

<p>S2MT01P01 SPRAY FORMULATION EFFICACY – A HOLISTIC AND FUTURISTIC PERSPECTIVE</p> <p>JERZY A. ZABKIEWICZ</p> <p><i>Plant Protection Chemistry NZ, Forest Research, PB 3020, Rotorua, New Zealand,</i> jaz@forestresearch.co.nz</p> <p>Improvements in agrichemical use and efficacy are required more than ever before due to economic and environmental pressures. In agricultural weed control, some methods provide a reduction in use rates by spot or “on demand” application of the herbicide. This does not depend on any improvements in spray efficacy and is not readily applicable to all situations.</p> <p>A holistic model for the behaviour of sprays applied to plants does not yet exist, though some individual factors can be expressed in specific models. Spray efficacy is a function of [deposition, retention, uptake, translocation and a.i. toxicity]. It is also recognised that spray formulants strongly influence at least three out of the five factors.</p> <p>This review will briefly consider the status of models involved with spray deposition and retention and the influence of adjuvants, then examine the pertinent theories and models for the uptake of xenobiotics into plant foliage and related formulation influences.</p> <p>The future lies in extending the fundamental understanding of plant:spray formulation interactions, and incorporating these findings into computer based spray formulation efficacy optimisation procedures, for product performance and crop productivity.</p>	<p>S2MT01P02 THE EVOLUTION OF GLYPHOSATE FORMULATIONS AND ASSOCIATED ADJUVANT USE.</p> <p>J.Koscelny¹, D. Heering, J. Graham, P. Feng and D. Sammons</p> <p>¹<i>Monsanto Company, 800 N. Lindbergh Blvd. St. Louis, Missouri 63167, USA, Jeffrey.koscelny@monsanto.com</i></p> <p>Since its discovery and subsequent introduction in several world markets in 1974, glyphosate has had an evolving, ever-increasing global impact on agriculture and agricultural practices. In the last few years, glyphosate has also contributed significantly to the growing worldwide adoption of conservation and reduced tillage practices as well as to the widespread use of glyphosate-tolerant crops. Recent formulation development has not only focused on delivering excellent control of a broad-spectrum of annual and perennial weed species, but also on minimizing crop response to foliar applications to glyphosate-tolerant crops. Water-soluble salts of glyphosate are used in most commercial glyphosate-based herbicides. Until recent years, the monoisopropylammonium (IPA) salt of glyphosate were the most widely used. However, numerous alkali metal and onium bases readily react with glyphosate to form salts, which, with few exceptions, exhibit both good water solubility and herbicidal activity. Recently, liquid formulations containing the potassium salt of glyphosate have been developed to capitalize on the ability to formulate liquids with higher concentrations and excellent viscosity characteristics. A significant difference between the many glyphosate products in the marketplace is the specific adjuvant system used in the formulated product. Surfactants generally enhance the retention and absorption of glyphosate by plants contacted by the spray solution. The introduction of glyphosate-tolerant crops has led to the development of formulations that seek to maximize the absorption and rapid uptake of the herbicide while minimizing localized phytotoxicity to the crop.</p>
<p>S2MT03P01 CLASSICAL BIOLOGICAL CONTROL OF INVASIVE WEEDS: SUCCESSES, CONCERNS, AND FUTURE ROLE</p> <p>J.H. Hoffmann</p> <p>Zoology Department, University of Cape Town, Rondebosch 7700, South Africa. hoff@botzoo.uct.ac.za</p> <p>Classical biological control of weeds is usually only considered to have succeeded when the weed almost disappears and is no longer considered a problem. However, outstanding successes, such as those in the early days against prickly pears in Australia and against hypericum in California, and, more recently, against some water weeds, are exceptional and seldom attained. In most cases, introduced biological control agents have a limited effect on the target weed species, leading to perceptions that the projects have been failures. However, even moderate levels of damage to the target weed can provide substantial benefits, especially when combinations of biological control agents are involved or when biological control is integrated with other control methods. The future of biological control of weeds will depend on funding agencies and land managers investing in biological control even though most agents will not cause outright removal of the weed problem. Examples are presented to demonstrate how, if expectations are tempered, seemingly-ineffective agents may provide substantial benefits for the management of weeds.</p>	<p>S2MT03P02 BIOHERBICIDES: RELEVANCE AND ROLE IN THE COMING DECADES</p> <p>R A Pitelli</p> <p><i>Faculty of Agricultural and Veterinary Sciences, University of the State of Sao Paulo, Rodovia Carlos Tonanni, Km 5, 14 870.000 and EcoSafe, Jaboticabal, SP, Brazil</i> rapitelli@ecosafe.agr.br</p> <p>Inundative biocontrol is theoretically easier than classical biocontrol: often the organism occurs in an endemic population in the weed-infested area and the cost of risk assessment studies is lower. Host specificity can be a problem in tropical regions with highly diversified weed communities. The control of a few species does not solve the problem because the uncontrolled populations utilize the unexploited resources, and the overall effects on reducing the weed interference can be low. In some situations control of a single species can be beneficial: (1) Weeds selected by the intensive use of a weed-control practice: <i>Senna obtusifolia</i> selected by herbicides could be a good target for <i>Alternaria cassiae</i>. (2) Weed biotypes resistant to herbicides, like <i>Euphorbia heterophylla</i> and <i>Sagittaria montevidensis</i>, resistant to ALS inhibitors, could be targeted by <i>Bipolaris euphorbiae</i> and <i>Cylindrocarpon</i> sp. (3) Parasitic weeds, like <i>Cuscuta</i> spp, is an opportunity to <i>Fusarium</i> sp. for biocontrol. (4) Weeds occurring in places where conventional control measures are not permitted. In Brazil, certain features of water reservoirs make it difficult for mechanical control of macrophytes and no herbicides are permitted for use in water bodies. So, there is a niche for bioherbicides. Despite these opportunities, there are difficulties facing bioherbicide use: high cost, production, storage, and delivery of the agent in an infective form and resistance development due co-evolution in biotic interactions. The commercial prospects for bioherbicides are with small companies having several biocontrol agents, each without a need for large-scale production, yet versatile to address the diversified market demands.</p>

S2MT09P01
PROMOTING INTEGRATED MANAGEMENT OF IMPERATA CYLINDRICA IN THE SAVANNAS OF WEST AFRICA

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Imperata cylindrica is a serious perennial weed in the moist savanna of West Africa where it causes severe crop yield losses, land abandonment, deforestation, food insecurity, and increases rural poverty. Hand hoeing is still the predominant management practice in most small-scale farms. Research has developed improved technologies such as herbicides and cover crops. However, their adoption by farmers is low because of inadequate linkages among researchers, extension agencies, and farmers. Recently, researchers, extension agencies, and farmers implemented participatory research and extension approaches in the savanna of Nigeria to promote the use of improved *Imperata* management practices and increase their likelihood of adoption. The technology development process consisted of community mobilization, problem diagnosis, action planning, experimentation, monitoring and evaluation. Dissemination of results was through the "mother-baby" method. The "mother trials" were researcher-designed and managed demonstration on-farm trials consisting of a wide range of weed control options. These afforded farmers and extension staff an opportunity to observe and compare different options for *Imperata* management. Farmers selected one or two technologies from the "mother trials", which they tested under their farming conditions. These are called "daughter trials". IITA researchers have teamed with partners who have a comparative advantage in technology transfer to create effective linkages between research results and farmers.

S2MT09P02
INTEGRATION OF ELEMENTS OF FARMING SYSTEM FOR SUSTAINABLE WEED AND PEST MANAGEMENT IN THE TROPICS

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Diversification of agricultural activities that links farm-based enterprises with cultivation of field crops help the resource poor farmers in the tropics to generate additional income, gainful employment and improve their dietary standards. Farming system approach has been observed to be a resource management strategy for achieving economic and sustainable agricultural production, catering to the diverse needs of tropical farm household while preserving the resource base and ensuring high environmental quality. A judicious combination of any one or more of the farming elements like poultry rearing, duckery, fish culture, cattle rearing, green manuring and dual culture of bio-fertilizers contribute significantly for weed and pest management in field crops. Cropping system strategies like rotation of crops in sequence, intercropping and mulching do influence the weed-pest complex of crops. All these elements alter the weed flora in cropped fields through their feeding habits, allelopathic or allelomediatory principles in their excreta, suppression through physical interference like shading and altered ecology. Some of these elements also supplement pest management directly by virtue of their predatory behaviour or indirectly through suppression of weeds that serve as alternate hosts and by inducing fast and robust crop growth. Field experiments at Faculty of Agriculture, Annamalai University, India revealed such beneficial interactions among component elements of different farming systems viz., Rice + Fish + Poultry, Rice + Azolla + Fish, Greenmanure - Rice, Rice - Pulse, Goat rearing + Sorghum and Cotton intercropped with pulse. All these approaches along with similar strategies involving other farming elements are discussed in this lecture.

S2MT12P01
EXPLORING GLYPHOSATE ACTION: AN EXAMPLE OF UTILIZING GENE-EXPRESSION PROFILING IN WEED SCIENCE RESEARCH

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Genomic approaches recently have become commonplace for biological research. In particular, gene expression profiling using DNA microarrays is being used to address a variety of questions in a variety of organisms, including plants. By simultaneously monitoring gene-expression levels of thousands of genes, DNA microarrays provide a powerful tool to ask questions related to: gene expression differences among different tissue types (e.g., roots versus leaves), the environmental effects (e.g., drought stress) on gene expression, and biotypic variability in gene expression. In terms of weed science research, gene-expression profiling is particularly well suited to investigate herbicidal effects on plants. We are using DNA microarrays generated from 27,000 soybean (*Glycine max*) genes to investigate glyphosate action. Using a 2-fold difference in gene expression as the criterion for differential expression, conventional (glyphosate-sensitive) soybean were found to have over 400 genes differentially expressed 24 hours after glyphosate treatment. As expected, down-regulated genes included those involved with cell division and photosynthesis; whereas up-regulated genes included several known stress-induced genes. We are also interested in what effects glyphosate may have on genetically modified, glyphosate-resistant soybean. Again using a 2-fold criterion for differential expression, no genes were differentially expressed in glyphosate-resistant soybean 24 hours after glyphosate treatment. Even with a less stringent criterion of 1.5-fold, no genes were differentially expressed. Routine use of DNA microarrays still has limitations in terms of reproducibility, high costs, and data analysis. However, this technology is already providing an incredible wealth of useful data.

S2MT12P02
The utility of EST analysis in weed science research: Exploring allelochemical biosynthesis in Sorghum as an example

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Expressed sequence tags (ESTs) are single-pass, cDNA sequences selected at random from complex phage or plasmid libraries. The large EST datasets which have been generated for many different organisms serve as indispensable tools for both structural and functional genomics research. Datasets derived from standard, non-amplified libraries also reflect the abundance of different mRNA species in the tissue or cell type from which the library was generated, thus creating an electronic gene expression profile of moderately to highly abundant mRNAs. Our research efforts directed toward the discovery of genes involved in the biosynthesis of the potent allelochemical sorgoleone exploits this latter aspect of EST datasets. Ultrastructural studies indicate that root hair cells in sorghum are the primary site of sorgoleone biosynthesis, and we have generated an EST database comprised of approximately 5,500 sequences from this cell type. Data mining strategies and other tools used for the identification and screening of candidate gene sequences from this database will be described.

S2MT20AP01
WEED FECUNDITY: CURRENT STATUS AND FUTURE NEEDS

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Seed rain is the major input to populations of annual weeds. During the last decade data on seed production have been published for several weed species that accurately reflect the reproductive potential under varying conditions. Many weed species produce thousands of seeds per plant, and several species can produce in excess of a million seeds per plant. Seed production at a range of density and proportional mix with competing species, allows for prediction of seed rain under different cropping conditions. Seed production by weeds at densities at and below the single season economic threshold provides information useful to making long-term management decisions. Estimating enormous seed rain from high densities of uncontrolled weeds is of limited value in relation to decision making. Serious problems exist with some protocols for assessing weed seed production, limiting the utility of the data generated. A serious problem also exists with "regionality" of data. Maximum seed production reported for the same weed species growing in different geographic regions varies by at least two orders of magnitude, and even within a single region large variations can occur among seasons and local microclimates. These variations suggest that the utility of a model developed in one region may be limited to that region. Models of weed population dynamics suggest that the best management strategy is to limit seed production, thus reducing the size of the weed seedbank over time. Overall weed management costs should decrease if a strategy to limit seed production is followed. Long-term experiments are needed to evaluate how changes in management impact weed seed rain and population dynamics.

S2MT20AP02
**WEED SEED PREDATION; THE MISSING LINK IN THE
POPULATION DYNAMICS OF ARABLE WEEDS
IN TEMPERATE REGIONS**

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Post-dispersal seed losses in annual arable weed species may be of significance for natural population control, especially if they can be manipulated. Modelling studies have indicated that the population growth of weeds is sensitive to seed mortality, and studies on the fate of weed seeds produced have shown that up to 70-99% of newly produced seeds cannot be retrieved in following years. Predation of surface seeds is responsible for the larger part of these losses, but is highly variable in space and time. Annual seed losses are a function of the temporal patterns of seed predation ('demand') and seed availability ('supply'), as defined by both seed shed and seed burial. Temporal patterns of seed predation are related to changes in the numbers and activity of seed predators present in the field. Very diverse groups of animals are known to consume seeds, including vertebrates and invertebrates, which differ in mobility, food and habitat preferences, and population dynamics, and may therefore respond differently to farming practices. Also the timing of seed shed is species, crop and climate specific. Seed burial is usually accomplished by tillage, although some burial will occur during the cropping season depending on weather, soil type, and seed characteristics. Here, the above concepts and their consequences for annual predation rates are illustrated by a study on seed predation and production in cereals and sugar beets in the Netherlands, and by examples found in literature. Understanding the temporal patterns is essential for manipulating and maximizing weed control by seed predators.

