) on coffee in relation with landscape fragmentation/connectivity, on the other hand. Specifically, a spatially-explicit individual-based model including three interacting modules was developed, to be used as a generic tool to improve our understanding of system functioning in our field-level case studies, by assessing relative attractiveness of the commercial vs trap crops, the spatiotemporal planting design of the crops, and the insect behavioural traits.
Considering how landscape structure impacts pest control has large relevance for development of effective IPM-programs. It has repeatedly been shown that complex landscapes host a higher abundance and diversity of natural enemies compared to simplified landscapes dominated by intensive agriculture. However, few studies have assessed how this affects the level and stability of biological control across landscapes, and ecological models, that can predict such relationships, are lacking. Aphids are major pests on cereal crops such as wheat and barley in Europe, and both generalist predators such as spiders and ground beetles and specialist enemies like parasitoids, hoverflies and ladybeetles are known to be important biological control agents in this system. First of all I will present an experiment in which we estimated how the level and spatial stability of biological control of cereal aphids varied with landscape complexity and crop rotation intensity using predator exclusion cages. We found that the average level of biological control increased with landscape complexity, but surprisingly, the spatial stability of biological control increased with increasing crop rotation intensity in the landscape. To provide a more mechanistic understanding of how different natural enemy taxa contribute to biological control of cereal aphids in different landscapes, we have constructed a semi-mechanistic model based on aphid population dynamics, predation rates and abundances of different natural enemy taxa in different landscapes. To parameterize the model we used literature reviews and analyses of our own data. This model maps biological control services across cereal fields in a Swedish agricultural region varying in landscape complexity. The model predicted that biological control would reduce crop damage by 45 – 70% and that the biological control effect would be higher in complex landscapes. The relative contribution of different predator taxa to biological control varied with landscape composition, but generalist predators collectively contributed with about 50% of the biological control effect in most landscapes. The model was able to predict a significant proportion of the biological control effect in the dataset available for validation. If this kind of ecological model is combined with similar models for other ecosystem services they may become powerful tools for designing multifunctional landscapes. Finally, landscape structure may have a large impact on the efficacy of local measures taken to enhance pest control. It has been hypothesized that such measures should have the largest effect in fields located in relatively simple landscapes, but be less effective in cleared landscapes lacking non-crop vegetation and in complex landscapes dominated by non-crop vegetation. In this presentation I will review the evidence for this hypothesis and exemplify with a study testing the impact of flower strips on biological control in different landscapes.
PARALLEL SESSION – ECOLOGICAL ENGINEERING AND ENVIRONMENTAL ASPECTS

EFFECTS OF GROUND COVER MANAGEMENT ON CARABID GROUND BEETLE POPULATIONS IN ORGANIC APPLE ORCHARDS IN THE UK

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To produce fruit more sustainably, integrated pest management (IPM) strategies can reduce pesticide use and thus pesticide residues in fruit. Using IPM in crop production often requires the use of predators and parasitoids to control pests. This can be achieved by enhancing the environment to attract and retain naturally occurring beneficial arthropod species, or in high value crops, such as soft fruit production, by releasing commercially produced predators and parasitoids when required. Much research has been done to develop strategies that enhance naturally occurring flying predators and parasitoids in orchards, for example the sowing of nectar and pollen producing plants or the use of attractive semiochemicals. However, the ground dwelling fauna in orchards has not been so extensively investigated. Carabids are the most abundant taxon caught in pitfall traps in apple orchards and many carabid species are generalist predators with the potential to contribute to biocontrol of pests that have a ground dwelling life stage such as codling moth (Cydia pomonella) and apple leaf midge (Dasineura mali). Earlier work at East Malling Research found that carabids were found more frequently in traps in particular types of vegetation, indicating that it may be possible to enhance numbers of these predators by manipulating vegetation in orchards. A replicated experiment was run over three years in an organic apple orchard at EMR to assess the effects of different ground cover management on carabids caught in pitfall traps within and outside the treated areas. Treatments were applied in the tree rows. Two plant species with different growth habits were sown; knapweed (Centaurea nigra) with an upright growth habit and clover (Trifolium pratense) with a spreading growth habit. These were compared with an organic mulch and bare soil. The type of ground cover used affected the total numbers of carabid beetles recorded. In general more carabids were caught in the tree rows than in the mulch or bare soil treatments. In general there was no overall effect of treatment on numbers of ground beetles caught in the grass alleys between the treated tree rows; effects of vegetation type were only detectable within the treatment plots.
PARALLEL SESSION – ECOLOGICAL ENGINEERING AND ENVIRONMENTAL ASPECTS

THE PROBLEM WITH CONSERVATION BIOLOGICAL CONTROL

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As an IPM tool, conservation biological control (CBC) seeks to suppress arthropod pests and the damage they cause by supporting endemic populations of their natural enemies. As with all attempts to manage natural populations, CBC suffers from an inherent lack of precision. This is accentuated because the majority of arthropods are unable to maintain viable populations within a cropped field so that the maintenance of diverse and abundant populations must be achieved beyond the field boundary. At these scales in particular, CBC strategies such as habitat manipulation tend to be non-specific approaches affecting extended communities of natural enemies, pests and other taxa. It follows from this that, to be effective, CBC should seek to combine a diverse regional 'pool' of abundant natural enemies combined with mechanisms to ensure the effective interactions (links) between these regional pools and pest regulation at the field scale. If true, this should be evident in the outcomes of previous CBC experiments. Therefore to test our proposition we first outline a consistent framework that places interventions, mechanisms, and outcomes within a multi-scalar view that captures the spatio-temporal and trophic complexity of CBC. Using the framework we have identified expectations of CBC strategies consistent with our proposition which, when framed as hypotheses, were tested using a meta-analysis of published studies. The results of this analysis were in part consistent with CBC framework set out. However, a particular feature of the analysis was the lack of studies in certain key areas against which our framework could be tested. For example tests of the population dynamic response to CBC are almost entirely absent from the existing literature; we are addressing this particular gap through the development of spatially explicit models capable of simulating the dynamics of pest populations across farmed landscapes but here we point towards the need for complimentary empirical studies. Other knowledge gaps are also discussed and the consequence of our findings for future CBC and IPM strategies considered.
The impact of companion planting on the abundance of lepidopteran pests on white cabbage

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Cruciferous plants are grown around the world while white cabbage (*Brassica oleracea* L. var. capitata) is one of the most cultivated cruciferous vegetable plants in temperate regions due to its high nutritional value. Insect pests of cabbage can cause severe economic damage; the most important ones belong to the order Lepidoptera, such as *Pieris brassicae* L., *P. rapae* L. (Pieridae), *Mamestra brassicae* L. (Noctuidae) and *Plutella xylostella* L. (Plutellidae). The aim of the study was to find out whether companion planting with *Anethum graveolens* L. will effectively decrease the abundance of lepidopteran pests on white cabbage and therefore prevent the damage. Studies were carried out in an experimental field of the Estonian University of Life Sciences from 2010 to 2012. The experimental layout was a randomised block design with four replicates of two treatments: cabbage plants intercropped with companion plant and control plots. Each plot measured 2x5 m, and was planted with ten cabbage plants in two rows. On intercropped plots *A. graveolens* was sown between the cabbage rows, control plots were non-intercropped. The buffer zone between plots was one meter of bare soil around each plot. To determine the abundance of lepidopteran pests, all pests from all cabbage plants were inspected weekly and all specimens were counted. The years significantly influenced the mean number of larvae of cabbage pests per cabbage plant. The infestation level was high in 2010, up to five specimens per plant; low in 2011, only one specimen per plant and medium in 2012, when the mean number of larvae per plant was three. When the abundance of larvae was pooled over three years, companion planting effectively reduced the number of pests’ larvae on cabbage plants. However, no evidence was found that companion planting lowered the abundance of pests neither in 2010 when high pest abundance was recorded, nor in 2011 when only few larvae were found. At the same time, in 2012 intercropping with *A. graveolens* had a significant effect on the abundance of pests, less lepidopteran larvae were found from plots planted with *A. graveolens*. The effect of companion planting was affected by the abundance of pests; in the year of high pest numbers all plants, even the less suitable ones, were infested whereas in the year with low number of pests, the abundance stayed low on both variants. As the mean number of larvae per plant was significantly diminished by intercropping over three years, it can be assumed that companion planting can only be effective if the population size of pests stays at a medium level.
PARALLEL SESSION – ECOLOGICAL ENGINEERING AND ENVIRONMENTAL ASPECTS