S2MT22P01
WEED MANAGEMENT IN MINOR CROPS IN NORTH AMERICA

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The IR-4 Project, established in 1963, is a publicly funded effort that supports the registration of pest control products on minor or specialty crops. Its mission is to provide pest management solutions to growers of vegetables, fruits, ornamentals, and other specialty crops. IR-4 develops data for submission to the EPA to support the regulatory clearance of new crop protection chemicals on specialty crops and assists in the maintenance of existing product registrations. IR-4 also provides help in the development and registration of biopesticides and expedites new pest control technologies. Since 1996, IR-4 has worked cooperatively with Canada in the development and exchange of food crop residue and performance data, which have been conducted as part of regular joint studies. Data packages developed for U. S. registrations have also been provided to the Pest Management Regulatory Agency (PMRA) of Canada that allows for its use in Canada and is in support of importation of U. S. agricultural products. The Canadian government has provided federal funding allowing Agriculture and Agri-Food Canada and the PMRA to give Canadian producers better access to minor use and reduced risk-products; helping to increase their international competitiveness. A Canadian Minor Use Program, similar to IR-4, was created in 2002 and has been named the Pest Management Centre. Under the North American Free Trade Agreement (NAFTA), the governments of Mexico, Canada, and United States have formed a Technical Working Group on Pesticides to develop a coordinated pesticides regulatory framework among NAFTA partners.

S2MT22P02
**RECENT DEVELOPMENTS IN MINOR USE ISSUES IN
EUROPE**

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The European Commission (EC) has recognised the need for authorised minor uses of plant protection products, especially in minor crops. These uses are often of insufficient marketing perspective to industry and few uses are applied for. This creates out of control crop protection situations on farms, sometimes leading to illegal use, toxicological concerns and environmental pollution. In order to address the situation the EC has created an Expert Group on Minor uses. This Expert Group consists of members from Belgium, France, Germany, Great Britain, Hungary, the Netherlands, Portugal, Spain and the European Commission. In the Expert Group on Minor Uses two co-ordinators have been appointed: France for Southern Europe, and the Netherlands for Northern Europe. Several activities are ongoing, and one effort is aimed at obtaining more plant protection solutions for minor crops through facilitating co-ordinated research (chemical, non-chemical and integrated control) and through better EU oriented harmonisation on the work floor of the national designated authorities in the Member States. This technical work is done in close collaboration with national co-ordinators from all Member States of the EU. The EU co-ordinators organise the work through a Technical Group. Though the Technical Group itself mainly consists of government officials, the group works closely with the farmers organisations, with plant protection industry and other stakeholders. The paper describes the approach taken and the state of the art of the progress made.

S4MT01P01

PLANT CUTICULAR WAES AND THEIR ROLE IN CONTROLLING PESTICIDE UPTAKE

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Cuticular waxes are the plants primary barrier against evaporative loss of water to the air. The study of their solid state properties can deliver important insight as to how xenobiotic substances find their way across this barrier and into the vascular system of the plant. The amorphous component of plant wax has often been cited as the route taken by xenobiotic materials. Very little is known about the nature or quantity of amorphous wax present in plants. Previous studies have shown that multiple analytical techniques are required to reveal structural details however these measurements have been made on real plant waxes where the degree of complexity present was limiting. X-ray analysis (wide/small angle and variable temperature) and DSC studies on binary and ternary mixtures of the chemical components of plant waxes showed a high degree of crystallinity in all of the samples. In each case crystalline to rotator phase transitions were observed prior to melting.

Some evidence for the formation of mixed crystals was found. This was also the case with extracted leaf wax. Powerful synchrotron x-rays were used for in situ probing of the crystalline part of the wax structure of whole plants.

S4MT01P02

THE PRACTICAL ASPECTS OF UTILIZING ADJUVANT TECHNOLOGY IN THE FIELD

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Adjuvant technology is increasing at a rapid pace and various modern adjuvants are molded around the requirements of a specific agrochemical or of a group of agrochemicals. There are obvious advantages to this approach such as individual components in the formulation that each address a specific limitation of the agrochemical and by so doing, increase activity under most conditions. The limitations of these adjuvants are however that they can only be used for a limited amount of agrochemicals and may be so specialized that they can negatively impact other tank components. Most adjuvant research is initiated in the laboratory and glasshouse and then verified under field conditions. There can however be various aspects that are not taken into account that differ drastically from the farm situation and that may influence agrochemical activity. This paper takes into account aspects that may make it difficult for the end–user to benefit from the specific attributes that are built into adjuvants. These aspects include salt antagonism, weed species, agrochemical rate, tank combinations, environmental factors and various others. These are possible reasons why the effect of adjuvant technology may sometimes be reduced in the field when compared to the effect under glasshouse and laboratory conditions. Adjuvant technology can only be successful when the end–use factors, that are different from glasshouse conditions and field experiments, are taken into account and tested prior to the commercialization of a new adjuvant.

S4MT01P03

GLYPHOSATE EFFICACY IS ENHANCED BY OPTIMIZING APPLICATION TECHNOLOGY AND ADJUVANTS

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Glyphosate is an important herbicide worldwide and its use will likely continue to increase due to development of glyphosate-resistant crops. A thorough understanding of the effects of application technology and techniques and adjuvants is needed to maximize glyphosate efficacy. Field experiments were conducted in North Dakota, USA, to examine the influence of spray volume on glyphosate efficacy as affected by glyphosate rate and formulation, ammonium sulfate adjuvant, and sprayer nozzle designs. Glyphosate efficacy on several grass bioassay species increased as spray volume decreased from 190 to 23 L/ha. To obtain equal efficacy, the glyphosate rate can be reduced by at least one-third when glyphosate is applied in 23 or 47 L/ha spray volume compared to 94 or 190 L/ha. Low spray volumes enhanced glyphosate efficacy primarily through high herbicide concentration in the spray deposit and reduced quantity of salts that antagonize glyphosate from the low carrier volume. Glyphosate applied in 23 L/ha spray volume with several drift-reducing nozzle designs provided control equal to glyphosate applied with standard flat-fan nozzles. Grass control within each spray volume was similar from several glyphosate formulations that contained surfactants. Glyphosate efficacy generally was maximized with ammonium sulfate at 0.5% w/v regardless of spray water quality. Ammonium sulfate at 2% w/v occasionally was antagonistic to glyphosate applied in spray water without antagonistic salts. Our research demonstrated that spray volume, nozzle design, spray water quality, and ammonium sulfate rate are important aspects to enhance efficacy and environmental safety from glyphosate.

S4MT01P04

MEASURING METABOLISM OF HERBICIDES WITH KAUTSKY CURVE PARAMETERS

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In a greenhouse, detoxification of metamilon, a 50% mixture of phenmedipham and desmedipham, and phenmedipham alone in sugar beet (*Beta vulgaris*) was measured with the Kautsky curve (fluorescence induction curve). Various parameters such as FV/Fm, [maximum quantum efficiency of PSII; FV/Fm = (Fm-F0)/Fm], Fvj, [the relative changes at the J step; Fvj = (Fm-Fj)/Fm] and Area, [the area between the Kautsky curve and maximum fluorescence (Fm)], were selected from the numerous parameters that can be derived from OJIP steps of the Kautsky curve. Already two hours after spraying, the mixture of phenmedipham and desmedipham at high doses decreased the FV/Fm parameter significantly, while phenmedipham did not produce any effect. At one and two DAS (Days After Spraying), the effect was significant for both herbicides at high doses. Recovery was detected three DAS for phenmedipham and a little later for the mixture of phenmedipham and desmedipham. Six DAS, recovery was complete for both herbicides. There was the same trend for Area and Fvj parameters as for FV/Fm. Two DAS, concentration of chlorophyll a, b and caretenoids decreased significantly for phenmedipham but not for the mixture phenmedipham and desmedipham and metamilon. The various fluorescence parameters are good indicators of measuring detoxification of the herbicides, and since it is a non-invasive method, it is easy to study time series of degradation events in intact plants.

S4MT01P04**MEASURING METABOLISM OF HERBICIDES WITH KAUTSKY CURVE PARAMETERS****M Abbaspoor and J C Streibig**

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S4MT01P05**AN EXCISED LEAF ASSAY FOR HIGH THROUGHPUT DETERMINATION OF PESTICIDE UPTAKE****G J Hall, P Carter, A Burrige and C Holness**

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Methodology and data are presented illustrating the development and successful use of an excised leaf assay for quantitative determination of pesticide uptake in place of whole plant systems. This system allows higher throughput determination of uptake, which allows higher numbers of treatments to be tested in a shorter space of time. This can be useful in allowing fuller investigation of; structure activity relationships for adjuvant choice, adjuvant blending effects, behaviour of pesticides in simple and complex mixtures e.t.c.

The assay is based on transfer of excised leaves to a simple agar and liquid medium kept in multi well plates in sealed units to maintain high humidity. Pesticide treatments are applied, residue removed after appropriate time points, and pesticide within plant also determined; by combustion and scintillation counting for radioactive materials or by HPLC and/or Mass Spectrometry for cold materials.

Data is presented showing; comparison between excised leaf and whole plant uptake, use of different species in the assay, comparison of different herbicides and comparison of different individual adjuvants at different rates.

It is concluded that the assay produces realistic uptake data, which can be as good as whole plant data and can test much higher numbers of treatments more easily.

S4MT03P01**HISTORY, OPPORTUNITIES AND CHALLENGES FOR BIOLOGICAL CONTROL IN AUSTRALIA, NEW ZEALAND AND THE PACIFIC ISLANDS****M H Julien¹, J K Scott², W Orapa³, and Q Paynter⁴**

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Biological control of weeds has a history spanning over a century; projects began on lantana in Hawaii (1902), and cactus in Australia (1912). Many projects have been initiated in Australia and New Zealand, while the Pacific Islands have largely depended on transfer projects. There are 31, 18, and 4 weeds that are currently biological control targets in these three countries, respectively. Current projects range from native range surveys for potential agents, to distribution of established agents. There are many opportunities for biological control in the region. For example; the Australian flora includes 2,000 species of naturalised plants, and 20 new exotic plant species are recorded in Australia annually. Seventy-one weeds made a national weeds list of which less than a third have had biological control projects including 11 that are current. As our capabilities and understanding improve, new avenues open, examples are, biological control of grass weeds, integrating biological control with other management tools. There are considerable challenges ahead; selecting the best agents, maintaining biosecurity, accurately predicting host ranges, predicting potential distributions, and maintaining support to work in the vast, sparsely populated, low economic value, lands of Australia and scattered islands of the Pacific, that may also have high cultural and biological diversity. This paper touches on the history of biological control of weeds in the region, current and potential activities, the opportunities they offer to improve our understanding and our ability to manage weeds, and the challenges weed researchers face while ensuring that biological control remains a cornerstone to sustainable weed management.

S4MT03P02**The Role of biological control in managing parasitic weeds****J. Sauerborn, D. Müller-Stöver and H. Buschmann**

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*In contrast to normal weeds, parasitic plants inflict fitness costs by withdrawing water, mineral, and photosynthates from the host. Crop-derived material is mainly transferred through straw-like intrusions into the crop's vascular tissue. Theoretically, resources are unlimited for parasitic weeds unless the host is killed. Frequent occurrence of host crops in agroecosystems results in favourable reproduction conditions for parasitic angiosperms making them a competitive species. Since parasitic weeds have similar nutritional requirements as their hosts, the damage inflicted by a parasitic plant is often directly proportional to its biomass. Agriculturally important are the genera *Alectra*, *Cuscuta*, *Orobancha*, and *Striga* attacking principal crops like cereals, legumes, and vegetables. The geographical distribution of the economically important species of *Alectra* and *Striga* is centred in Africa, but they also occur in parts of India and China. Crop damaging *Orobancha* species are found in the Mediterranean region in South and East Europe and West Asia. Both *Orobancha* and *Striga* are likely to spread with host concentration and climatic change.*

Contrary to normal weeds, the most damage to the host is done by the time the parasitic weed emerges. Therefore, control methods should focus on reducing seed set. Because of the tight interconnection between the parasitic weed and its host, herbicidal control is difficult since chemical herbicides cannot selectively distinguish between the species. The high specificity of many organisms (fungi, bacteria, arthropods) to feed exclusively on selected hosts, in our case parasitic weeds, can be considered an advantage because these organisms may work as bio controller where other weed control options have failed.

S4MT03P03**WEED PROBLEMS ARISING FROM AGRO-FORESTRY: THE CASE OF *PROSOPIS* SPECIES, AND PROSPECTS FOR THEIR CONTROL IN AFRICA**H G Zimmermann¹ and C L Lennox²¹Plant Protection Research Institute, Agricultural Research Council, Private Bag X134, Queenswood, Pretoria 0121. helmuthzim@netactive.co.za²Weeds Pathology Unit, ARC-PPRI, Private Bag X5017, Stellenbosch 7599, South Africa. E-mail address vredcl@plant3.agric.za

The major alien plant invasions in Africa often originate from well-intentioned agro-forestry projects. Such invasions are characterized by a long time-lag between establishment and the first signs of invasiveness, the perennial nature of the problems, and conflicts of interest that complicate control. Agro-forestry species in the genus *Prosopis*, and their hybrids, seriously threaten the biodiversity and natural resources in Africa. Their invasion passes through three phases: 1) *Prosopis* is deliberately established and utilized in suitable areas. 2) It starts invading. The central, dense populations become useless and troublesome, while the sparser, peripheral populations continue to be utilized and tolerated. This conflict of interest impedes the control and management of *prosopis*. 3) *Prosopis* now invades and densifies at a large scale. The emphasis shifts to control, which is still dominated by conflicts of interest. Conventional chemical and mechanical control methods are no longer practical, and need to be supplemented with innovative, integrated control measures. These include selected biological control agents, e.g. those that only reduce seed production, and commercially driven utilization projects, which add value to the resource. However, conflicts of interest seriously restrict the integrated approach, and no lasting solution is known yet.

S4MT03P04**USING PROBABILISTIC RISK ASSESSMENT IN DECISION-MAKING FOR BIOLOGICAL CONTROL****Mark G. Wright**

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Invasive species and the threats they pose are rapidly increasing with the globalization of markets and increased movement of goods and people worldwide. Concomitant with this challenge is the development and implementation of appropriate political, regulatory and technical strategies to minimize the introduction of exotic species and, should they occur, the appropriate response. The latter may include all components of an integrated pest management strategy including cultural, chemical and biological tools, each of which comes with a set of risks. The challenge faced is to determine which option poses the least environmental risk.

Biological control of invasive species is an attractive and frequently used strategy for the management of invasive species, but has attracted considerable criticism as a potential ecological risk. This paper discusses a novel approach to assessing potential risks of new introductions for biological control, using probabilistic-risk assessment methods. This requires quantification of key ecological traits of the candidate introduction, estimation of probabilities associated with various contingencies and the use of "precision trees" (and possibly other methods) to evaluate potential risk. A risk analysis for an insect biological control agent (*Trichogramma ostriniae*) is used for illustrative purposes. The proposed procedure offers a valuable conceptual model for effective risk assessment procedures in insect biological control. The appropriateness of probabilistic risk assessment for weed biological control is assessed and discussed using retrospective analyses of selected case studies. Application of these procedures for assessing risks posed by insect biocontrol agents to weed biocontrol agents is also considered.

S4MT09P01**INTEGRATED MANAGEMENT OF INVASIVE WEEDS: DEPLOYMENT OF BIOHERBICIDES AND OTHER METHODS FOR CONTROL OF FOUR EXOTIC PLANTS ON FEDERAL LANDS IN BRITISH COLUMBIA, CANADA**
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Scotch broom (*Cytisus scoparius*), Gorse (*Ulex europaeus*) Daphne (*Daphne laureola*) and English ivy (*Hedera helix*) are invasive plants that pose a serious threat to Garry oak and associated ecosystems on federal lands in Victoria, British Columbia. They colonize disturbed areas quickly, form dense monospecific stands, remain persistent for a long time and defy eradication. They suppress and inhibit the growth of native plants, and ultimately arrest forest succession. Several federal departments (Depts. of Environment, National Defence, Fisheries and Oceans, Indian Affairs and Parks Canada) have expressed concerns regarding their rapid incursion, adverse impacts and degradation of native habitats. We have conducted research to examine the population dynamics, phenology and control methods of these invasive plants on federal lands near Victoria, BC. Several methods of control (manual cutting, application of the registered herbicide triclopyr, fungal bioherbicides, *Chondrostereum purpureum*, *Fusarium tumidum*, and a commercial plastic mulch) were tested. Results showed that some treatments (mulch and herbicide) provided 100% efficacy on resprouting behaviour of the all four invasive species. While one bioherbicide (*F. tumidum*) was very effective on Scotch broom under the greenhouse conditions, the other one (*C. purpureum*) produced a variable response under field conditions. Manual cutting was the least effective. Also a novel prospective bioagent was isolated from dying and dead samples of Daphne from the field and results suggest that it may hold great potential for control. Continued research is necessary to determine the appropriate formulations of these bioagents as well as the effectiveness of the different and integrated control treatments over a period of years.

S4MT09P02**IMPLEMENTATION OF AN AUTOMATED DECISION SUPPORT SYSTEM FOR INTEGRATED WEED MANAGEMENT IN SUGARCANE**J.C. Díaz¹, L. Rodríguez¹, C. Urquiaga¹ and S. Hernández²¹National Sugarcane Research Institute (INICA), Carr. Central Martínez Prieto km 2½, Boyeros, Havana, C.P. 19390, Cuba, e-mail: jcdiaz@inica.edu.cu ² Empresa Comercial de Servicios Agroquímicos, e-mail: naranjo@gea.get.tur.cu

A computer-based decision support system was developed on a Windows environment and implemented in all sugarcane estates throughout Cuba to assist integrated weed management in sugarcane. It comprises three interrelated sections. A Knowledge Base component contains extensive information on the 32 most widespread weed species (including color images of plants at different stages), herbicides and herbicide treatments currently in use, costs and productivity of all chemical, mechanized and manual weed control operations and spray nozzle specifications. Secondly, an Immediate Herbicide Treatment Recommendation Subsystem recommends best immediate herbicide treatments for any area, according to the control of prevalent weed species, treatment costs and existing weed-crop-environment conditions and, optionally, the amount and mixing order of each product to be placed in the sprayer tank. A third Annual Weed Control Planning Subsystem assists in developing chemical, mechanical, animal driven and manual weed control plans, of both areas and required inputs, by fortnights and annual total, for the whole estate, farms or sections and individual fields. Easy to fill out forms assist compiling information on field weed species surveys, farm available spraying equipment, implements and labor, and treatment preferences. Implementation in few estates during several years has shown greatest acceptance among growers of the two former sections, and in the latter, a close relationship of total planned farm herbicide budget with expected crop yields, due to variable yield thresholds included to allocate herbicide treatments.

S4MT09P03**CHARACTERISTICS, IMPACT AND MANAGEMENT OF WEEDY RICE (*ORYZA SPP*) IN RICE (*O. SATIVA*) IN LATIN AMERICA****B E Valverde**

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Weedy rice (*Oryza spp*) is the most difficult to control weed in rice (*O. sativa*). In Latin America weedy *Oryza sativa* is the most widely distributed weedy rice species but *O. rufipogon* and the native tetraploid *O. latifolia* are also weedy in rice fields. Ample morphological variability and genetic diversity has been documented in populations of weedy rice collected in northern Latin America (Colombia, Costa Rica, Nicaragua, Panama and Venezuela). Other independent studies in the region (Costa Rica, Colombia, Venezuela, Brazil and Uruguay) also document the variability of weedy rice populations. The economic impact of weedy rice, although not properly quantified in most countries, is severe enough as to causing abandonment of otherwise productive land. No single conventional control tactic is able to provide adequate weedy rice management but judicious combinations allow sustained and efficient reduction of weedy rice populations. Among tactics farmers use as part of an integrated strategy are stale seedbed preparation to allow chemical control of early seedling flushes with non-selective herbicides, minimum tillage operations, planting of certified seed, pre-plant application of herbicides on standing water, increased seeding densities, manual roughing, slashing of immature panicles, and application of growth regulators to prevent seed filling in weedy rice. Where possible, crop rotation is an effective option to help in controlling weedy rice. Herbicide resistant rice cultivars are now commercially planted in some countries mostly aiming to controlling weedy rice. But there are concerns regarding resistance genes moving to weedy rice populations and about managing volunteers.

S4MT09P05**WEED DIVERSITY REDUCED BY THE DOMINANCE OF BARLEY AND PEA MONOCULTURES AND MIXTURES****S L Poggio¹**

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Intercropping, the cultivation of two or more crops in the same land area, is an alternative to diversify agro-ecosystems that may help solving some negative effects of modern agriculture. Weed suppression is an advantage of intercropping that may contribute to reduce herbicide application in agriculture. To study the effect of intercropping on weed communities, field experiments were carried out at Buenos Aires and Rojas (Argentina) involving monocultures and mixtures of barley and pea, and a control treatment in which weeds grew in the absence of crops. Effects on weed communities were characterised in terms of growth, species diversity (richness and equitability), rank-abundance plots, and plant functional traits. Plant nitrogen and interception of solar radiation were also measured. Mixtures and barley strongly dominated over weeds, suppressing growth and reducing the community diversity. Those treatments reduced both nitrogen in weed biomass and radiation reaching weed leaves. On average, species richness was reduced almost a 50% by mixtures and barley. Pea effects on weed communities were less suppressive and more variable. Winter annuals were mainly suppressed by crop treatments, while spring annuals were less abundant in the unsown control. Divergence in the abundance of winter and summer emerging weeds could be attributed to the different canopy dynamic of crop treatments, which would have differently modified the environment experienced by weeds (e.g. light quality, temperature). This work contributes to improve our understanding of plant succession in agro ecosystems and may help in developing low-input practices for weed management.

S4MT09P04**PERENNIAL GRASSES FOR VULPIA CONTROL IN TEMPERATE PASTURES – HOW TO MANAGE FOR REAL SUSTAINABILITY****P M Dowling¹, G D Millar¹, S J Betts¹ and J A Tarleton¹**

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In the high rainfall zone of temperate Australia, declining pasture productivity is associated with reduced fertiliser inputs and lowered levels of perenniality due to economic pressures and inappropriate grazing management. A consequence of this is increased incidence of annual weed species such as vulpia. Pastures can be resown but this is largely uneconomic except in more favoured environments. There is increasing recognition that reducing the stocking rate will increase the life of a perennial grass pasture, but this is not popular with producers. Another option for producers to consider is to reduce grazing pressure on the pasture around the time of seedhead emergence in spring and summer. This action achieves two goals. Firstly it allows the perennial plant to increase in size allowing it to cope better with environmental and defoliation stress. Secondly, and more importantly, there is greater seed production which increases recruitment opportunities in the following autumn. Periodic recruitment of perennial grasses is regarded as vital for the long-term viability of the pasture since it would be comprised by plants of different ages. The aim of this study was to explore the relationship between seed production and seedling recruitment of phalaris, a widely sown perennial grass, that was subjected to different levels of grazing management. Results showed that despite huge levels of seed production, recruitment was generally low. However, recruitment of these perennials needs to be encouraged especially since there is no reliable information on the longevity of these important perennial grass plants.

S4MT09P06**RATIONALE BEHIND THE INTEGRATED MANAGEMENT OF RAGWORT****K J B Potter^{1*}, J E Ireson², G R Allen¹**

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The existing integrated management strategy for ragwort (*Senecio jacobaea*) aims to combine the biological, chemical, and cultural techniques available for ragwort control into an efficient and cost-effective strategy that can be implemented by land managers and farmers. The purpose of this study was to validate some of the current integrated management recommendations, investigate factors that affect populations of the ragwort flea beetle (*Longitarsus flavicornis*), a ragwort biological agent, and provide data to substantiate the formulation of new management recommendations. Research was performed over a three year period and involved both field and laboratory based trials. Results indicated that 2,4-D application to larval infested ragwort in autumn led to a decrease in the percentage adult *L. flavicornis* emergence of 35% while application in spring resulted in a decrease in the percentage adult emergence of 19% in the first spring spray trial and 33% in a second spring spray trial. Waterlogged soil conditions were found to be detrimental to *L. flavicornis* larval survival and *L. flavicornis* eggs were shown to be prone to desiccating environmental conditions. Univariate and ordination analysis also indicated that no single factor or suite of soil factors could explain the current pattern of establishment success and effective ragwort control by *L. flavicornis* within Tasmania. This research has enabled us to refine the existing ragwort management recommendations and identify gaps in our knowledge of the system. It has also highlighted the need to include the more recent ragwort biological control agent introductions into a further revised management strategy.

S4MT09P07**COMMUNITY ENGAGEMENT IN STRATEGIC WEED MANAGEMENT IN VICTORIA, AUSTRALIA.****Leigh Dennis¹ and Tony Lovick²**

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The responsibility for the management of weeds in Australia is devolved to the States. The Victorian Pest Management Framework for Action (VPMF) provides the principles and planning framework for pest management in the state of Victoria. The Weed Management Strategy (WMS) under the VPMF reflects these principles and provides strategic actions and timeframes to deliver the outcomes of these principles state-wide. Regional Weed Action Plans (RWAP) further devolve the delivery of these principles and strategic actions at the regional level. Community and stakeholder involvement has been seen as being critical in the development of the VPMF, WMS and RWAPs as without the acceptance of these principles and actions, the successful delivery of the outcomes these strategic documents aim to deliver would be severely compromised. In the following paper, the development of the VPMF and WMS is outlined with particular emphasis placed on the reasoning behind these strategic documents and the processes used to engage the key stakeholders in their development at a state-wide level. The second part of the paper looks at how the strategic actions of these documents are delivered through RWAPs. The Corangamite RWAP will be presented as a case study in community engagement, empowerment and decision making in the creation and delivery of this plan.

S4MT12P01**Recombinant Antibody Technology for Weed Science****J. Christopher Hall**

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Plant-derived antibodies (Abs) are potent reagents that can be used in plant protection and environmental monitoring. Advances in molecular biology allow the creation of recombinant antibodies (rAbs) new and specific properties. Animal immunization and hybridoma technology are no longer necessary for identification of antibody coding sequences with specific antigen affinities. Cloned antibody genes can be amplified and selected from phage display, cell-surface display, or cell-free display libraries for an unlimited range of antigens including proteins, carbohydrates, nucleic acids and pesticides (<1000 Da). A useful feature of recombinant display systems is the linking of phenotype and genotype of Abs during selection; allowing co-selection of the desired Abs and their encoding genes based on the binding characteristics of the displayed Abs. This Ab DNA can be further manipulated for high-level expression, post-translation modification, and/or affinity and specificity improvement, and subsequently expressed in *E. coli*, yeast, or plants. We made a single-chain-recombinant antibody (scFv) against picloram when expressed in tobacco protected it from picloram in a dose-dependent manner. This is the first successful use of an antibody to confer *in vivo* crop resistance to a xenobiotic of low molecular weight (i.e. < 1000 Da). Our results suggest the possibility for a generic antibody-based approach for creating crops resistant to low molecular weight xenobiotics for use in bioremediation of contaminated soils, crop protection and as novel selectable markers.