EFFECTS OF NITROGEN FERTILIZATION ON INSECT PESTS, THEIR PARASITOIDS, PLANT DISEASES AND VOLATILE ORGANIC COMPOUNDS IN BRASSICA NAPUS

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Nitrogen (N) availability is a key factor influencing the yield of Brassica napus L. Thus, mineral fertilization is widely used to improve the quality and quantity of seeds. In this study, we conducted field experiments to determine the impact of nitrogen fertilization on B. napus pests, their parasitoids and plant diseases. The field studies were conducted with seven different N-fertilizer levels: 0, 60, 80, 100, 120, 140 and 160 kg of N per hectare in 10 m² randomized replicate plots of winter oilseed rape. Abundance of Meligethes aeneus Fab. (Coleoptera: Nititulidae) larvae and its’ parasitoids were determined by dissecting flowers and second instar larvae, respectively. The occurrence of Ceutorchynchus obstrictus Marsh. (Coleoptera: Curculionidae) and its parasitism rate were determined by counting damaged pods and emerged parasitoids or their remains from pods. Plant disease assessments were carried out visually at the mature pod stage (BBCH 80–85), the abundance of Alternaria brassicae (Berk.) Sacc. lesions was rated on a qualitative scale from 0 to 6 (no disease; 5%; 10%; 20%; 30%; 50%; over 50%). The volatile organic compounds measurements were carried out using multichamber cuvette system for collecting and Shimadzu TD20 automated cartridge desorber combined with Shimadzu 2010 plus GC MS instrument for analysing. The compounds were identified by comparing their mass spectra with a NIST library (National Institute of Standards and Technology) and with authentic standards. The results showed that N treatment had an impact on the abundance of M. aeneus and C. obstrictus as well as A. brassicae. Since pest abundance was not correlated with the flower and silique numbers, the feeding and oviposition sites, plant smell bouquets were analysed to determine potentially attractive or repellent volatile organic compounds. We detected 19 different compounds among which acetic acid and several lipoxygenase pathway products were emitted at higher levels from N-treated plants. Emission of a few other terpenoid compounds was correlated with the pest abundance in field conditions. Abundance of parasitoids of both pests was related to the host availability rather than to the fertilization treatment. Therefore, we suggest that plant chemical cues play a minor role in localization of hosts in close proximity to parasitoid. The levels of A. brassicae decreased with increasing N availability, possibly reflecting enhanced emissions of acetic acid, a known antifungal volatile. This study demonstrates the effects of N fertilization on bud and flower volatile bouquets, which might play a role in B. napus insect pest host selection and in resistance to fungal plant diseases. Further studies are necessary to investigate the behavioural responses of insects to the changed volatile bouquets.
PARALLEL SESSION – PEST AND DISEASE FORECASTING MODELS

ANALYSIS OF THE INFLUENCE OF SUNFLOWER CANOPY ON PHOMOPSIS HELIANTHI EPIDEMICS AS A FUNCTION OF CROPPING PRACTICES

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Phomopsis stem canker (Diaporthe helianthi Munt.-Cvet.) can cause drastic reductions in sunflower (Helianthus annuus L.) yield and oil content in the main areas of production. The influence of crop management on the incidence and severity of phomopsis stem canker have already been studied in field experiments. However, a more thorough study was required to analyse the effects of soil, crop status (including canopy development) and microclimate on the epidemics of this airborne pathogen, under the influence of cropping practices throughout a growing season. In a 2-year study (2010-2011), carried out in Toulouse (France), the effects of cropping practices (plant density, N fertilisation, and irrigation) and genotypic tolerance (susceptible to tolerant cultivars) on the epidemics of Diaporthe helianthi were monitored under conditions of reinforced inoculum. Data on inoculum, plant injury, microclimate, crop N status and canopy development were collected. Data on atmospheric ascospore concentration were used to assess the predictive quality of the Asphodel model regarding spore ejection. No statistically significant difference was found between observed and simulated values for both years over a three-day time range. In 2010, despite irrigation, the dry weather strongly limited the incidence of phomopsis on leaves. In 2011, two main waves of infection were observed: from mid-June to the beginning of July, and from the end of July to the beginning of August. For both years, the Nitrogen Nutrition Indices (NNI) were significantly different between N fertilisation treatments. Differences in NNI at anthesis due to plant density or water regime were not significant. For both years, the number of hours of high Relative Humidity (higher than 85%) within the canopy during vegetative growth, which are supposed to promote spore release and leaf infection, was positively related to maximum Leaf Area Index at anthesis. The development of disease injury was broken down into three stages: leaf infection, leaf-to-stem passage and girdling spots on stem. This enabled to analyse the effects of cropping practices on each of these stages in order to acquire knowledge for the prediction of Phomopsis stem canker severity on sunflower. The interpretation of results showed that: (i) the number of leaf symptoms was determined by the canopy microclimate, especially during vegetative stages, but that after flowering, green leaf tissues potentially available for leaf infection could be an additional limiting variable; (ii) the leaf-to-stem passage was determined by leaf length and senescence rate, either natural or induced by phoma black stem; (iii) the proportion of girdling symptoms on stems was related to stem diameter. This knowledge will help the design of crop management systems, reducing the risk of crop losses caused by phomopsis stem canker on sunflower.
Fruit and vegetables represent an important sector in the world agricultural industry. These commodities are subject to high qualitative and quantitative losses, from the field to the post-harvest period. Fungi are a particularly insidious group among contaminating agents since they can induce a significant product loss and also, many of them can synthesize different toxic secondary metabolites known as mycotoxins. This impairs the product quality and health characteristics. Post-harvest is a critical stage in the production of horticultural foodstuffs, in particular where storage facilities are limited and/or when long-term storage is applied. Until now the most common approach to extend the shelf life of these products has been the use of fungicides, but the growing concern about environmental protection and sustainable agriculture has led to take into consideration environment friendly crop protection strategies. Recent research shows interesting results related to the application of physical means like ozone (O₃) to prevent the growth of fungal contaminants and the production of mycotoxins on different types of fruit (apples, cherries, oranges). Moreover, O₃ treatment allows the degradation of some widely used pesticides like methylparathion, parathion and cypermethrin. In this study some apple varieties (Gala, Golden, Fuji) were challenged with a *Penicillium expansum* patulin producing isolate after being harvested and stored in cold rooms under O₃ (0.5 ppm) at 1°C±1. Every 15 days samples were collected to analyze the amount of Colony Forming Units (CFUs) and to check for the presence of the mycotoxin patulin; the activity of some Pathogenesis Related proteins (PRPs) was also evaluated. The results suggest that O₃ at the tested concentration significantly reduces the number of CFUs and patulin biosynthesis linked with *P. expansum* contamination during the post-harvest period. PRPs activity was not significantly altered by O₃; just some peroxidase or phenylalanine ammonia-lyase induction was reported in the first or in the last incubation period, respectively. The lack of PRPs involvement was very likely due to the length of the trial period, or we can alternatively assume that the enzymes studied are not involved in the apple response to ozone exposure. The results highlighted that ozone treatment can be useful to extend apple fruit shelf life and decay control with a view to applying environment friendly storage strategies.
Since the second half of the 19th century, Europe has to deal with a number of devastating diseases which almost caused disappearing of cultivated grapevine from the old Continent. Agricultural management (pest and fungal pathogens) and grafting on wild resistant rootstocks (Phylloxera) were adopted to control major diseases, and since the advent of more and more sophisticated chemicals, pests and pathogens have been successfully controlled, but with high environmental costs. Actually, European breeders tried for many decades to develop new varieties using the sexual compatibility between Vitis spp., both from American as well as Asiatic origin, carrying genetic resistances to the major diseases. In spite of their enormous efforts, those wild accessions were carrying also many low quality traits and undesirable aromas which caused their debacle. In the middle of the last century, hybrids were prohibited for cultivation and wine production in the major wine producing countries and only few middle European breeding institutes like Germans, Austrian, Hungarian and some Eastern countries continued on these attempts with low success rate. After a hundred years experiences, several backcrosses into V. vinifera background and improved knowledge, like the sequencing of the grapevine genome, grapevine breeding is facing a new deal of opportunities. Several new varieties, with no longer much traces of non-vinifera chromosomal DNA but with an interesting resistance level, mainly to powdery and downy mildews, reached the market in the North of the Alps and two of them have been registered to the National catalogues also in Italy, with a few more coming also in France. Tools for increasing success rate, based on the over hundred years of experience and molecular markers for resistance as well as quality traits, will guarantee future grape varieties (wine and table grape) with improved quality married with several natural resistances which will impact on a new grape orchard management, environmentally and economically more sustainable.
Whiteflies (*Bemisia tabaci* and *Trialeurodes vaporariorum*) are a major problem in tomato growing. They feed directly from phloem sap causing both direct (yield reduction) and indirect damage (virus transmission). Whiteflies are difficult to control with insecticides. Also, they develop resistance to the insecticides very quickly. To overcome these problems, the use of resistant varieties has been proposed as an effective alternative. Plant resistance can act at different stages of the insect’s life cycle, which may be based on different resistance mechanisms. We have carried out a broad screening for whitefly resistance in tomato wild relatives. All plants were phenotyped by non-choice insect assays, resulting in the identification of several interesting accessions. In the next phase we focused our efforts on mapping whitefly adult survival in a population derived from *S. galapagense*, and fine mapping of a QTL affecting oviposition rate which was derived from *S. habrochaites*. The analysis performed on the *S. galapagense* mapping population resulted in the identification of two QTLs affecting whitefly adult survival, a major QTL that confers full resistance when present in homozygote state and a minor QTL, which is effective when the first QTL is present in heterozygote state. Acyl sugars are the most likely compounds affecting the reduction in adult survival. The fine mapping of a QTL affecting oviposition rate, but not adult survival in *S. habrochaites* resulted in the identification of one introgression. By combining resistances based on different mechanisms it may be possible to develop tomato varieties with a durable resistance against whiteflies and possibly other insects as well.
Durable resistance to plant pathogens is highly desired but hard to achieve. In a modelling study, we explore the factors that promote or jeopardize durability of resistance. The purpose of the project is to derive strategies of host plant breeding and spatio-temporal plant genotype deployment that reduce as much as possible the rate of resistance breaking. In other words: the purpose is to manage evolution. We use a spatial implicit model to calculate the development of resistance breaking phenotype in the pathogen population to assess under which conditions pyramiding is the most durable solution. The host and pathogen interaction is modelled with gene for gene relationships governing compatibility. We assess the pros and cons of pyramiding and sequential use of resistance genes and how life history traits of the pathogen affect the most durable solution. The model will be applied to pathosystems of global importance, particularly yellow rust of wheat (*Triticum aestivum*), caused by the fungal pathogen *Puccinia striiformis* f. sp. tritici and Septoria leaf blotch, caused by *Mycosphaerella graminicola*. For both diseases, the development of durable resistance is of great importance. Model parameterization will be achieved by a combination of analysis of process-based information on pathogen life tables and analysis of historical patterns of pathotype dynamics (inverse modelling). The modelling results will be linked to field work in the PURE project that aims at the development of European farming systems that reduce the use of pesticides (http://www.pure-ipm.eu/project).
PARALLEL SESSION — BREEDING FOR RESISTANCE

NEW RESISTANCE-GENES DEPLOYMENT STRATEGIES AS NON CHEMICAL ALTERNATIVES FOR THE DURABLE MANAGEMENT OF ROOT-KNOT NEMATODES IN VEGETABLE CROPS ROTATION

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The current restrictions on the use of chemical nematicides have contributed to increase root-knot nematode (RKN) problems in horticultural crops. In this context, plant resistance appears as the most effective method of control, but the possible occurrence of virulent nematode populations able to reproduce on R-plants may constitute a severe threat to this control strategy. In Capsicum annuum, resistance to RKN is controlled by several linked dominant genes — the N and Me genes. To implement a rational management of the R-lines increasing the durability of the R-genes, we tested several R-gene deployment strategies. We focused our attention on 2 dominant R-genes, Me1 and Me3, originating from two genetically different pepper lines because i) they were effective against the main RKN species, including the most common species in tropical areas, ii) they were stable at high temperature, and iii) they direct different response patterns in root cells linked to the frequency of emergence of virulent nematode genotypes. Experiments were conducted in climate-controlled rooms, in greenhouses, and under 3-years-field agronomic conditions comparing i) the succession of the same R-gene every year, when introgressed in a resistant vs. a susceptible genetic background, ii) the alternance of single R-genes in rotation, iii) the mixture of genotypes bearing single R-genes sown in the same plot, and iv) the pyramiding of two R-genes in one genotype. At the plant level, we showed that i) the choice of the R-genes and the genetic backgrounds in which they are introgressed are important to lower the frequency of resistance breakdown, and ii) the pyramiding of two different R-genes in one genotype totally suppressed the emergence of virulent isolates. At the field and rotation level, we confirmed the previous results and showed that i/ alternating different R-genes in rotation was efficient to reduce the selection pressure of R-genes on the pathogens, and ii) to use of a good fertilization for R-plants is important to increase their "trap" effect and so to decrease the amount of pathogens in the soil, improving the soil health (reduction of parasite populations under their damage threshold). These results are in good agreement with concepts recently developed from the analysis of very different plant-pathogen interactions: pepper-virus, rapeseed-fungus, rice-bacteria. The RKN model studied, here, could thus contribute to generalize strategies for the breeding and management of R-cultivars strengthening and increasing the durability of qualitative resistances.

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POSTER

EVALUATION OF PLUM POX VIRUS SENSIBILITY ON DIFFERENT STONE-FRUIT VARIETIES IN EMILIA ROMAGNA REGION (ITALY)

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Sharka, caused by Plum pox virus (PPV), is a serious stone fruit disease easily transmitted by aphids and by vegetative multiplication. In Emilia Romagna some PPV foci are present yet, despite of compulsory controls and eradication of infected plants. The introduction and cultivation of less-sensitive varieties represent the only chance to maintain stone fruit industry in these places. For 8 years an experimental activity was addressed to evaluate long-established and new varieties from breeding activity, in order to individuate someone less susceptible, tolerant or partially resistant to PPV. During the years 2003 – 2012, 79 peach, 50 nectarine, 48 apricot and 28 plum varieties, grown in screen house, after chip budding inoculation with PPV M strain, were inspected to evaluate symptom expression on leaves, flowers and fruits. Few varieties, remained symptomless, were re-inoculated with the same PPV isolate and submitted to further observations and analysis for at least 3 years. Every year, in spring, leaves samples were collected from inoculated plants and appropriate analysis, based on serological (ELISA) and molecular (Real time PCR) tests were performed, in order to confirm the virus infection in symptomatic and non–symptomatic samples. A large number of inoculated plants of the tested varieties showed on leaves light chlorotic rings, and blotches, vein clearing and distortion in spring; almost all peach varieties with rosaceous flowers displayed colour breaking on petals. Some peach and apricot and few plum varieties respectively, showed evident fruit deformations with typical rings and mottling. Other peaches and nectarines have not shown fruit symptoms to date. In 2012, only 10 apricot, 1 peach and 1 plum varieties still showed no symptoms on both leaves and fruits and resulted negative at ELISA and Real time PCR assays. These experimental data evidenced high sensibility of stone fruit germplasm to PPV-M, and in particular of all traditional varieties, as well as new developed cultivars obtained in Italy or imported from other European countries. The few varieties that appear promising for PPV tolerance or resistance are mainly of apricot. These results have to be confirmed by field evaluation even if the information gathered in the Emilia-Romagna region by inspectors of the local Plant Protection Service, confirmed, for some varieties, the behaviour showed in screen-house.
HAS WHEAT GENETIC IMPROVEMENT DELIVERED REAL BENEFITS TO IPM IN EUROPE?

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Today wheat is the UK’s largest crop and constitutes almost half of the EU cereal production at 131.7 million tonnes. Domestication of wheat increased yields, but in the last 15 years those increases have slowed and we now face yield stagnation across the EU and in many parts of the world. This is partly because domestication has eroded wheat diversity. Research at NIAB is focusing on extending the bread wheat gene pool by understanding, exploiting and incorporating novel genetic diversity from wild and cultivated relatives of bread wheat.