S4MT12P02**Molecular tools for understanding distribution and spread of weed genotypes****C Preston and J Baker**

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There is increasing interest in documenting and understanding the spread of weed genes or genotypes in cropping systems. In part, this is driven by concern about the ecological consequences from the introduction of genetically-engineered crop varieties. Despite this, applications such as managing the spread of herbicide resistant weeds or understanding the importance of immigration of new genes to the awakening of sleeper weeds are probably more important. There are a variety of molecular tools that can be applied to these problems. However, it is important to understand the strengths and weaknesses of these tools and the pollination biology of the target species before choosing the appropriate approach. For example, molecular markers that are unassociated with the gene of interest may be useful with species that are mostly self-pollinated, but are generally impractical for tracking gene movement in species with significant levels of outcrossing. This paper will discuss the application of molecular and other tools to the movement of herbicide resistance genes within and between populations. Examples include the evolution and movement of paraquat resistance in *Hordeum glaucum* Steud. and *H. leporinum* Link, understanding the structure of canola (*Brassica napus* L.) populations on roadsides, the spread of chlorsulfuron resistance in *Lolium rigidum* Gaud. within and between crop fields, and the spread of wind-borne seeds of *Lactuca serriola* L. across the landscape. In each case, the application of different molecular tools in combination with other techniques to the problem will be illustrated.

S4MT12P03**CYTOGENETIC APPROACHES IN WEED SCIENCE****Henri Darmency**

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Simply checking the chromosome number of weeds was often the key to avoid mistakes when choosing and describing the plant material under study. Knowledge of weeds at the genomic level was shown to be necessary in most cases to explain morphological and adaptive variations within apparently single taxonomic species. Ploidy levels could be correlated to specific habitats in some instances; in others, mixed ploidy levels were found at the same location. In the sixties, cytogenetic studies of weeds were carried out to investigate direct effects on herbicide response. Reciprocally, chromosomal variations caused by herbicide treatment were also investigated. More successfully, accurate description of chromosomes (X and Y, B chromosomes, occurrence of translocation, aneuploidy) provided explanations of phenomena such as plant sexuality, genetic diversity, and potential for adaptation. The behavior of ploidy levels was essential to understand how plant-pathogen equilibrium established and how it evolved after colonization of foreign habitats. Identification of parental origin of chromosomes in polyploids was utilized to confirm phylogeny and species relationship. Cytogenetic tools were also used recently to check gene flow between genera or species, especially in the case of herbicide resistance genes from transgenic crops. Finally, one weed arose as the reference plant model for chromosome mapping and gene function, *Arabidopsis*, which soon will be the source of both a better knowledge of weed characteristics and improved weed management strategies. Examples are discussed with special emphasis given to recent microscopy and molecular techniques.

S4MT12P04**QUANTITATIVE EXPRESSION ANALYSIS OF GH3, A GENE INDUCED BY PLANT GROWTH REGULATOR HERBICIDES IN SOYBEAN.****Kevin B. Kelley¹, Kris N. Lambert¹, Aaron G. Hager¹, and Dean E. Riechers¹**¹Department of Crop Sciences, University of Illinois, Urbana, Illinois 61801, USA
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Symptoms resembling off-target plant growth regulator (PGR) herbicide injury are frequently found in soybean fields, but the causal agent is often difficult to identify. The expression of *GH3*, an auxin-regulated soybean gene, was quantified from soybean leaves injured by PGR and non-PGR herbicides using real-time RT-PCR to ascertain its suitability for detection of PGR herbicides as the cause of injury. Cloned *GH3* cDNA of known concentration was used to develop a standard curve used for absolute quantification of gene expression. *GH3* was highly induced by dicamba within 3 days after treatment (DAT), remained high 7 DAT, but induction was much lower at 17 DAT. *GH3* was also highly induced at 7 DAT by dicamba + diflufenzopyr, and to a lesser extent by the other PGR herbicides clopyralid and 2,4-D. The non-PGR herbicides glyphosate, imazethapyr, and fomesafen did not significantly induce *GH3* expression above a low constitutive level. Preliminary immunoblot analysis indicates that differential expression of *GH3* protein can also be detected, which may enable the development of an ELISA that is more conducive to field use and processing larger numbers of samples. These results indicate that using the overexpression of auxin-responsive genes for detection of PGR herbicide injury is feasible. *GH3* is a potential candidate from which a novel diagnostic assay could be developed, though the assay would be useful for a limited time after exposure.

S4MT20AP01**PREDICTING DORMANCY CHANGES IN WEED SEED BANKS: A SIMULATION MODEL FOR *POLYGONUM AVICULARE* L. R Benech-Arnold and D Batlla**

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Dormancy is a common attribute of many weed seed populations, and this hampers the task of predicting emergence from seed banks under field conditions. Of the many environmental factors that regulate seed behaviour in the field, temperature has been identified as one of the main factors governing changes in dormancy status of seed populations. On this basis, a stratification thermal time index was developed to account for the effect of variable stratification temperatures on dormancy loss of *P. aviculare* seeds. To develop the thermal time index, changes in the thermal range permissive for germination of *P. aviculare* buried seeds were related to the accumulation of thermal time units under a threshold temperature for dormancy loss to occur. A set of experiments was designed to assess changes in the permissive thermal range for germination, the base water potential, the response to alternating temperatures and the sensitivity to light of *P. aviculare* seeds buried at different stratification temperatures. Changes in seed responses to the different environmental factors were satisfactorily described by the thermal time index. The data obtained with the whole experimental set was used to generate a model that might be able to predict seed responses to the most important environmental factors that usually trigger germination under natural conditions in relation to the temperature experienced by the buried seed-bank during winter. Moreover, model performance was evaluated against independent data showing acceptable prediction of timing and percentage of weed emergence under field and controlled conditions.

S4MT20AP02**MODELLING THE EFFECTS OF FARMING PRACTICES ON WEED EMERGENCE****N Colbach¹, C Dürr², J Roger-Estrade³ and B Chauvel¹**¹UMR Biologie et Gestion des Adventices, INRA, BP 86510, 17 rue Sully, 21065 DIJON Cedex, France, colbach@dijon.inra.fr; ²Unité d'Agronomie, INRA, rue Fernand Christ, 02007 LAON Cedex, France; ³UMR d'Agronomie, INRA-INAPG, BP 01, 78850 THIVERVAL-GRIGNON, France

Early weed demography models used a few key life-stages and directly related seed banks to emerged seedlings without distinguishing the underlying biological processes. Seedling emergence rates were linked to soil tillage without taking into account environmental conditions. These models were adequate to compare cropping systems over long terms within a given region. Recently, other authors analysed germination processes in detail, particularly as functions of hydro-thermal time. However, additional processes (e.g., seed survival and dormancy) and factors (e.g., tillage) were not taken into account. These models are interesting in situations with little tillage, high weed seed production and low dormancy. To develop models that can be used to advise farmers on strategic management decisions in a wide range of situations, modelling all processes and factors involved in the seed bank-seedling relationship may be necessary. "Black boxes" must be split into mechanistic relationships to distinguish the various underlying biological processes and to correctly quantify the impact of cropping system elements on these processes. The blackgrass (*Alopecurus myosuroides* Huds.) model, ALOMYSys, follows this principle. The emergence process depends on sub-models predicting (a) soil environment (structure, climate) resulting from the cropping system, (b) vertical weed seed distribution in soil after tillage, and (c) seed survival, germination and pre-emergence growth as a function of soil environment, seed depth, seed characteristics and past history. For each situation defined by the preceding crop sequence, the following crop, the labour and organisational constraints of the farmer, etc., this model can be used to determine the optimal tillage modes and sowing dates, based on frequency analyses using local climatic scenarios.

S4MT20AP03**BIODIVERSITY IN UK HORTICULTURAL SYSTEMS – THE RÔLE OF THE WEED SEEDBANK****A C Grundy¹, C Knott², P J Lutman³, E J P Marshall⁴, K Sunderland¹, B Smith¹ and J Fenlon¹**¹Horticulture Research International Wellesbourne, Warwick CV35 9RF, UK, andrea.grundy@hri.ac.uk; ²55 Church Street, Werrington, Peterborough PE4 6QU, UK, cathy.knott@btinternet.com; ³Rothamsted Research, Harpenden, Herts, AL5 2JQ, peter.lutman@bbsrc.ac.uk; ⁴Marshall Agroecology Limited, 2 Nut Tree Cottages, Barton, Winscombe, Somerset BS25 1DU, UK, jon.marshall@agroecol.co.uk

There is concern that the biodiversity of UK rural ecosystems is declining as a result of intensive agriculture and horticulture. Weeds play a key role in this decline. The weed seedbank provides both the foundation of future weed populations and a direct source of food to birds and invertebrates. Over the last 50 years this seedbank has undergone changes in density and species content in response to long-term general trends in agricultural practice. The most influential changes in arable systems have been in the type and timing of cultivation, stubble management, a move towards autumn sowing (cereals/oilseed rape), choice and diversity crops within a rotation and the introduction of herbicides. Arable studies have indicated that seedbank numbers are now critically low for many rare species, however no seedbank surveys have been specifically made of vegetable fields since the early 1970's, so information is lacking. Several measures have been suggested to help conserve and promote rare and/or beneficial weed species, for example field margins. Unfortunately, many of these schemes may not be appropriate to horticulture and developing desirable communities from the natural seedbank and seed rain can be an unreliable process. A recent review¹ has highlighted that in comparison with arable crops, horticulture leaves a small 'footprint' with a zero tolerance policy for weeds. However, the combination of soil types, wide range of crops and crop architectures, diverse weed species and spring cropping in horticulture may provide several new opportunities to complement and enhance strategies already in place in cereal crops.

¹"The impact of herbicides on weed abundance and biodiversity in horticultural crops" commissioned by the UK Department for the Environment, Food and Rural Affairs (Defra), 2003.

S4MT20AP04**MODELING EMERGENCE: INTEGRATING SOIL DEPTH DISTRIBUTIONS OF MICROCLIMATE AND SEEDS****F Forcella** and **D W Archer**USDA-ARS, 803 Iowa Avenue, Morris MN 56267, USA,
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Weed seedling emergence models are useful management tools. However, these models are in a state of infancy, and many improvements will be necessary before they are widely accepted by weed managers. Our objectives were to improve emergence models by integrating depth distributions of soil water, soil temperature, and soil hydrothermal time with depth distributions of seed burial tolerances and seed densities. Methods included (a) simulation of soil hydrothermal time from the soil surface to 15 cm depth at 1-cm increments using the SHAW model, which was produced by USDA-ARS (Idaho, USA); (b) adoption of *Chenopodium album* as a model weed species, as well as its hydrothermal-based seed germination model developed at the University of Guelph (Ontario, Canada), (c) employment of a burial tolerance model for *C. album* created at HRI (Wellesbourne, UK), and (d) adaptation of tillage-burial-depth transition matrices conceived by HRI and the former IACR (Long Ashton, UK). Results or simulations arising from the integration of these models revealed a much greater level of detail involving the timing and extent of emergence compared to other models that use hydrothermal time calculated from a single soil depth (e.g., 5 cm). We concluded that integration of depth distributions of soil microclimate, seed densities, and burial tolerances with seed germination functions improves emergence models considerably and is one step closer to making such models better management tools.

S4MT22P01**WEED MANAGEMENT IN MINOR CROPS. A VIEW FROM CHEMICAL INDUSTRY****M Quadranti** and **D Nevill***Syngenta Crop Protection Research, Stein, Switzerland*

The first problem in discussing the issues of weed control in minor crops arises in determining what constitutes a minor crop. In the majority of countries, minor crops are not precisely defined groups and do not have a clearly defined characteristic. The FIFRA defines the term "minor use" as any use of a pesticide on a commercial agricultural crop where the total US average for the crop is less than 300 k acres. The variety of agricultural goods commonly referred to as minor crop is nearly limitless. Weed control is an essential component of productive agriculture, and weed management is also imperative to the successful production of most minor crops. Increasingly stringent pesticide regulation and subsequent agrochemical reviews are reducing the range of pesticides available to minor crop growers and crop protection companies are often unwilling to (re)register for use on individual minor crops because of the limited revenues that they are able to obtain from these markets. Despite great advances in weed control technology finding new substances with better characteristics over the existing herbicides is imperative for both major and minor crops. We will review recent advances in the science and some components which will enable continued innovation and growth for research-based companies. The cost of searching for and developing new molecules puts a high strain on the R&D budget of the crop protection industry. Several companies will certainly continue to support product development for minor crops use where economically feasible.

S4MT22P02**PHYSICAL AND CULTURAL WEED CONTROL IN MINOR CROPS****B Melander**¹ and **P Barberi**²¹Danish Institute of Agricultural Sciences, Department of Crop Protection, Research Centre Flakkebjerg, DK-4200 Slagelse, Denmark, bo.melander@agrsci.dk; ²Land Lab, Scuola Superiore Sant'Anna, P.za Martiri della Libertà 33, 56127 Pisa, Italy, barberi@sssup.it

This paper summarises the major European achievements with physical and cultural weed control methods in minor row crops. Minor crops, such as vegetables, sweet maize and potatoes, present two different situations for physical weed control of entirely different difficulty. Inter-row weeds are easily removed by inter-row cultivation while intra-row weeds, i.e. those growing between the crop plants in the rows, still constitute a major challenge aimed at minimising laborious hand weeding. Investigations have focussed on optimising the use of mechanical principles against intra-row weeds, e.g. harrowing, brush weeding and finger weeding. These methods have been successful in some transplants, potatoes and maize, and may become alternatives to chemical control. However, in sown crops with low initial growth rates and in general in organic farming, current intra-row mechanical methods have to act in combination with thermal and cultural methods to achieve sufficient control, though some subsequent hand weeding may be needed. As such, methods worth mentioning are: mulching with dead or living materials; intercropping (e.g. celery in transplanted leek); optimised crop spatial arrangement (e.g. in pigeon bean); and solarisation to reduce soil seed viability. Although the need for hand weeding has been reduced markedly, this is still to be fully achieved. The direction in research has thus moved to new methods. Robotic weeding is now being investigated for row crops with abundant and precise spacing between individual plants, and soil steaming prior to sowing row crops that develop dense crop stands shows promise of effective and prolonged control.