UK Perspective on wheat performance. The period from the 1940s to the 1990s saw exceptional growth in wheat yields in the UK. National average yields rose from 2.7 t/ha to 7.6 t/ha (1 t/ha per decade). From 1980 to 1996, wheat yields in the UK improved rapidly, by an average of 0.10 t/ha per year. Since then, yields have stagnated. This situation is reflected across the whole of Europe. In the UK efforts of the plant breeders have delivered yield increases of 0.05 t/ha per year through new varieties. This yield increase has not been transferred to on-farm yields. Fungicide-untreated yields remain stubbornly low. Average responses to fungicides in UK Recommended list trials are about 17% (1.5 t/ha). The UK Recommended List trialing system has attempted to improve disease resistance in UK varieties by introducing minimum standards for some diseases. This has prevented very susceptible varieties from being recommended and thus generally improved disease standards in the UK. However, the UK Recommended List of varieties is still dominated by very high yielding varieties which demand high fungicide inputs. Disease resistance is a major target for wheat breeders but so too are many other attributes including height, flowering time, straw stiffness, yield, maturity, specific weight, HFN, bread-making quality etc. These combined targets make wheat breeding very difficult indeed. It is likely that in the medium term, highly resistant varieties are likely to suffer a significant yield penalty.

Pesticide use. In the UK over the last 10 years there has been no reduction in the area of wheat treated with fungicides or the amount of fungicide applied. The UK Government have published their “UK Pesticides Strategy: A strategy for the sustainable use of plant protection products”. The policy encourages the introduction of cost-effective alternative approaches and greater use of integrated crop and pest management, which includes the use of disease-resistant varieties. However, it is clear that plant breeders are struggling to achieve the many demands on their breeding programmes and in the short to medium term, improvements in disease resistance are unlikely to have a significant impact on fungicide use. In the medium term, disease resistance is likely to continue to increase but yields may be penalised as a result.
CHARACTERIZATION OF RESISTANCE IN PEAR GENOTYPES TO PEAR PSYLLA CACOPSYLLA PYRI

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Most of the present P. communis breeding programmes in the world are aimed not only to upgrade fruit quality but to introduce resistance to the main diseases and pests, such as pear psylla. The resistant selections obtained from P. communis x P. ussuriensis crosses readily exhibited egg-laying non-preference, and high mortality to nymphs. The aim of the present study was to develop molecular and chemical markers linked to psylla resistance other than the tissue localization of mechanisms of resistance in pear resistant selection. Construction of a linkage map and molecular marker development: seedlings derived from the cross NY10353 x Doyenne du Comice have been replicated by grafting each seedling on quince and trials for phenotyping have been conducted in a tunnel. The following parameters have been evaluated as soon as the plants were available: number of adults and eggs per seedlings (antixenosis), number of nymphs and the honeydew production (antibiosis). By using the above described progeny the construction of a map frame based on microsatellites was started to identify the genomic locations of markers associated with psylla resistance. During the first year the DNA from each seedling and the parental lines have been extracted and a “Genome Scanning Approach” was used to identify genomic regions putatively involved in psylla resistance by using apple SSRs which are easily transferable from apple to pear. The analysis of the SSRs marker is still in progress on the resulting parental maps, and by merging molecular and phenotypic data already available it was possible to identify a major QTL for psylla resistance in linkage group 17 of the resistant parent. The molecular markers linked to psylla resistance developed in this project will be tested in the future for their application for MAS (marker assisted selection). A Candidate Gene Approach will be also started for identification and mapping of putative genes involved in psylla-pear interaction. Indications about putative genes involved in pear-psylla interaction in the resistant genotype NY10353 will be used to develop sequence-specific molecular markers. The mapping activity will be further implemented and all the polymorphic markers available will be mapped. Chemical analysis of compounds will be linked to psylla resistance. The activity to identify chemical compounds putatively involved in pear resistance will be investigated by HPLC in the resistant genotype NY10353 and susceptible cv. Doyenne du Comice and Bartlett. The plant penetration and feeding behavior of C. pyri on resistant genotype NY10353 will be determined by EPG system. These data will be employed for tissue localization of mechanisms of resistance in pear.
**POSTER**

**DO WE NEED TO WORRY ABOUT ASYMPTOMATIC INFECTION OF PATHOGENS?**

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Scald, *Rhynchosporium*, or leaf blotch of barley, caused by the fungus *Rhynchosporium commune*, can be of considerable importance to barley growers worldwide. It is the most serious disease on winter and spring barley in the UK, causing substantial losses nationally, despite expenditure of £50M per year on fungicides. The disease is difficult to control with fungicides and severe epidemics may appear suddenly. The sources of infection responsible for such epidemics are not well understood as in general we only have data on disease rather than the presence of the pathogen. However, the ready availability of molecular probes and quantitative PCR enable detection and quantification of pathogen DNA in barley plants in both pre-symptomatic phases of infection and where they remain asymptomatic throughout their life cycle. Seed-borne inoculum was identified as a significant source for early infection of barley crops, with substantial amounts of *R. commune* DNA found in seedlings of crops grown from infected seed. However, there was little evidence that severity of seed infection influenced amounts of pathogen DNA (leaves) or disease severity (leaves) or yield loss later in the cropping season. The discovery that *R. commune* can colonise barley crops extensively throughout the cropping season (from seed to seed) in the absence of visual symptoms has completely changed the understanding of the disease by industry with implications for the use of fungicides, breeding programmes and national variety recommended lists. Even when substantial early symptomless infection was identified in winter barley crops, epidemic severity late in the season was largely dependent on amount of spring rainfall that encouraged secondary disease spread by splash dispersal of pathogen spores. Therefore the PCR quantification of early *R. commune* infection could not be used to accurately predict epidemic severity late in the season. Similarly, early season PCR assessments of cultivar resistance could not be used to accurately predict resistance ratings based on late season disease assessments. Clearly whether fungal infections caused by species such as *R. commune* are symptomatic or not is determined by many complex factors and is dynamic. However, by using internal comparisons in mapping populations and disease nurseries, new sources of resistance to *R. commune* have been identified, molecular markers have been developed, and methods to screen material for resistance have been improved, all of which could considerably improve resistance sustainability in practice. In conjunction with a breeding company, KWS-UK, the genetic basis of several different components of resistance to *R. commune* in barley was investigated in a mapping population derived from a cross between winter and spring barley types. Both the severity of visual disease symptoms and amount of *R. commune* DNA in leaf tissues were assessed in field trials in Scotland in the 2007/2008 and 2008/2009 growing seasons. Relative expression of symptoms was defined as the residual values from a linear regression of amount of *R. commune* DNA against visual plot disease score at GS 50. Amount of *R. commune* DNA and...
visual disease score were highly correlated traits and identified nearly identical QTL. The genetic control of relative expression of symptoms was less clear. However, a QTL on chromosome 7H was identified as having a significant effect on the expression of visual disease symptoms relative to overall amount of R. commune colonisation. Clearly understanding the genetic basis of pathogen infection of plants is critical to decisions about control; for example whether it is likely to remain restricted, become symptomatic as adult plants, remain benign, be extensive but not damaging to yield, or be a reservoir of variability. Furthermore, these options do not consider interactions of other organisms that frequently form part of the disease complex in the field in practice.
In 2005 carpophores and rizhomorphs were collected in 40 forestall sites in Trentino region, they were isolated and identified by mating tests method. The results have demonstrated the presences of 5 different species of Armillaria (A. cepistipe, A. ostoyae, A. gallica, A. mellea and A. borealis) in the monitored area. One year later, Prodorutti et al. have identified in highbush blueberry (Vaccinium corymbosum) orchards only two species of this pathogen (A. gallica and A. mellea). Those works in forest and in field have confirmed that in Trentino region exist 5 species of Armillaria. The aim of these trials is to establish the potential aggressiveness of the five pathogens toward highbush blueberry plants (A. cepistipe, A. ostoyae, and A. borealis never observed on highbush blueberry). Two experiments were carried out, the first in vitro and the second in greenhouse. In laboratory the 5 species of Armillaria were grown in Petri dishes containing malt extract agar (MEA). Five repetitions for every different species of pathogen were made. The plates were incubated at 25°C and the growth of Armillaria was evaluated at 5, 10, 15 and 20 days. For the greenhouse trial, the 5 species of Armillaria were grown in Petri dishes containing MEA and sterilized apple tree shoots (7 mm diameter, 5 mm length). The plates were incubated at 25°C. After 21 days, 2-year-old highbush blueberry potted plants, variety Elliot, were infected by the apple tree shoots put into the grass, near the roots. Teen replications for every different species of pathogen were made. The pots were stored in the greenhouse and regularly irrigated. The manifestation of symptoms on plants was weekly observed during the entire season. The results obtained in vitro after 20 days of growth observation have evidenced an high aggressiveness of A. mellea, A. borealis and A. cepistipes. The development of the three pathogen were about 90 mm, but among all the theses we cannot observe significant differences (P<0.05). In the treatments with A. ostoyae and A. gallica the growth of pathogen was low, about 50 mm, without significant differences (P<0.05). In greenhouse the major number of symptomatic plants was monitored in the treatments inoculated with A. gallica (60%) and A. mellea (50%). The disease incidence of A. borealis was 20% and no plants inoculated with A. cepistipes and A. ostoyae were infected. This work demonstrates that among the 5 different species of Armillaria identified in Trentino, only A. gallica and A. mellea are potential pathogens in highbush blueberry orchards. A. ostoyae, A. cepistipes and A. borealis are three typical species of the forest and even if they are noticeable in the entire Trentino region, they do not attack highbush blueberry, though A. borealis has some potentiality.
BREEDING FOR CABBAGE WHITEFLY RESISTANCE IN *BRASSICA OLERACEA*