S4MT22P03**SPLIT APPLICATIONS OF HERBICIDES FOR ENHANCED WEED CONTROL IN CABBAGE SEED CROPS****T W Miller**¹, **C R Libbey**¹, **R K Peterson**¹, and **B G Maupin**¹¹Washington State University Research and Extension Unit, 16650 State Route 536, Mount Vernon, WA, 98273, USA, twmiller@wsu.edu

The production of high quality seed requires that cabbage seed fields be maintained as free of weeds as possible. Weed competition from autumn through early spring, when cabbage plants are small and weed growth can be high, may be the most problematic time for cabbage seed production. Trials have been conducted from 2001-2003 at the Washington State University Research and Extension Unit to evaluate split applications of several herbicides to extend the effective period of weed control. Cabbage seedlings were transplanted in early September and herbicides applied at transplanting and again approximately 4 weeks later. In 2001-02, most herbicide combinations were providing excellent weed control in cabbage at 1 month after transplanting. Combinations with napropamide were generally the poorest, except when followed by sulfentrazone, pyridate, or simazine. Simazine followed by napropamide or hand weeding followed by napropamide, clopyralid, clomazone, or simazine also were performing poorly by early October. With the exception of napropamide (53%) and simazine (73%) in 2002-03, all treatments gave very effective weed control (93 to 99%) by early October. Control from single herbicides had declined to unacceptably low levels by late April, however. Several split applications improved the level of weed control through April, especially oxyfluorfen + clomazone or simazine, sulfentrazone + sulfentrazone, clomazone, or simazine, s-metolachlor + sulfentrazone or clomazone, dimethenamid-p + sulfentrazone, napropamide, pyridate, clomazone, or simazine, clomazone + pyridate, clomazone, or simazine, and simazine + sulfentrazone, clomazone, or simazine. Cabbage injury was uniformly low (0 to 7%) in October and January.

S4MT22P04**THE BIOLOGY AND CONTROL OF *TORILIS NODOSA* AND *ANTHRISCUS CAUCALIS* IN PYRETHRUM****R P Rawnsley¹, P A Lane¹, P H Brown¹ and T Groom²**

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Torilis nodosa and *Anthriscus caucalis* have become established as two of the major problematic weeds of pyrethrum (*Tanacetum cinerariaefolium*) production in Tasmania, Australia. This has occurred due to the unavailability of effective chemical control, the ability of the seed to attach its self to farm and harvesting machinery, and the possible contamination of pyrethrum seed. Little information regarding these two species has been published, particularly in Australia, and this paper provides a summary of a 3-year study of the biology and control of these Apiaceae weeds. A complete survey of all pyrethrum crops in Tasmania over two years found that more than 30% of all pyrethrum crops have either one or both species, with *A. caucalis* being the most prevalent. Both species were assessed as emerging in autumn, over wintering as rosettes, flowering in spring and seeds maturing over the spring and summer period. Seed germinability tests found that *A. caucalis* seeds have a low initial germinability with impermeable seed coat dormancy and a physiological dormancy that is broken by dry storage at 20°C. *Torilis nodosa* was found to have high initial germinability with no inducement into dormancy detected with cold stratification. The optimum germination temperature for *A. caucalis* and *T. nodosa* was 6°C to 15°C and 18°C to 25°C, respectively. Pot studies and field trials have also been undertaken to identify potential chemical control options.

S4MT22P05**POTENTIAL OF STALE SEED BED PREPARATION IN INTEGRATED AND ORGANIC CROP PRODUCTION****L A P Lotz¹, RY van der Weide², P Bleeker² and R Groeneveld¹**

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This paper reviews a study over six years to assess the potential of stale seed beds in various crops. Using stale seed beds, the farmer has to optimize the combined effect of, firstly, the delaying of the sowing time of the crop and, secondly, the timing of the stale seed bed (i.e. the period after the soil has been cultivated properly to stimulate emergence of weeds that are subsequently controlled by the definitive seed bed preparation). The effect of delaying crop sowing was analyzed using a historical data set from field experiments with 14 crops, e.g. broad bean, red beet, celeriac, green pea, evening primrose, scorzonera, silage maize, sugar beet. For sugar beet and maize, the experimental data were further analyzed using a model for crop growth. These analyses resulted into a table that gives for each crop the sowing date with on average the highest yield, and a yield reduction factor for every day the sowing is delayed. Effects of the length of the stale seedbed were analyzed using another historical data set on periodicity of emergence of a large number of different weed species. By combining results on both effects, a prototype Decision Support System was developed to advice the farmer in which crop and with which weed species a stale seedbed will be cost effective. In addition, innovations were developed to further increase the weed reduction, e.g. by covering a rotary harrow to prevent light induced weed germination while controlling the weeds. The results are discussed considering the response of farmers on the results.

S4MT22P06**CRITICAL PERIODS OF WEED CONTROL IN SUGAR CANE IN MAURITIUS****S Seeruttun¹ and P J W Lutman²**

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Weed control in sugar cane in Mauritius has to date aimed at total eradication of weeds from planting, or harvest in ratoon cane (cane planted in previous years), up to complete canopy closure. In the humid and superhumid areas the latter may take between 20 and 30 weeks; this involves two or three herbicide applications and is often complemented by manual weeding. To develop weed management strategies for reducing costs of weed control, critical periods of weed competition have been studied in six field trials, five in ratoon cane and one in plant cane, established between 1999 and 2003. In ratoon cane where weed infestation or weed-free periods were imposed from 8 to 14 weeks after harvest (WAH) of the previous crop, critical periods with natural weed infestations started 12.6 and ended 26.8 WAH under normal growth conditions. A simulated weed infestation of 50% of the full infestation reduced the critical period. In plant cane, the critical period was longer and control measures should be maintained up to 29 weeks after planting to keep yield losses to only 5%. The results confirm the justification of a second herbicide application in these areas and could be used to decide on the timing and herbicide treatments to avoid the third application or any manual intervention.

S6MT01P00**EVALUATION OF BETANAL PROGRESS OF IN FAILED WEED CONTROL PROGRAM IN SUGAR BEET****M. Bazoobandi¹ and P. Shimi²**

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There have been numerous increasing reports claiming unsatisfactory weed control applying phenmedipham+desmedipham (betanal AM) in sugar beet farms during last several years in Khorasan province, the most important sugar beet cropping area in Iran. Whatever the reason is, farmers demand new herbicides to reduce crop loss. The objective of this study was to evaluate new herbicide phenmedipham+desmedipham+ethofumesate (progress OF) for effective weed control in this area. The present investigation was carried out at the farm of Khorasan Agricultural Research Center during growing season of 2002. The experiment was laid out in a randomized complete block design. Treatments consisted of different dose and mode of application of the new herbicide alone and in combination with metamiltron. No-spray was included in the experiment. Each treatment replicated three times. Results revealed that application of new herbicide at the rate of 1 liter at cotyledons stage followed by 1 liter two weeks later, significantly provided better control compared to earlier conventional one. Combination of new herbicide with metamiltron resulted in broader spectrum of weed control. Since only concentration and origin of new and old formulation of betanal were the source of variation, it can be concluded that either development of herbicide resistance or ineffective local formulation caused the poor weed control.

S6MT01P00**GRAMINICIDES AND BORON COMPATIBILITY ON VOLUNTEER CORN CONTROL AND MINERAL NUTRITION IN SUNFLOWER CROP****A. M. Brighenti¹, C. Castro¹**¹ *Embrapa Soybean, P O Box 231, Londrina, Paraná State, Brazil, brighenti@cnpso.embrapa.br, ccastro@cnpso.embrapa.br*

Low levels of boron (B), characteristic of Brazilian soils, can take to the deficiency of this nutrient, mainly in the sunflower flowering and maturation stages. In the savannahs area, the culture is sowed after soybean or corn and volunteer corn plants can compete with sunflower. The experiment was carried out at Barra Bonita farm, Chapadão do Céu county, Goiás State, Brazil, to evaluate the control of volunteer corn with graminicides, alone or in combination with boron fertilizer, as well as, the response of sunflower crop to this micronutrient. The experiment was arranged in a split-plot design in a randomized complete blocks, with five replicates. The treatments were haloxyfop-methyl (48 g a.i./ha) plus 1.2 L/ha of mineral oil, sethoxydim (220 g a.i./ha) plus 1.2 L/ha of mineral oil, clethodim (120 g a.i./ha) plus 1.2 L/ha of mineral oil, fluzafop-p-butyl (187 g a.i./ha) and an unweeded control as the main plots and the absence and the presence of boron as the subplots. The treatments were applied alone or in combination with 400 g/ha of B (H₃BO₃ and Na₂B₃O₁₃.4H₂O). All herbicides applied alone or in association with two B sources were efficient on volunteer corn control with values of 100%. The boron content increased on sunflower leaves when the nutrient were applied with herbicides. The values were on average of 54 mg/kg in the leaves that didn't receive boron and 66 mg/kg when this micronutrient was applied. The application of graminicides with boron is a good strategy for controlling volunteer corn and avoiding B deficiency in sunflower crop.

S6MT01P00**PHYTOTOXICITY OF NEW HERBICIDES IN SUGARCANE**

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Mechanical eradication of sugarcane by ploughing can lead to weed problems, for example *Rottboellia cochinchinensis* (Lour.) Clayton, *Panicum maximum* Jacq., *P. schinzii* Hack., *Cyperus esculentus* L. and *C. rotundus* L. These species germinate rapidly and suppress growth of newly planted sugarcane. Registered herbicides are required to effectively control these species. The South African Sugar Association Experiment Station (SASEX) is frequently requested by agrochemical companies to determine the phytotoxicity of specific products to supplement their field trial data on the use of these chemicals in sugarcane. The objective was to evaluate the phytotoxicity of four different treatments; (i) metribuzin + chlorimuron-ethyl, (ii) metribuzin + chlorimuron ethyl + pendimethalin, (iii) pendimethalin + ametryne + atrazine, and (iv) pendimethalin + diuron. Test products were compared with metribuzin + diuron, an industry standard that is registered for use in sugarcane. Pot trials were conducted in different soils, according to the specific company requirements. Products were applied to two or three cultivars, all as single and double dosages. No significant differences were recorded in stalk height and both fresh and dry mass between the industry standard and the tested herbicide treatments, irrespective of dosage. The importance of this study is that it will assist in the registration of four new tank mixtures for the pre-emergence control of *R. cochinchinensis*, *Panicum maximum*, *P. schinzii*, *C. esculentus* and *C. rotundus* in sugarcane.

S6MT01P00**DIAGNOSIS AND REDUCTION OF HAZARDS OF SEVERAL HERBICIDES TO TRANSPLANTING RICE****Chen Zhishi and Wu Jinglun***Institute of Plant Protection, Jiangsu Academy of Agricultural Sciences, Nanjing 210014, China, wujl4390228@163.com*

To verify the symptoms of different kinds of herbicides hazards to rice, the sensitivity difference between *indica* and *japonica* rice and the role of the agricultural treatments to reduce the hazards, several kinds of commonly used herbicides including amides, heterocyclics, sulfonyleureas, phenoxy carboxylic acid, diphenyl ether, organophosphorus and thiocarbamates were over dosage applied to the transplanting *indica* and *japonica* rice by puddling treatment and mist spray. The results showed that the different degree of the hazards was produced. The symptoms of the herbicide hazards were mainly including dwarfing, yellowing, inhibited tillers, distorted leaves, seriously withered leaves and no tillers and even died plants in rice plants. There was the difference of sensitivity to the different herbicides between *indica* and *japonica* rice. By water washing, laying aside lands and fertilizer application, the hazards of some herbicides such as agritox and metolachlor to rice could be reduced. But some herbicides such as setoff, glyphosate and paraquat could not be reduced and would make great loss to rice yield.

S6MT01P00**HERBICIDE EFFICACY AND SELECTIVITY OF NEW TRIFLOXYSULFURON PLUS AMETRYN FORMULATION AND TANK MIXTURE IN SUGARCANE****J.C. Diaz¹, F. Hernández¹, C. Fernandez¹, R. Ruaznabar¹ and J.J. Diaz²**

¹*National Sugarcane Research Institute (INICA), Carr. Central Martínez Prieto km 2½, Boyeros, Havana, C.P. 19390, Cuba, e-mail: jcdiaz@inica.edu.cu* ²*Grupo Empresarial MINAZ Matanzas* Six field trials were conducted on various weed, crop, soil and climatic conditions in Cuba. The formulation trifloxysulfuron 1.75% + ametryn 73.15% (Krismat WDG 75) effectively controlled annual grasses: *Rottboellia cochinchinensis* (Lour.) Clayton, *Echinochloa colona* (L.) Link, *Eleusine indica* (L.) Gaertn., *Digitaria adscendens* (Kunth) Henr., *Brachiaria fasciculata* (Sw.) Blake, *Leptochloa panicea* (Retz.) Ohwi, and *Sorghum sudanense* (Piper) Stapf.; and annual broadleaves: *Amaranthus dubius* Mart., *Euphorbia heterophylla* L., *Chamaesyse hyssopifolia* (L.) Small., *Ipomoea trifida* (Kunth) and *Crotón lobatus* L., postemergence under moderate to high soil moisture, while *Sorghum halepense* (L.) Pers. was not controlled. Furthermore, selectivity in sugarcane, applied broadcast on the crop foliage, was very high in all four assessed cultivars (CP52-43, Co997, C323-68 and C1051-73, the two former ametryn-susceptible), showing very slight and short lasting to no phytotoxicity symptoms, even better than standard ametryn 2.4 kg a.i./ha. Dosages of 0.035-0.044 kg a.i./ha trifloxysulfuron + 1.46-1.83 kg a.i./ha ametryn (2 - 2.5 kg/ha commercial product), plus 0.1 % v/v nonionic surfactant, were similar to better than standard ametryn 2.4 kg a.i./ha and MSMA + ametryn, 2.16 + 0.8 kg a.i./ha, respectively, and is recommended: the lower rate in a younger weed growth (5 to 15 cm) stage, and the higher rate in a more advanced (20 -40 cm) stage. Higher surfactant concentrations did not improve efficacy. Under low soil moisture, herbicide efficacy was overall poor, including standards. Tank mixtures of trifloxysulfuron WDG 75 (Envoke) plus ametryn also showed effective control of *Rottboellia cochinchinensis* and *Euphorbia heterophylla* and high crop (B77418) selectivity.

<p>S6MT01P00 EFFICACY OF SOME NEW HERBICIDES ON WEED AND YIELD COMPONENTS OF WHEAT</p> <p><u>Imtiaz Khan</u>, Gul Hassan, Muhammad Azim Khan and Muhammad Isfaq Khan</p> <p><i>Department of Weed Science, NWFP Agricultural University, Peshawar 25130, Pakistan, imtiazagri@yahoo.com</i></p> <p>Field study was conducted at Malkandher Research Farm, NWFP Agricultural University, Peshawar during Rabi 2002-03 to investigate the effectiveness on grass and broadleaf weed of various herbicides including newly introduced formulation of tribenuron methyl and thifensulfuron methyl. The experiment was laid out in randomized complete block design with 4 replications. The experiment was included 11 commercial herbicides. The herbicidal treatments were postemergence applications of 37 g/ha thifensulfuron methyl, 50 g/ha thifensulfuron methyl, 50 g/ha tribenuron-methyl, 150 g/ha triasulfuron + terbutryn, 450 g/ha bromoxynil + MCPA, 10 g/ha isoproturon, 13 g/ha carfentrazone ethyl, 490 g/ha MCPA, and 96 g/ha chlorfluazuron. Ghaznavi-98 variety of wheat was planted during the third week of October 2002. The number of tillers per plant, 1000 kernel weight (g), biological yield (t/ha) and grain yield (t/ha) were recorded. The maximum grain yield was recorded with new soluble or SG formulation of tribenuron and thifensulfuron, 40% emulsifiable concentrate or EC formulation of bromoxynil, and 64% water dispersible granule or WDG formulation of terbutryne trisulfuron with grain yield of 4.133, 3.866 and 3.599 t/ha respectively. The untreated plots yielded 2.133 t/ha.</p>	<p>S6MT01P00 Sprays, spreading and significance for cuticular uptake</p> <p>Jerzy A. Zabkiewicz and W. Alison Forster</p> <p>Plant Protection Chemistry^{NZ}, Forest Research, Rotorua, New Zealand Jaz@forestresearch.co.nz</p> <p>It is well known that adjuvants can affect the behaviour of droplets once they have landed on a leaf, most often through droplet spreading behaviour. Recent studies have shown that this affects the distribution and concentration of a.i. which is left after droplet dry-down. This is termed the 'initial dose' if expressed as a mass per unit area, and has significance in the creation of differing concentration gradients from the exterior to the interior of the plant cuticle. This is of fundamental relevance to the 'driving force' component of Fick's law relating to cuticular diffusion mechanisms.</p> <p>The present study illustrates the differences and significance of differing droplet spreading behaviour by solutions of 2,4-D and two surfactants, over a wide a.i. concentration range on three plant species. As concentration increases, so percentage uptake decreases; but if calculated vs the initial molar concentration of a.i. applied, the total mass taken up continues to increase. Uptake still shows species differences, and differences due to the different surfactants, which are much smaller. Comparison of mass uptake vs initial dose shows a linear relationship unless there are extra-cuticular effects such as precipitation of the a.i. If such effects are excluded, then cuticular uptake shows an excellent linear relationship over a 5-decade range. This approach has considerable scope for developing models of a.i. uptake including the influence of species and surfactant structure.</p>
<p>S6MT01P00 THE POSSIBILITY OF WEED CONTROL WITH NICOSULFURON IN MAIZE</p> <p>Viktor Zadorozhny</p> <p><i>Feed Research Institute of the Ukrainian Academy of Agricultural Sciences, Prospekt Yunosti 16, UA 21100 Vinnitsa, Ukraine E-mail: fri@mai.vinnica.ua</i></p> <p>Introduction. The composition of weed communities in maize in the forest-steppe zone of Ukraine consisted 12-16 species of annual and perennial weeds. Weed infestation was in interval from 46 to 490 plants per m², among which a share of annual grass reached 53-86 %. This problem is increasing and can only be solved if integrated weed management methods are implemented. Post emergence herbicides play an important role in this approach. The objective of this research was to investigate the possibility of application of reduced doses of nicosulfuron used as post-emergence weed control, alone or with ammonium nitrate in maize. Field trials were conducted during 1998-2003 at the Feed Research Institute of UAAS. Soil was a grey wooded type with 2.2-2.4 % o.m. content and pH 5.2-5.5. Results showed that overall weed infestation of maize 30 DAT after application of nicosulfuron at 37.5 and 50 a.i. g ha⁻¹ was reduced by 78-84%. Nicosulfuron efficiency was 5-7% higher at the first date of application than at the second date of application which was 3-6 days later. The ammonium nitrate addition to the nicosulfuron at 25-40 a.i. g ha⁻¹ to increased activity by 8-22% of herbicide against weeds including <i>Chenopodium album</i>. Conclusions. The efficacy of nicosulfuron was the highest when it was applied at early stages of weed plant development. In this case the adequate level of weed control can be achieved with the dose of nicosulfuron at 37.5 a.i. g ha⁻¹. Inclusion ammonium nitrate to the spray solution of nicosulfuron allow reducing application rate by 25 % without any loss efficacy.</p>	<p>S6MT01P00 A NOVEL FORMULATION OF GYLPHOSATE – 88.8% WATER SOLUBLE GRANULE</p> <p>Hongxiu Zhang</p> <p><i>Nantong Feitian Chemical & Industrial Co. Ltd., Nantong, Jiangsu 226001, P. R. China, zhxnt@pub.nt.jsinfo.net</i></p> <p>Glyphosate is a widely-used nonselective herbicide. In order to enhance the weed control efficacy and reduce transportation cost, we innovated and patented a novel high content formulation 88.8% water soluble granule of this herbicide in China. A plant-derived surfactant SDP was added in this formulation, which significantly improved the abilities of wetting, penetrating, absorption, and translocation of the herbicide and then resulted in good performance in weed control. Findings from a lot of experiments conducted in different regions of China showed that this formulation could provide stable and excellent control at rates of 90-135 g/ha for annual weeds, 135-180 g/ha for perennial weeds, and 180-225 g/ha for brushes.</p>

S6MT03P00**BIOLOGICAL CONTROL OF TROPICAL SODA APPLE WITH A NOVEL VIRUS-BASED BIOHERBICIDE****R Charudattan¹, M S Elliott¹, J T DeValerio¹, J Horrell¹, and E Hiebert¹**¹Plant Pathology Department, PO Box 110680, University of Florida, Gainesville, Florida 32611-0680, USA, rcharudattan@ifas.ufl.edu

Tropical soda apple (*Solanum viarum*; TSA), a highly invasive weed in Florida and the Southeastern USA, is susceptible to Tobacco mild green mosaic tobamovirus (TMGMV). TMGMV kills TSA by triggering a delayed hypersensitive host reaction. TMGMV-inoculated TSA develops foliar local lesions, systemic foliar necrosis, and systemic wilting about 14 days post-inoculation. Plants of different sizes and ages are killed; up to 99% control has been seen in field trials. TSA can be killed by inoculating just a few leaves per plant; complete foliar coverage is not needed. We have developed methods for large-scale production of TMGMV, its storage, and field application. A risk-analysis study has confirmed that a vast majority of the plant species tested are not at risk, but pepper and tobacco are hosts of concern. TMGMV-induced hypersensitivity is highly host-specific, but infectivity, resistance reaction (HR response), and susceptibility (mild chlorosis) are less host-specific. TMGMV can be recovered from soil and roots of potted TMGMV-infected TSA but not from field soil in which infected TSA was grown and killed by the virus. The risk posed by the use of the virus is negligible and manageable because: TMGMV is unlikely to spread from treated sites since it has no natural vectors; we will not introduce anything new to the regions where the virus will be used because it is naturally present; and site-restrictions can further prevent dangers to pepper and tobacco crops. We are attempting to register TMGMV as the first viral bioherbicide

S6MT03P00**ENHANCING CONIDIA YIELD BY DACTYLARIA HIGGINSII, A POTENTIAL BIOHERBICIDE FOR WEEDY CYPERACEAE, WITH PLANT GROWTH REGULATORS AND BIOSTIMULANTS****J.P. MORALES-PAYAN^{1,2}, R CHARUDATTAN², J T DeVALERIO², and W M STALL¹.**¹Horticultural Sciences Department and ²Department of Plant Pathology, University of Florida, Gainesville, FL. 32611-0690. pmorales@ifas.ufl.edu

One of the limitations for the development of *Dactylaria higginsii*, a potential bioherbicide for weeds in the Cyperaceae, is its low conidia yield in culture media. Experiments were conducted to determine the yield and disease severity (DS) caused by conidia produced in PDA culture medium amended with indole butyric acid (IBA) (0, 0.01, and 0.1%), acetylthioproline (AP) (0.03 and 0.3%), a triterpenic acid-rich extract from *Abies sibirica* (TTA) (0.01 and 0.1%), and a commercial mixture of zeatine + indole acetic acid + gibberellic acid + micronutrients (ZIGM) (0.25 and 2.5%). In general, the 0.01% TTA, 0.1% IBA, and 2.5% ZIGM amendments did not affect conidia yield or DS produced by the conidia in *Cyperus rotundus*. In medium amended with 0.1% TTA, conidia yield was 65% lower, conidia were smaller, and DS was 50% lower than with conidia produced on control medium. Amending the medium with 0.3% AP did not affect conidia yield, but conidia were smaller and DS was reduced by 40%. Conidia yield increased with the 0.03% AP, 0.01% IBA, and 0.25% ZIGM amendments, but the extent of yield improvement was inconsistent for the same amendment. On average, conidia yield was tripled and DS was not affected by the amendment of 0.03% AP or 0.25% ZIGM. Medium amended with 0.01% IBA produced five times as many conidia as control medium, and DS was not affected. These results suggest that conidia yield in *D. higginsii* may be manipulated by amending culture media with some biostimulants and plant growth regulators.

S6MT03P00**PESTA FORMULATION AND SEED TREATMENT TECHNOLOGY: ATTRACTIVE DELIVERY SYSTEMS FOR STRIGA MYCOHERBICIDES - STEP TOWARDS PRACTICAL FIELD APPLICATION****Jürgen Kroschel¹ and Abuelgasim Elzein²**¹Institute of Plant Production and Agroecology in the Tropics and Subtropics, University of Hohenheim (380), D-70593 Stuttgart, Germany, E-mail: kroschel@uni-hohenheim.de; ²Department of Crop Protection, University of Zalingi, P.O. Box 6, Zalingi, Sudan, E-mail: gasim@uni-hohenheim.de

Fusarium oxysporum "Foxy 2" proved to be highly virulent against its target weed *Striga hermonthica*, host specific and it can be mass-produced. This research focused on the development of appropriate formulations, thereby reducing the amount of inoculum required for a practical field application. 'Pesta' granules were made by encapsulating chlamydo-spores or microconidia in a matrix composed of durum wheat-flour, kaolin, and sucrose. Their efficacy was tested using 0.5 g of granules per kg soil⁻¹. Sorghum seeds were also coated with Foxy 2 to further minimize the inoculum amount and to facilitate delivery. Hence, the criteria of Foxy 2 of being a promising candidate for controlling *Striga* when applied as a seed treatment were investigated. All types of the 'Pesta' formulated propagules reduced *Striga* emergence and significantly improved the panicle yield of sorghum in pot trials. The calculated efficacy of freshly formulated chlamydo-spores (77%) was higher than that of dried chlamydo-spores (59%) or microconidia (65%) preparations. Further, the 85-100% shelf-life of Pesta granules prepared with chlamydo-spores for at least one year at 4°C would be adequate for commercialization. Foxy 2 survived the seed coating and showed excellent viability on seeds for at least one year of storage. The fungus was also able to colonize the root system of sorghum, and to show promising efficacy in controlling *Striga* of up to 80%. By adopting formulation technology, a dramatic reduction (95%) in the required end-use dosage of fungal inoculum was achieved. In addition, an optimized seed coating protocol was provided. Both technologies offer a significant practical solution for large scale application. **Appropriate topic: Biological Control An abstract for short oral presentation**

S6MT03P00**BIOLOGY AND HOST SPECIFICITY OF PLECTONYCHA CORRENTINA LAC. (CHRYSOMELIDAE), A CANDIDATE FOR BIOCONTROL OF MADEIRA VINE (ANREDERA CORDIFOLIA)****D. Gandolfo¹, C. Cagnotti¹, F. McKay¹ and S. Nesar²**¹South American Biological Control Laboratory, USDA-ARS, Bolivar 1559 (B1686EFA), Hurlingham, Argentina. dgandolfo@speedy.com.ar, ² Agricultural Research Council, Plant Protection Research Institute, Private Bag X134, Pretoria, 0001, South Africa

Anredera cordifolia (Madeira vine) (Basellaceae) is native to southern South America. It has become an environmental weed in Australia, New Zealand and South Africa. Madeira vine is a perennial climber that forms mats over trees and shrubs disrupting rainforest and riparian communities. It reproduces mostly by aerial and underground tubers. Surveys of natural enemies of *A. cordifolia* conducted in Argentina indicated that *Plectonycha correntina* is a promising agent for biocontrol of this weed. Larvae and adults are leaf-feeders; larvae live enclosed in a sticky substance formed by plant juices and feces, which they rid themselves of before pupation in a foamy cell in soil crevices. Host range was investigated by no-choice larval developmental and adult feeding and oviposition choice tests. Insects were exposed to 14 species in the Basellaceae (3 species), Portulacaceae (4), Crassulaceae (3), Cactaceae (3) and Aizoaceae (1). Besides Madeira vine, larvae were able to develop, though with increased mortality, in the two other tested Basellaceae species (*Ullucus tuberosus*, and *Basella alba*). Adults feeding and oviposition tests showed equivalent results. When *A. cordifolia* was not present (choice minus control design) some nibbling was recorded on tested plants and few eggs that failed to develop were laid on *Talinum paniculatum* (Portulacaceae). Results suggest that *P. correntina* has a narrow host range, with Madeira vine as the primary host, but other species in the Basellaceae family might act as secondary hosts. Therefore, the safety of this agent will depend on the composition of the flora in the area of introduction.