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The cabbage whitefly (*Aleyrodes proletella*) is a phloem-feeding insect that is becoming more and more of a problem in Western Europe. Especially Brussels sprouts, kale and Savoy cabbage can be heavily infested. Besides causing cosmetic damage, whiteflies excrete a sugary substance (honeydew) that allows the growth of sooty mould. Both types of damage reduce the marketability of the crop. The use of pesticides is hazardous to the environment and usually not very effective as whiteflies feed on the underside of leaves. Breeding for resistance would be a sustainable alternative. We have carried out a large resistance screening in the field. The screening included 434 accessions of crop wild relatives (CWR) and *Brassica* landraces (Pelgrom et al 2012). Several accessions of *B. oleracea* subsp. *capitata* were found to be resistant as well as some CWR, including *B. incana* and *B. villosa*. Previous studies have shown differences in the natural occurrence of adults, eggs, and nymphs on the closely related *B. oleracea* cultivars Christmas Drumhead and Rivera grown in the field (Broekgaarden et al 2010) also indicating that resistance is present in these heading cabbages. We aimed to identify the nature of these differences and to gain insight into the resistance mechanisms against *A. proletella*. We used no-choice experiments on field- and greenhouse-grown plants to show that the differences between the two cultivars are mainly based on antibiosis (traits that reduce herbivore performance) and not on antixenosis (traits that deter herbivory). This was further supported by laboratory choice experiments that indicated little or no discrimination between the two cultivars based on plant volatiles. We showed that resistance is dependent on plant age, that is, resistance increased during plant development, and is mainly independent of environmental factors. Analysis of probing behaviour revealed that the resistance trait affects *A. proletella* at the phloem level and that morphological differences between the two cultivars are most likely not involved. We hypothesize that compounds present in the phloem reduce sap ingestion by the whitefly and that this explains the observed resistance (Broekgaarden et al 2012).
POSTER
FUNGICIDE REDUCTION BY USING MILDEW RESISTANT GRAPE VARIETIES

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Downy mildew (Oomycota: *Plasmopara viticola*) and powdery mildew (Ascomycota: *Erysiphe necator*) are the pathogens in charge of most of the pesticide applications in viticulture. In Europe quality wine is made from European or “noble” varieties that are generally susceptible to these two diseases. Only since a few years new resistant varieties are available especially in Germany, Switzerland, Austria, and the Netherlands. Their potential for quality wine production can be high. As wine economy is one of the most conservative businesses, a lot of attention is on varieties, tradition and terroir. In some countries the new resistant varieties are still regarded as “hybrids”, a word which in a viticultural context is often associated with bad quality. With regard to the wine potential and by applying the O.I.V. criteria for *Vitis vinifera* - varieties they can be classified as “European varieties” or “noble varieties” in other countries. Here the authors present two projects about the possible reduction potential of plant protection products (here copper) in mildew resistant grape varieties, financed by the PURE-Project and the German BÖLN-Programm (German federal research programm for organic farming and other forms of sustainable agriculture), respectively. Reducing fungicides in resistant varieties can be equivalent with a shortening of the spraying season or with the extension of spraying intervals. Within the BÖLN project we followed the first and within PURE the second strategy. The trials were done in four adjacent organically managed vineyards, two of which with classical varieties and two with resistant varieties. As sulphur treatments in organic vineyards are considered as not problematic for the environment we focused on the reduction of copper. Copper is a heavy metal widely used in organic viticulture; as a drawback it shows a high aquatic toxicity that accumulates in the soil and can be toxic both for plants and grazing animals. Using a plot sprayer we sprayed up to nine different strategies in fourfold repetition each. Copper amounts were reduced in several degrees; in this way we wanted to learn about the number of essential applications per season. During the seasons 2011 and 2012 field observations were performed every week to observe the epidemiology of downy mildew. In late season one exact monitoring was carried out according to the EPPO standard PP 1/31(3). Both disease incidence and disease severity of leaves and clusters were calculated in each variant. For the estimation of severity we used ≤ 10%-intervals. Both years were characterized by a low disease pressure so that we could not find any berry attack by *Plasmopara*. In the two years disease severity on leaves in the untreated control plots ranged between 22 % and 25 % in the susceptible variety Pinot Noir and between 1% and 5 % in the resistant variety Calandro. Pinot Blanc and the resistant variety Regent were intermediate. That is the difference between Calandro and the “resistant” Regent was nearly as big as between Calandro and the susceptible Pinot Blanc. In effect, the resistant variety Calandro wouldn’t have needed any copper sprayings in both years under the local trial conditions. Regent on the other side needed a certain number of copper sprayings in 2012 to stay under a level of 5 % disease severity. Extending the application intervals by only spraying every second time was an acceptable strategy for both resistant varieties and Pinot Blanc but not for Pinot Noir in 2012. The relative
resistance of the varieties decreased as follows: Calandro > Regent > Pinot Blanc > Pinot Noir. For the reduction potential of fungicides other than copper against *Plasmopara viticola* probably the same alignment of the varieties is to be expected. The results are promising with regard to the reduction potential of resistant varieties for fungicides, but it should be kept in mind that this potential is as well correlated with the local and annual disease pressure. Both in 2011 and 2012 powdery mildew could be controlled sufficiently by sulphur applications.
EVALUATION OF RESISTANCE AGAINST FUSARIUM HEAD BLIGHT IN WHEAT VARIETIES

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Fusarium head blight (FHB) is caused by different fungi part of the genus Fusarium and Micodochium nivale. The disease can entail severe yield losses and the accumulation of different types of mycotoxins in the grains. Spores of the pathogens can infect the flowers under wet, especially rainy, conditions. Once established in the flower, the progression of the infection depends mainly on suitable climatic conditions and the resistance reaction of the plant. Wet and warm conditions promote the infection, while dryness or temperatures below 18°C slows it down. Wheat disposes of different types of resistance mechanisms able to impede primary infection of the spikelet (type 1) or the resistance against progression of the disease throughout the spike (type 2). Other resistance types influence the infection of the developing grains or the accumulation of mycotoxins therein. In the last years, several FHB epidemics have caused damage to wheat production in Europe and raised concerns about safety of food. Use of chemical fungicides having only a limited efficacy, control of the disease relays greatly on appropriate cultivation techniques to avoid infections and the use of resistant wheat varieties. The present work addresses the evaluation of the resistance against FHB in wheat varieties in the interplay between visible symptoms and accumulation of the mycotoxin deoxynivalenol (DON) in the kernels, climatic conditions and plant resistances. Several recent wheat varieties have been tested in two trial sites Nyon (canton Vaud, Western Switzerland) and Cadenazzo (canton Ticino, Southern Switzerland, South of the Alps) with artificial inoculation with high pathogenic strains of Fusarium culmorum during 4 years. Disease severity has been scored as symptoms on spike but also on grain as Fusarium damaged kernels (FDK), modification of kernel size and accumulation of DON. Correlations of symptom scorings with climatic parameters allow to better understand resistance reactions of plants and hence improve selection methods for breeding of resistant wheat varieties.
LOCAL AND LANDSCAPE EFFECTS ON THE FUNCTIONAL BIODIVERSITY IN MANGO ORCHARDS ON REUNION ISLAND