S6MT03P00**INVESTIGATION OF *MICROSPHAEROPSIS AMARANTHI* AS A BIOHERBICIDE FOR WATERHEMP, *AMARANTHUS TUBERCULATUS* SAUER.****D A Smith and S G Hallett**

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Waterhemp, *Amaranthus tuberculatus* Sauer. has become a key weed of Midwestern cropping systems in the last 10-15 years, and its ascendance has been attributed to the widespread adoption of no-till cropping systems and the development of herbicide resistant biotypes. Waterhemp is now a frequent escape from weed management systems in Midwestern corn and soybeans, and as such represents an excellent target for a host-specific bioherbicide, provided such a bioherbicide can be integrated into cropping systems. *Microspheeropsis amarantii* is a virulent fungal pathogen of waterhemp with a host range limited to the Amaranthaceae. We conducted a range of experiments to investigate the potential of *M. amarantii* to be integrated into corn/soybean weed management systems dominated by herbicides. There was a strong interaction between *M. amarantii* and glyphosate when conidia of the fungus were sprayed onto plants 24 h after glyphosate, suggesting that *M. amarantii* could be used to increase the efficacy of waterhemp control at current use rates of glyphosate. In experiments designed to simulate interactions in a spray tank during field application, conidia of *M. amarantii* were incubated in solutions of a wide range of different herbicides and adjuvants. These experiments revealed that many herbicides and adjuvants were strongly inhibitory to the germinability of conidia of *M. amarantii*. We conclude that although *M. amarantii* is virulent against waterhemp and has the potential to interact positively with glyphosate on plants, its integration into cropping systems will be hampered by incompatibility with herbicides and adjuvants.

S6MT03P00**NEW NATURAL WEED - VIRUS RELATIONS****G Kazinczi¹, J Horváth², A P Takács¹, J Mikulás³, E Pocsai⁴ and L Magyar⁵**

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The aim of our work was to detect new data about the role of weeds in the virus epidemiology. Between 1997 and 2003 years samples of 17 weed species showing different virus symptoms (mosaic, chlorotic-necrotic lesions, leaf deformation, chlorotic rings, chlorotic patterns) and symptomless ones were collected from different parts of Hungary from arable and waste lands and water ecosystems. Virus infection was evaluated by biotest, DAS ELISA, electronmicroscopical and immunosorbent electromicroscopical (ISEM) methods. A lot of new natural host-virus relations were detected which has a great virus epidemiological and economical importance. The most important are the followings: *Asclepias syriaca* - Tobacco mosaic virus, Alfalfa mosaic virus, Tomato spotted wilt virus; *Alisma plantago-aquatica* - Potato virus Y, Sowbane mosaic virus; *Ambrosia artemisiifolia* - Cucumber mosaic virus; *Mercurialis annua* - Sowbane mosaic virus; *Solidago gigantea* - Cucumber mosaic virus, Raspberry ringspot virus, Beet necrotic yellow vein virus. The importance of perennials (*A. syriaca*, *A. plantago-aquatica*, *Cirsium canum*, *Lysimachia vulgaris*, *Lythrum salicaria*, *S. gigantea*) is especially high, regarding that these species are not only infection sources but have a great importance in overwintering of plant viruses.

S6MT03P00**BIOLOGICAL CONTROL OF INVASIVE *PROSOPIS* SPP. IN SOUTH AFRICA THROUGH THE USE OF FUNGAL AGENTS****C L Lennox**

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Prosopis glandulosa var. *torreyana* and *P. velutina* (prosopis), native to North and Central America, are declared invaders in South Africa. Long-term, economically viable management of prosopis will only be achieved through the integration of biological control with other control methods. In September/October 2001, a survey was made of pathogens on prosopis in Mexico and Texas. A pod disease, caused by an as yet unidentified fungus, and characterized by black/grey acervuli, flattening of the pods and seed decay, was found in both Mexico and Texas. A gall rust (*Ravenelia arizonica*) was recorded in both countries. The leaflet rust (*Ravenelia holwayi*) was found in Texas. Species of *Diplodia*, *Phoma* and *Sphaeropsis* species were also regularly isolated from material collected in both countries. In November 2001, a decision was taken at a national workshop on the status and long-term management of prosopis in South Africa to limit biological control agents to those targeting flowers, pods and seeds. The unidentified pod pathogen satisfied these criteria. In pathogenicity tests conducted in quarantine, 30% of inoculated plants were killed while a further 40% showed disease symptoms. Preliminary host specificity tests showed the pod pathogen to be specific to prosopis. This fungus is currently being described as a new species which will be placed in a newly-erected genus.

S6MT03P00**PROSPECTS FOR THE BIOLOGICAL CONTROL OF WILD RADISH USING PLANT PATHOGENS****A Maxwell¹ and J K Scott¹**

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Wild radish (*Raphanus raphanistrum*) is rated as one of the most serious weeds of the grain-cropping region of southern Australia. As a result of increasing herbicide usage in cropping systems of southern Australia, populations of this weed have developed multiple resistance to herbicide groups B, C and F. To widen the management options we are examining the potential to apply inundative or classical biological control to WR. A survey for pathogens of WR was conducted in order to identify gaps in the pathogen profile that could be filled via classical introductions, and to determine whether fungi suitable for development into a mycoherbicide were present. Disease symptoms, incidence and severity on WR were rated at 75 locations throughout the grain-growing region of south-western Australia, and pathogens isolated and identified. Ten disease symptoms were recorded on WR. *Alternaria infectoria*, *Leptosphaeria maculans* and *Peronospora parasitica* were the most severe and common causes of disease. Based on their morphological identity, all of the important fungal pathogens of WR known from elsewhere are present in south-western Australia. However, the taxonomy of some of these species, including *P. parasitica* is under debate and molecular data is required to clarify the status of species within these genera. Research is currently being conducted to compare the molecular taxonomy and host range of *Alternaria* and *Peronospora* pathogens of *Brassica* species. This information will enable a decision to be made on whether a classical or inundative strategy for the biological control of wild radish, is most promising.

S6MT03P00**BIOLOGY AND HOST RANGE OF A SEED-FEEDING WEEVIL, *APION* N. SP. (COLEOPTERA: BRENTIDAE), A CANDIDATE FOR THE BIOLOGICAL CONTROL OF MESQUITE IN SOUTH AFRICA.****F. Mc Kay¹, D. E. Gandolfo¹, S. Nesar² and H. A. Cordo¹**¹ USDA-ARS, South American Biological Control Laboratory, Bolivar 1559, B1686EFA, Hurlingham, Buenos Aires, Argentina. fermc@ciudad.com.ar;² ARC-Plant Protection Research Institute, Private Bag X134, Queenswood, 0121 South Africa, rietsn@plant2.agric.za

Many *Prosopis* spp. (mesquite) were introduced to South Africa from North and South America in the late 1800s to provide shade, firewood and fodder. At least four species, *Prosopis velutina* Wootton, *P. glandulosa* Torrey var. *glandulosa*, *P. glandulosa* Torrey var. *torreyana* (L. Benson) M.C. Johnston, and *P. chilensis* have become widespread in the dry northwestern parts of the country. In this region plants often form dense impenetrable thickets where most of the beneficial attributes of the plant are lost. They also use much of the scarce underground water. To inhibit the spread of the weed without diminishing its useful attributes biocontrol programmes have been restricted to seed-feeding organisms, which resulted in the release of two bruchid species in the 1980s. Subsequent surveys in Argentina revealed the presence of a potential agent, an undescribed *Apion* species. Adults feed on leaves and green pods. Eggs are oviposited in immature pods and larvae develop in the seeds. Larval activity does not affect the development of the pods, which retain much of their value as fodder. Adult feeding and oviposition preference trials were performed on 19 species in the Leguminosae (nine genera) in no-choice and paired-choice trials. Eggs were only laid in mesquite species in both trials. Adult feeding was intense on the *Prosopis* spp. tested, with some negligible feeding damage on non-target species. The biological characteristics and narrow host range of *Apion* n. sp. suggest that it is a safe and promising agent for the biological control of mesquite in South Africa.

S6MT03P00**SOME ECOLOGICAL FEATURES OF BLACKBERRY (*RUBUS* SPP.) AND ASSOCIATED BIOLOGICAL CONTROL AGENTS IN NORTHERN AFFORESTATIONS OF IRAN.****M. Mohammadi¹ and A. N. Salari¹**¹ Research Institute of Forests and Rangelands, P.O.Box 13185-116, Tehran, Iran.Email: mohammadi@rifr-ac.ir

The genera of *Rubus* has 8 species and 5 hybrids in Iran. All of them are growing in northern afforestations of Iran from 0-2300 m above sea level, except, *R. saxatilis* L. In northern parts of Iran, Blackberry plants reproduce rapidly and vastly, They get hard (or sometimes impossible) in regeneration of forest tree species. These bushes grow very well in area having more than 600-mm rainfall and also humidity is important for their growth. Lack of human sources in the growing season and high expenditures to control Black berries in one hand and failure in routine practices such as clear cutting by human power and difficulty of applying chemical control measures especially in hillsides and slope areas in other hand, to research on possible biological control of bushes in Northern provinces. Because of different species and variation between their hybrids, destroying and mechanical or chemical control of these species are very difficult, so biological control is very important.

According to 5 years survey and study during 1997-2002, on biological control agents of blackberries, 9 species including 3 fungi (*Fragmidium iranicum*, *Cercospora rubri* and *Botrytis* spp.), five insects (*Decorana capitata*, *Aphis idaei*, *Platycoleis* sp. and two unknown species) and one spider mite (*Tetranychus urticae*) were collected as biological control agents in northern afforestations of Iran.

It was concluded that through protection and conservation of selected agents and further mass rearing and releasing them, it is possible to control blackberries in forest stands and plantations.

S6MT03P00**REACTION OF WILD TAPERI, *PHYSALIS MINIMA* L. AGAINST THE INFESTATION OF YELLOW MITE, *POLYPHAGOTARSONEMUS LATUS* BANKS (ACARI: TARSONEMIDAE) IN ENTISOL OF INDIA****P.K. Sarkar¹, A.K. Somchoudhury² and R.K. Ghosh³**^{1,2} Department of Agricultural Entomology, ³ Department of Agronomy

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An attempt was made during 1999-2000 & 2000-2001 to study the reaction of *Physalis minima* against yellow mite, *Polyphagotarsonemus latus*, a very common and obnoxious arachnid pest of Chilli. The mites were distributed on the topmost portion of the weed canopy; specially on the apical primordial leaves and distributed up to fourth leaf. The infestation caused inverted boat shaped curling of the leaves. The leaves became leathery and brittle. The males found to move very fast on the leaf surface and carry the quiescent larvae with the help of their fourth pair of legs to the topmost portion of the plant canopy. The species is photopositive in nature afterwards become photonegative. The mites feed on the cell sap and inject toxin, which resulted in the symptoms. The mites were prevalent during pre-monsoon months i.e. January end to June - July. The population varied from 12-27 /leaf. Intermittent rainfall followed by a dry spell was favoured by the mite species. It was very interesting to note that, there were no predatory mite in association with the yellow mite. The interaction study between the incidence of yellow mite in one hand with different abiotic factors like temperature, relative humidity, rainfall and sunshine hours on the other revealed that, the mites maintained a positive relationship with temperature, relative humidity & rainfall and a negative correlation with sunshine hour.

S6MT03P00**WEEDS AS NATURAL RESERVOIR OF PREDATORY PHYTOSEIID MITE (ACARI: PHYTOSEIIDAE) FAUNA IN FRUIT ORCHARDS IN INCEPTISOL OF INDIA****P. K. Sarkar¹, Prakash Ghosh², A. K. Somchoudhury³ and R. K. Ghosh⁴**¹⁻³ Department of Agricultural Entomology & ⁴ Department of Agronomy

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Observation on population dynamics of predatory mites were recorded in two consecutive years 2000-2001 and 2001-2002 on different weeds found in the vicinity of a fruit orchard containing Mango, Litchi, Pomalo and Coconut plantation. These fruit trees were infested with different plant feeding mite species and used to cause havoc loss in yield. The joint occurrence of plant feeding and predatory mites in those fruit plants revealed the presence of *Amblyseius aceriae*, *A. coccococius*, *A. largoensis*, *A. mangiferae* and *A. ovalis* in moderate or negligible number due to indiscriminate use of different pesticides.

Different weed species within the orchard were found to maintain a good and steady number of predatory phytoseiid mites belonging under the Genus *Amblyseius* (Acari : Phytoseiidae). The other important predatory groups were *Lasioseius*, *Bdellodes*, *Neocunaxoides*, *Agistemus* and *Leptus*. The mites of the genus *Amblyseius* were relatively wide spread on wild plants and have immense potentiality in controlling plant feeding mites. The mites of other genus are also promising.

The number of predatory mites (*Amblyseius*) varied from 2-7 per leaf. The predatory mite population were found to be maximum during December - January / February (6.55 and 4.55 / leaf, respectively) coinciding with the mean ambient atmospheric temperature to the tune of 15- 20^o C and 60-72 % RH. The population dwindles with the increase in atmospheric temperature from March onwards. However, the mites were recorded through out the year in varied numbers. Detailed studies were conducted on the seasonal incidence and the food preference of the predatory arachnids.