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Mango production, which is an important part of tropical areas’ economy, is at a phytosanitary and technical dead-end on Reunion Island. The use of chemical insecticides doesn’t limit the losses in economy, caused by harmful insects (Diptera, Heteroptera, Homoptera and Thysanoptera). The inefficiency of these energizing and chemical inputs, dictate plant protection evolution towards agro-ecological practices. One of them is to create habitats in crops, in order to promote diversity and abundance of pests’ natural enemies. Management of functional biodiversity requires the understanding of the ecological processes involved and the capacity to identify the factors governing predatory arthropod communities in agro-ecosystems. The integrative approach of this study is to characterize the richness and diversity of arthropod predators in mango orchards, depending on various factors: plant species richness in the crop, farming practices and landscape context. The study focuses on epigeal arthropod predators, which are involved in the cycle of several pest species, such as Cecidomyiidae and Tephritidae whose last instar is characterized by a fall to the ground, so as to achieve their pupal stage in the soil. Twenty-four plots were considered, divided into the mango production basins of Reunion Island. Characterization of the composition and properties (richness and diversity) of predatory arthropod communities was conducted by sampling, using pitfall traps. Vegetation adventitious inventory within the orchards permitted to quantify plant species richness. Plots were pooled (fuzzy partitioning) according to their agricultural practices and landscape context. The measures of 17 parameters, corresponding to the nature and frequency of the plant treatment, as well as the weed vegetation management, have identified four practices intensity regimes. The landscape has been mapped to a circle of 400 m radius around each plot; the 11 measured parameters, characterizing the landscape structure and heterogeneity, have distinguished three types of landscape contexts. Richness and evenness of predatory arthropod communities were correlated and compared to these three scales of factors. Trappings revealed that predator communities consisted mainly of ants (Hymenoptera: Formicinae) and of 11 spider families (Araneae). Analysis highlighted the fact that these communities had: (1) a diversity positively correlated with the richness of the vegetation, (2) a greater richness in more moderate cultural practices, (3) a species richness higher when landscape context is heterogeneous, with fragmented mango orchards. To our knowledge, this is the first simultaneous detection of local and landscape factors effects on terrestrial arthropod predators’ diversity in a tropical agro-ecosystem.
POSTER
EFFECT OF CULTIVATION AND CHEMICAL TREATMENT ON DIFFERENT GUILD OF ARTHROPODS IN GRASSLAND OF INNER MONGOLIA

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In grassland of Inner Mongolia, China, outbreak of pests is getting serious probably due to intensification of agricultural activities. The area of cropland has increased from 43,300 km² in 1949 to 76,300 km² in 2005. Pesticide application is a main method for pest management in grassland of Inner Mongolia. To clarify the influence of agricultural activities on characteristic of arthropod distribution under field condition using a combination of several covariates: pesticide application, landscape, climatic factors and plant type, which are commonly known as determinants of arthropod population. Sweep net samplings were conducted at 41 sites in natural grassland. Consequently, 1287 individuals belonging to 23 families and 9 orders of arthropods were collected. We grouped samples into 2 guild types, predators and herbivore. We analyzed six groups (grasshopper, herivory Coleoptera, herbivory Hemiptera, Cicadidae, Araneae, predatory Coleoptera) of them. We analyzed the relationship between sampled population size of each group and environmental factors by negative binomial regression analysis. The best model of each group was determined by Akaike’s Information Criteria. The result of negative binomial regression revealed that pesticide application, vegetation coverage, agricultural site and dominant plants were selected as parameters of the best model of grasshoppers showing positive relationship. In other words, more grasshoppers were sampled at sites where pesticide was applied, vegetation coverage was relatively high, agricultural site and dominant species was Cyperaceae or Asterales. Pesticide application and dominant plants were also selected as parameters for best model of Araneae, but these parameter values were negative. Additionally, the parameter of mean temperature is negative and the parameter of agricultural site is positive. It was implying that Araneae has a trend of occurrence at sites with low temperature, no pesticide applied, near to cropland site and dominant by neither Cyperaceae nor Asterales. Herbivory Coleoptera likely occurred at areas with lower temperature and near to cropland area. Predatory Coleoptera likely occurred at areas with taller vegetation. Herbivory Hemiptera except Cicadellidae usually occurred at sites with a taller and higher density of plants and far from cropland areas. Because the utilization of grassland of Inner Mongolia tends to be intensified, according to the result of this study, it will cause the increasing of population of grasshopper and decreasing of population of spider. Pesticide application as a traditional pest management strategy can lead to extinct of spider. Our results suggest that the current use of pesticides may not be effective for pest control and that alternative options should be considered in the grasslands of Inner Mongolia.
Manipulation with the different attractiveness of host plants to insect pests is a useful tool in ecologically sustainable and economically viable integrated pest management. There is growing interest in the value of enhanced agro-ecosystem diversity and “push-pull” strategies for suppression of insect pests. Crucifer-specialist insects are attracted and stimulated to oviposit on the plants that contain secondary metabolites – glucosinolates or their degradation products. But not all plants that are suitable for feeding and oviposition, do not offer safe environment for the development of larvae. These plants are called dead-end trap crops. In our study, we compared the oviposition activity and larval survival of Meligethes aeneus on the buds of Brassica napus, B. rapa, B. nigra, B. juncea, Eruca sativa, Raphanus sativus and Sinapis alba to assess their potential as trap-crop for oilseed rape. The studies were carried out in an experimental field of the Estonian University of Life Sciences in 2011 and 2012, Tartu County, Estonia. The plants were grown in a randomized complete block design with three replicates of each plant species. To determine the oviposition activity of M. aeneus, green (BBCH 51–53) and yellow buds (BBCH 59) were collected from randomly chosen plants and dissected under a microscope. All eggs, larvae, infested and non-infested buds were counted. Overall infestation rate of green and yellow buds of different plant species varied from 0 to 71%. The least attractive plants were S. alba and E. sativa in both growth stages and years as their infestation rate reached only up to 30.7% in green buds and 44% in yellow buds. Other plant species were similarly attractive to M. aeneus as oviposition sites. The mean number of M. aeneus eggs in the green buds was extremely low on S. alba and E. sativa, which indicates that the architecture of plants and/or chemical composition of buds were unattractive to beetles. In 2011, the most preferable plant to M. aeneus was B. nigra at green as well as yellow bud stage of plants. The number of larvae in yellow buds on B. napus, B. rapa, B. juncea and B. nigra was greater than on R. sativus, E. sativa and S. alba. Dead larvae were found only in the buds of E. sativa and R. sativus. All dead larvae were in first instar or were perished during moulting to the second instar stage. In 2011, the ratio of dead and alive larvae on R. sativus was almost equal; the average mortality was 46%, but in 2012 it was only 27%. The average mortality of larvae on E. sativa was much lower and stayed around 20%. Therefore, we can conclude that R. sativus is equal in value as oviposition site for M. aeneus in attractiveness with oilseed rape, but can perform as dead-end trap-crop because almost a third of the larvae cannot survive.
THE IMPACT OF COMPANION PLANTING ON THE ABUNDANCE OF LEPIDOPTERAN PESTS ON WHITE CABBAGE

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Cruciferous plants are grown around the world while white cabbage (Brassica oleracea L. var. capitata) is one of the most cultivated cruciferous vegetable plants in temperate regions due to its high nutritional value. Insect pests of cabbage can cause severe economic damage; the most important ones belong to the order Lepidoptera, such as Pieris brassicae L., P. rapae L. (Pieridae), Mamestra brassicae L. (Noctuidae) and Plutella xylostella L. (Plutellidae). The aim of the study was to find out whether companion planting with Anethum graveolens L. will effectively decrease the abundance of lepidopteran pests on white cabbage and therefore prevent the damage. Studies were carried out in an experimental field of the Estonian University of Life Sciences from 2010 to 2012. The experimental layout was a randomised block design with four replicates of two treatments: cabbage plants intercropped with companion plant and control plots. Each plot measured 2x5 m, and was planted with ten cabbage plants in two rows. On intercropped plots A. graveolens was sown between the cabbage rows, control plots were non-intercropped. The buffer zone between plots was one meter of bare soil around each plot. To determine the abundance of lepidopteran pests, all pests from all cabbage plants were inspected weekly and all specimens were counted. The years significantly influenced the mean number of larvae of cabbage pests per cabbage plant. The infestation level was high in 2010, up to five specimens per plant, the threshold level in Estonia is five caterpillars per plant on at least 25% of the plants; low in 2011, only one specimen per plant and medium in 2012, when the mean number of larvae per plant was three. When the abundance of larvae was pooled over three years, companion planting effectively reduced the number of pests’ larvae on cabbage plants. However, no evidence was found that companion planting lowered the abundance of pests neither in 2010 when high pest abundance was recorded, nor in 2011 when only few larvae were found. At the same time, in 2012 intercropping with A. graveolens had a significant effect on the abundance of pests, less lepidopteran larvae were found from plots planted with A. graveolens. The effect of companion planting was affected by the abundance of pests; in the year of high pest numbers all plants, even the less suitable ones, were infested whereas in the year with low number of pests, the abundance stayed low on both variants. As the mean number of larvae per plant was significantly diminished by intercropping over three years, it can be assumed that companion planting can only be effective if the population size of pests stays at a medium level.
Identifying management options that enhance ecosystem services has become a critical issue. As an important service that could reduce pesticide use, pest control resulting from the activity of naturally present predators and parasitoids is frequently cited. However, the link between management options, pest control and crop yield is still poorly understood. In particular, the role of plant diversity in and around cultivated fields requires more scientific support to identify the plant species that indeed favour pest population regulation. Movements of predators and parasitoids between crops and non-cultivated plants imply that insects can colonize and develop on hosts with potentially contrasting characteristics. For example, Brassicaceae crops have many wild relatives growing in non-cultivated areas or as weeds in cultivated fields. These species differ in a number of traits associated with plant defences that may have an impact on the natural enemies of their herbivores. To determine to what extent wild plants (including weeds present in the fields) may serve as refuges for aphid parasitoids, we investigated the suitability (in terms of colonization and population growth) of two cultivated species (Brassica oleracea and B. napus) and two non-cultivated species (B. nigra and Sinapis arvensis) for two common pest aphid species, the cabbage aphid (Brevicoryne brassicae) and the green peach aphid (Myzus persicae) and for their main parasitoid (Diaeretiella rapae). We recorded colonization of B. oleracea by aphids under field conditions. B. oleracea was surrounded by B. oleracea (control), B. napus, B. nigra (weed), or Solanum lycopersicum. The focal plant B. oleracea was more colonized by the specialist aphid Brevicoryne brassicae when it was surrounded by B. nigra or B. napus. In contrast, B. oleracea was less colonized by the generalist aphid when it was surrounded by S. lycopersicum, B. nigra, or B. napus. Population growth rates of the two aphids were smaller on the two cultivated plant species B. oleracea and B. napus. Similarly, the performance of the parasitoid was affected by the host plant on which the aphid was feeding. Unexpectedly, parasitism rate was lower on B. oleracea. Thus, variation in host plant characteristics had an impact on the fitness of the parasitoid through its aphid host. Thus, in temporally changing landscapes, pests and natural enemies may utilize crops and wild related host species with contrasting impacts on their fitness. Furthermore, attraction or repulsion of the specialist aphid B. brassicae and the generalist aphid M. persicae resulted in decreased or increased colonization of the crop B. oleracea. Careful spatial and temporal management of weed populations could thus favour pest control in Brassicaceae crops.
Enhancement of disease suppressive properties of soils limits disease development and is, as a result, essential for sustainable agriculture. Moreover, it can be a profitable strategy for farmers to manage diseases with lowered levels or without pesticides. Agricultural soils differ in their suppressiveness towards soil-borne plant pathogens, which can be attributed to soil type, organic matter content, as well as by management practices such as crop rotation, tillage and fertilization. The objective of the current research is to devise management strategies supporting disease suppression based on the response of pathogen-suppressing soil microbial communities. A field trial is being conducted to test experimentally the effect of crop rotation and management treatments on crop health and yield, as well as the suppressive response of the soil and its physical, chemical and biological properties. An experimental site with an on-station field trial with a winter-wheat rotation in the North of France has been selected. Soil samples are taken twice in the cropping seasons of winter wheat in 2012 and 2013. Soil suppressiveness is tested in bioassays with three different soil-borne pathogens in winter wheat under controlled environmental conditions. Biological targets which are assumed to provide complementary information on soil quality and diseases suppressive capacity of soil have been selected: 1) fungal and bacterial diversity and community structure, being important quality parameters of soil life; 2) arbuscular mycorrhizal fungi (AMF), obligatory mutualistic symbionts that supply plants with inorganic nutrients and protect them against diverse abiotic and biotic stresses; 3) Lysobacter spp., a recently described antagonist that correlates with soil suppressiveness in Dutch soils; 4) community structure of nematodes, expressed as maturity index, proposed as indicator for soil quality. A preliminary consideration of the results so far shows a variable response to crop sequence and management for bacterial and fungal, AMF, and nematode communities. Some limited changes in disease suppression were detected. Lysobacter spp. is present in the selected field, but is not influenced by the soil treatments. Correlation between the treatments and the different measurements will be performed when all samples have been analysed (i.e. mid 2013).
SPATIAL AND TEMPORAL DYNAMICS OF *FRANKLINIELLA OCCIDENTALIS* AND ITS NATURAL ENEMIES IN ORNAMENTAL CROP SYSTEMS

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*Frankliniella occidentalis* Pergande (Thysanoptera: Thripidae) is a major problem of various ornamental and vegetable crops. Failures in insecticide applications to control this pest is frequently reported because of resistance. Alternative control strategies are based on augmentative biological control. Conservation biological control through the empowerment of natural occurring biocontrol agents is often overlooked in ornamental crop systems. We explored the potential for conservation biological control of *F. occidentalis* on ornamentals grown in open field and under greenhouse. We investigated the spatial structures of the pest and its natural enemies and their evolution over time. Spatial patterns in *F. occidentalis* and its natural enemies distributions on ornamental crops are reported. An association was found between the distributions of the pest and its natural enemies, in particular in open field. The study provided interesting information on the role of surrounding environment on interactions between the pest and its natural enemies populations on ornamentals.
A STRATEGY TO PREVENT CROP PEST RESISTANCE LEADING TO A REDUCTION OF PESTICIDES IN PLANT PROTECTION, USING POLLEN BEETLE AS AN EXAMPLE

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Monitoring of crop pests’ susceptibility levels to active substances of plant protection products is now one of more important elements of IPM. The presence of resistance in some species necessitated the increase of treatments in the practice of plant protection and forced the scientific world to identify protocols to prevent this phenomenon. On the basis of intensive scientific research into pesticide mode of action, mechanisms of pest resistance and agronomic conditions favouring resistance, the strategies of plant protection to reduce the negative effects of resistance whilst decreasing the number of chemical treatments and the selective pressure on pests, are being elaborated and introduced into practice. An example is the strategy worked out in Poland for preventing resistance of pollen beetle (*Meligethes aeneus* F.), the most important oilseed rape pest in the country. The strategy relies on controlling chemical protection of oilseed rape, aiming to achieve the highest level of effective pollen beetle control and, at the same time, decreasing the selective pressure of insecticides and other undesirable effects, especially on beneficial insects. The work presents main elements of the strategy of oilseed rape protection in Poland, taking into consideration the conditions of oilseed rape protection in this country.
EFFECTS OF NITROGEN FERTILIZATION ON INSECT PESTS, THEIR PARASITOIDS, PLANT DISEASES AND VOLATILE ORGANIC COMPOUNDS IN BRASSICA NAPUS

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Nitrogen (N) availability is a key factor influencing the yield of \textit{Brassica napus} L. Thus, mineral fertilization is widely used to improve the quality and quantity of seeds. In this study, we conducted field experiments to determine the impact of nitrogen fertilization on \textit{B. napus} pests, their parasitoids and plant diseases. The field studies were conducted with seven different N-fertilizer levels: 0, 60, 80, 100, 120, 140 and 160 kg of N per hectare in 10 m\textsuperscript{2} randomized replicate plots of winter oilseed rape. Abundance of \textit{Meligethes aeneus} Fab. (Coleoptera: Nititulidae) larvae and its’ parasitoids were determined by dissecting flowers and second instar larvae, respectively. The occurrence of \textit{Ceutorchynchus obstrictus} Marsh. (Coleoptera: Curculionidae) and its parasitism rate were determined by counting damaged pods and emerged parasitoids or their remains from pods. Plant disease assessments were carried out visually at the mature pod stage (BBCH 80–85), the abundance of \textit{Alternaria brassicae} (Berk.) Sacc. lesions was rated on a qualitative scale from 0 to 6 (no disease; 5%; 10%; 20%; 30%; 50%; over 50%). The volatile organic compounds measurements were carried out using multichamber cuvette system for collecting and Shimadzu TD20 automated cartridge desorber combined with Shimadzu 2010 plus GC MS instrument for analysing. The compounds were identified by comparing their mass spectra with a NIST library (National Institute of Standards and Technology) and with authentic standards. The results showed that N treatment had an impact on the abundance of \textit{M. aeneus} and \textit{C. obstrictus} as well as \textit{A. brassicae}. Since pest abundance was not correlated with the flower and silique numbers, the feeding and oviposition sites, plant smell bouquets were analysed to determine potentially attractive or repellent volatile organic compounds. We detected 19 different compounds among which acetic acid and several lipoxygenase pathway products were emitted at higher levels from N-treated plants. Emission of a few other terpenoid compounds was correlated with the pest abundance in field conditions. Abundance of parasitoids of both pests was related to the host availability rather than to the fertilization treatment. Therefore, we suggest that plant chemical cues play a minor role in localization of hosts in close proximity to parasitoid. The levels of \textit{A. brassicae} decreased with increasing N availability, possibly reflecting enhanced emissions of acetic acid, a known antifungal volatile. This study demonstrates the effects of N fertilization on bud and flower volatile bouquets, which might play a role in \textit{B. napus} insect pest host selection and in resistance to fungal plant diseases. Further studies are necessary to investigate the behavioural responses of insects to the changed volatile bouquets.
**POSTER**

**COMPARATIVE MORPHOLOGY AND EVOLUTIONARY GENOMICS PROVIDE USEFUL CLUES FOR MANAGEMENT OF AN EMERGING DROSOPHILA PEST**

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*Drosophila suzukii* is one of the few fruit flies to lay eggs and feed on fresh fruit. Its recent outbreak in western countries, and its peculiar ecological behaviour makes it an emerging model for pest management and biology. A recent genomic survey suggested that *D. suzukii* unusual behaviour is intimately linked with an ecological pre-adaptations to temperate climates and the ability of overwinter in sexual diapause state. Here we provide comparative morphological and behavioural evidences supporting that diapause occurs preferentially in females, is temperature dependent, and is likely mediated by an enlargeable highly pigmented spermatecha. Comparative genomics reveal a cytochrome associated with spermatecha as the gene under stronger positive selection in *D. suzukii* genome. Evolutionary genomics further identify two genes under positive or abnormal evolution involved in insecticide resistance and immune response to parasitoids. Based on our results, we advocate that early spring trapping is key for *D. suzukii* population control as it may target the few overwintering females exiting diapause. Our results show that evolutionary genomics and comparative morphology are useful tools to guide application in the field of pest management.
The use of conventional farming systems has negative effects on the environment, often leading to a loss of biodiversity. The use of mixture of pesticides for the protection of crops can represent a source of contamination and degradation of the environment. Such a behaviour has been investigated at different biological levels, ranging from the aboveground level (plants, birds, spiders, grasshoppers, predatory insects) passing to the belowground level (ants, soil microorganisms) and under different land use types. On the other hand, organic farming relies on the use of a limited range of organically approved pesticides, thus causing less disturbances and favouring higher biodiversity compared to the conventional farming system. However, the beneficial impact of organic farming has been mostly observed in the case of annual crops, which usually undergo higher levels of disturbances due to management practices, compared to perennial crops. The effect of the farming system in the vineyard environment has been poorly investigated and the understanding of its impact is fundamental for the maintenance of this economically important agroecosystem.

We selected four couples of vineyards cultivated respectively through conventional and organic farming systems in Piemonte (Italy), a region where viticulture is widespread. Four areas were selected, three in the province of Turin and one in the province of Cuneo. Soil samples were collected during 2011 in April and October, corresponding to spring and autumn season when soil temperature was approximately 12-16 °C. Inside each of the eight vineyards an area of 500 m² was selected and soil samples were collected according to a W shaped design. Composite samples from each vineyard were then analyzed by automated ribosomal intergenic spacer analysis (ARISA) an ITS based method to characterize the soil bacterial and fungal community structure inside each vineyard. Multivariate analysis and non-parametric MANOVA (NP-MANOVA) were used to assess the effect of area (A1-A2-A3-A4), soil management (C/O), sampling time and site and the interactions among these factors.

Soil bacterial community was mainly affected by the effect of the area considered and this was due to differences in the physicochemical characteristic of the study area. In particular, the area of Cuneo was geographically distant and characterized by differences in the granulometry, pH macro and micro elements that caused differences in the bacterial community, thus overwhelming the effect of the farming system. When considering only the three areas in the province of Turin, the effect of area was absent and an effect of the farming (C/O) was visible (P=0.0386) and not dependent on the sampling time (P=0.3607). In the case of the fungal microbial community an effect of area was present (P=0.0005), while an effect of the farming system was not found (P=0.19) and it was not time dependent (P=0.83). The fungal and bacterial diversity were mainly unaffected by the farming system, while an effect of the area was found.
THE ROLE OF AGRONOMIC METHODS IN IPM STRATEGIES FOR WEED CONTROL IN BLUE LUPINE (*LUPINUS ANGUSTIFLOLIUS* L.)

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Species of lupine (*Lupinus* sp.) is known as a valuable high protein plant that can be an alternative to the commonly used soybean meal in feed. In conventional agriculture lupine crop is considered to be very dependent on the protection of herbicide. Lupine is considered to be highly dependent on herbicide use in conventional farming. Some studies indicate the possibility of weed control by harrowing. The European Union will apply IPM strategies, which aims to reduce the use of pesticides including herbicides. The aim of this study was to assess the potential of lupine weed control through the use of harrowing and sowing mixed with cereals as part of IPM strategies. In the years 2010-2012 at the Institute of Plant Protection - National Research Institute were conducted field experiments in Field Research Station IOR-PIB in Winna Gora. In the study were evaluated two methods of weed control: A-mechanically (harrowing after sowing and the emergence of lupine), B- chemical (herbicides applied to the soil and foliage). Both methods of weed control were tested in pure sowings (normal sowing: 100% lupine) and in mixtures with cereal (normal sowing: 60% lupine + 40% barley). The experiment was set up in randomised complete block design with four replications. Soil type was classified as podsolic with a pH 5.5-6.0. Plots were 11 m long with a 1.5 m wide. The biological effect was evaluated as reduction of weed biomass as compared to untreated. The study reported 16 segetal weed species. Dominated: *Chenopodium album* (fat hen), *Echinochloa crus-galli* (L.) P. Beauv. (barnyardgrass), *Matricaria maritima* L. subsp. *inodora* (false chamomille). In individual years the effectiveness of weed control in the tested systems varied. In 2010 and 2012 the mass of weeds was significantly lower in herbicidal treatments. In 2011, less weed infestation was observed in the plots with harrowing. In general, in this year poor rainfall and low soil moisture after lupine sowing was noticed. Under these conditions, the effectiveness of herbicides applied immediately after sowing was poor and harrowing significantly reduced the number of the dominant weed species. In lupine – barley mixture weed infestation was significantly lower than the pure sowing regardless of the method of weed control. The results showed good perspectives to introduce agronomic methods to weed control in lupine.
Microorganisms are involved in many important processes in soil, as nutrient cycling and organic matter decomposition and transformation, which contribute to soil quality and are essential for long-term sustainability of agricultural systems. Recent studies have demonstrated the impacts of organic and conventional production systems on the soil microbial and chemical characteristics. The principal input of conventional agriculture is the large dependence on intensive chemicals, characterized by extensive application of synthetic fertilizers, insecticides, fungicides and herbicides. These agricultural practices have been associated with loss of soil fertility, groundwater and environmental pollution, as well as with the loss of soil microbial diversity. On the other hand, organic agriculture eliminates the use of synthetic fertilizers and pesticides, animal drugs and food additives and attempt to close nutrient cycle. The adverse effects of conventional farming system on soil productivity and environmental quality have led to an increasing interest in organic farming that is gaining worldwide acceptance and has been expanding in the last decade. We investigated the effects of conventional and biodynamic management on microbial communities in vineyards soil to establish if agriculture practices affect microbial biodiversity and composition on soil. Another important objective was to identify microbial species or model groups that would be indicative of the organic farming soil status. Three different agricultural practices were evaluated: conventional, organic (biodynamic) and biodynamic with green manure’s application. Genomic DNA from soil was extracted and amplified by PCR using 16S rDNA and ITS fragments, respectively to bacteria and fungi, and analysing by DGGE to assess diversity indices, identify shared similarities and compute statistical differences between communities. First results indicate that microbial communities respond sensitively to management practices. Majority of fungal and bacteria species were common to all the analyzed soils, whereas some of them were restricted to different agricultural practices. The presence of specific groups correlate with the management agricultural systems will be investigated a matter using the 454 sequencing method.