S6MT03P00**BIOLOGICAL CONTROL OF RAGWORT (*SENECIO JACOBAEA*): MONITORING FOR NON-TARGET IMPACTS OF *COCHYLIS ATRICAPITANA* AND *PLATYPTILIA ISODACTYLA* ON NATIVE AUSTRALIAN *SENECIO* SPECIES.****K.A Snell¹ and D.A McLaren^{1,2}**¹Primary Industries Research Victoria (PIRVic), Department of Primary Industries, Frankston Centre, PO Box 48, Frankston 3199, Australia²CRC for Australian Weed Management

Despite rigorous host range and specificity testing before the approved release of weed biological control agents there is still a great need to ensure the post release safety of non-target plants. This is to confirm, as testing predicts, that agents continue to remain specific to their host plants and do not cause detrimental impacts upon non-target plant species. Six sites across Victoria where two ragwort biological control agents (crown-boring moth, *Cochylis atricapitana* and plume moth, *Platyptilia isodactyla*) have established were sampled twice over a two-year period to monitor for any impacts to non-target native *Senecio* species. Transects were used to randomly collect native *Senecio* plants, bolting ragwort plants and ragwort rosettes, which were then assessed in detail in a laboratory for attack from the two agents. Attack upon ragwort by *C. atricapitana* and *P. isodactyla* was found to be quite high, however there was no definite evidence of attack upon native *Senecio* plants from either agent. Feeding damage was notable on native *Senecio* plants, although this damage was believed to result entirely from larvae of the native moth *Patagoniodes farinaria* and other unidentified insects. Therefore, the ragwort biological control agents *C. atricapitana* and *P. isodactyla* were considered to have remained host-specific to ragwort, thus confirming the safety of both non-target native *Senecio* species and the ragwort biological control program.

S6MT03P00**BIOLOGICAL CONTROL OF *CHROMOLAENA ODORATA*, A MAJOR WEED OF THE DEVELOPING WORLD**Lorraine W. Strathie¹, Costas Zachariades¹, Alana den Breeÿen², Nomahlubi Sishuba¹ and Milly Gareeb¹Agricultural Research Council, Plant Protection Research Institute, ¹Private Bag X6006, Hilton, 3245, South Africa, ntlws@natal1.agric.za, ntczs@natal1.agric.za, ntns@natal1.agric.za, ntmg@natal1.agric.za;²Current address: Department of Plant Pathology, University of Florida,P.O. Box 110680 Gainesville, Florida 32611-0680, alanadenbreeeyen@webmail.co.za

Chromolaena odorata (Asteraceae), a neotropical shrub, is widely invasive in the Old World humid tropics and subtropics. Throughout much of this range it is perceived to impact primarily on agriculture, but in some countries, such as South Africa, it has been shown to also impact substantially on biodiversity. Non-biological control methods are well developed, but in many situations are not economically or logistically viable. Initial research on the biological control of *C. odorata*, conducted nearly 40 years ago, indicated that effective candidate agents are available in the neotropics. However, because the countries most affected by this weed are resource-poor, subsequent research and implementation was limited for the most part. Over the past decade, biocontrol of *C. odorata* has received increased attention and funding, resulting in a good measure of control in some countries. Nevertheless, conflicts of interest regarding its status as a weed in parts of Africa continue to hamper biocontrol initiatives there. The presence of a different biotype of the weed in southern Africa resulted in problems of incompatibility between the plant and candidate agents in the past, but these have been resolved recently. Overall, with increased awareness and implementation, prospects for the sustainable control of *C. odorata* using insect and fungal natural enemies are now good in much of the developing world.

S6MT03P00**BIOLOGICAL CONTROL OF WEEDS IN MEXICO****José G. Torres and Silvia Rodríguez**

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Few efforts have been made to develop biological control of weeds in Mexico. This presentation gives an overview of the status of the current biological control projects based on reports received from various researchers. Projects targeted for biological control include *Eichhornia crassipes*, *Salvinia molesta*, *Convolvulus arvensis* and *Tamarix ramosissima*. The weevils, *Neochetina eichhorniae*, and *N. bruchi* have both been released on *E. crassipes* with varying results. In order to improve the biological control of water hyacinth further research on the host-specificity of the mirid, *Eccritotarsus catarinensis*, and several pathogens in quarantine are ongoing. Mass-rearing programmes under quarantine conditions are in place for the weevil, *Cyrtobagous salviniae* for the control of *S. molesta* and the eriophyid mite, *Aceria malherbae*, for the control of *C. arvensis*. Field cage testing will be conducted on the leaf beetle, *Diorhabda elongata*, for possible release on *T. ramosissima* by 2004. Only biological control agents which have already been released in other countries, are considered for importation into Mexico at this stage.

S6MT03P00**CONDITIONS FAVOURING INFECTION OF *PUCCINIA CONOCLINII* ON *CAMPULOCLINIUM MACROCEPHALUM*****C. Van Rooi**Agricultural Research Council – Plant Protection Research Institute, Private Bag X5017, Stellenbosch, 7599, South Africa vredcvr@plant3.agric.za

Campuloclinium macrocephalum (Less.) DC, or pompom weed is becoming an increasingly important weed in the Eastern Cape, KwaZulu Natal, Mpumalanga, Gauteng and Northern Provinces of South Africa. This perennial herb species is native to Brazil and was imported to South Africa as an ornamental species as early as 1972. Plant populations of *C. macrocephalum* have increased exponentially over the last two decades and the most worrying feature of the weed is its ability to invade undisturbed, climax grasslands and wetlands. It has the potential to invade the entire Gauteng area, becoming as serious a problem as black wattle. *Campuloclinium macrocephalum* is a suitable target plant for classical biocontrol agents. Two species of rust fungi are recorded on *C. macrocephalum* in Brazil, namely *Puccinia eupatorii* and *Puccinia conoclinii*. *Puccinia conoclinii* has recently been introduced into quarantine at ARC-PPRI in Stellenbosch. In order to investigate the suitability of *P. conoclinii* as a potential biological control agent of this invasive weed in South Africa, experiments were conducted to determine the conditions favouring infection. The optimum temperature for germination and infection and minimum dew period requirements are discussed.

S6MT09P00**PIGWEED (*AMARANTHUS RETROFLEXUS*) COMPETITION EFFECT ON YIELD, YIELD COMPONENTS AND MORPHOLOGICAL CHARACTERISTICS OF SOYBEAN (*GLYCINEMAX*) CULTIVARS****M. Samaey¹, Gh. A. Akbari² and E. Zand**1- University of Tehran, Abouraihan Campus. m_samaei@hotmail.com2- University of Tehran, Abouraihan Campus. ghakbari@ut.ac.ir3- Research institute for insect and disease in Iran. eszand@yahoo.com

A factorial experiment in a randomized complete block design form was carried out with three replications. The treatments were included soybean cultivars (L11, Clark and Pershing) and pigweed densities (control plots, 4, 8, 16 and 32 pigweeds per meter of row) in soybean plots and monoculture plots of pigweeds. Soybean density was 40 plants m⁻². The effect of pigweed competition varied with soybean cultivar. When grown with 4 pigweed plants m⁻¹ of row, marketably yield of soybean was reduced 30% for cultivar L11, 23% for cultivar Clark and 17% for cultivar Pershing compared to cultivars grown in monoculture. Across pigweed densities, height of soybean cultivars, seed per pod, 100-seed weight, number of nodes in main stem was not reduced compared to that of cultivars grown in monoculture. But harvest index, number of pod and branches of soybean cultivars grown with pigweed was reduced compared to that of cultivars grown in monoculture. Yield loss at high weed density varied among cultivars. However, cultivar Pershing had low yield loss at low weed density. The results of this study suggest that high soybean tolerance be used to supplement control options.

S6MT09P00**EFFECT "IN VITRO" OF HERBICIDES ON SPORULATION OF *BEAUVERIA BASSIANA*****E A D Costa¹, M B Matallo¹ and J E M Almeida¹**¹ Instituto Biológico, C.P. 70 CEP:13001-970 Campinas São Paulo Brasil, matallo@biologico.sp.gov.br

The conservation of biological control agents is one of the strategies adopted for the exploitation of entomopathogens. To preserve or to use it in combination with chemicals is necessary to know the action of products on the microorganisms. In Brazil, the fungus *Beauveria bassiana* is used to control *Mahavarva fimbriolata* in programs involving sugar cane. We investigated, "in vitro", the toxic action of herbicides on sporulation of *B. bassiana*. The study was carried out under completely random design and six replications. Glyphosate, butafenacil, 2,4 - D, metribuzin, oxasulfuron, s-metolachlor and tryfloxysulfuron sodium were individually added to the culture medium and poured into petri dishes. *B. bassiana* was transferred to the medium containing the herbicides at the minimum and maximum doses recommended by manufacturer, inoculated and incubated during 14 days at 26 °C under a 14h photoperiod. For counting the number of conidia the colonies were cut out and transferred to glass tubes containing 10 ml sterile distilled water plus adhesive spreader. Diluted microorganism suspensions were counted in a Neubauer hemocytometer. The data were submitted to F test and the means discriminated by Fischer's least significant difference procedure at 5% level. Except butafenacil, all herbicides affected conidial production regardless concentrations used. Results indicate only a possibility of damage occurrence. Field assays have been made to confirm it.

S6MT09P00**DESSICATION TIMING OF *AVENA STRIGOSA*, *LOLIUM MULTIFLORUM* AND *RAPHANUS SATIVUS* IN PRE SEEDING OF THE A CORN CROP (*ZEA MAYS*)****P J Christoffoleti¹, A Marochi², R F Lopez-Ovejero¹ And A Galli²**¹University of São Paulo – ESALQ/USP – Brazil – pjchrist@esalq.usp.br; ²Monsanto - Brazil

The chemical management of the soil cover vegetation during the winter time (inter season) of the species *Avena strigosa*, *Lolium multiflorum* or *Raphanus sativus* in order to obtain soil cover with the plant residue, in the areas where no tillage is practiced in Brazil in the corn crop, is an usual practice among growers. Depending on the timing of the desiccation prior to corn seeding, however, some negative interference in the crop growth, development and yield might occur (the interference can be caused by higher incidence of insects, lower water conservation, low efficiency of the planting equipments, allelopathic effects of the cover crop, among others). An experiment was conducted with different formulations and doses of glyphosate for desiccation at different timing prior to corn planting, in Ponta Grossa, PR, Brazil, during the growing season 2001/02. The results allowed to conclude that the desiccation of the soil cover crops *Avena strigosa*, *Lolium multiflorum* or *Raphanus sativus*, when glyphosate was sprayed right before crop seeding was efficient on the control of weeds, but affected negatively the corn plant population and the development of the crop and made possible a higher incidence of insects that attacked the crop. However, there are options of timing of desiccations of the cover crops that guarantee a better development of crop resulting in better corn yield (desiccation at 7 days, at 14 days and at 28 + 0 (two timings of desiccation) prior to corn planting).

S6MT09P00**WEED SUPPRESSION BY WATERMELON IN THE HUMID TROPICS****O. D. Ojo**National Horticultural Research Institute, PMB 5432, Idi Ishin, Ibadan, Nigeria. Tel.:2348023935021; E-Mail: davidajo@hotmail.com

In-situ live mulch such as watermelon could suppress weeds as well as provide additional income from produce harvested, thereby making this technology easily adoptable as an alternative weed control strategy for vegetable farmers. Experiments were therefore carried out to preliminarily investigate the weed suppression mechanism of watermelon as a cover crop in the humid tropics of sub-Saharan Africa. Three sowing densities of watermelon (1.5 x 0.45m, 1.5 x 0.90m and 1.5 x 1.35m) were chosen in the 2-yr experiment. There was a control plot left bare without watermelon cultivation. Total weed density and biomass varied in the watermelon treatments relative to bare soil treatment, but consistently decreased from those recorded in the control treatment as crop density increased. Transmitted light was reduced by 82% under live mulch compared to 21% under bare soil treatment. Soil temperature and diurnal soil temperature amplitude were also reduced as crop density increased. Soil moisture content was greater in the live mulch treatments compared to the bare soil treatment at 50% anthesis and harvest. Changes in weed biomass, light transmittance, diurnal temperature amplitude and soil moisture retention explained the weed suppression capabilities of watermelon in intercrop for the sub-Saharan Africa humid tropics.

Keywords: Watermelon, weed density, weed biomass, light transmittance, soil temperature, soil moisture"

S6MT09P00**CHANGES IN WEED COMMUNITY COMPOSITION AS INFLUENCED BY HERBACEOUS LEGUMES AND MANAGEMENT SYSTEMS IN THE NORTHERN GUINEA SAVANNA OF NIGERIA**L G Owoye^{1*}, P J Pieterse² and D Chikoye¹

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Weed problems are one of the major constraints to effective crop production in the moist savanna of Nigeria. Weed suppression by rotational cropping with herbaceous legumes may lead to a reduction in weed pressure. Six herbaceous legumes viz. *Centrosema pascuorum*, *Aeschynomene histrix*, *Stylosanthes guianensis*, (forage legumes) *Arachis hypogaea*, *Glycine max* and *Vigna unguiculata* (grain legumes) sown as a legume fallow were compared with natural vegetation fallow under different management systems. The three management systems considered were 1) 'residues retained in the field', 2) 'residues taken out of the field' and 3) 'compost generated from feeding herbaceous legumes to livestock returned to the field'. These subplots were fitted into the experimental design before subsequent cropping of maize and replicated four times. Further sub treatments involved a rotation of fallow-fallow-maize and fallow-maize-maize. Weed growth suppression tended to be higher under *C. pascuorum* among the forage legumes and *V. unguiculata* among the grain legumes. The management systems applied and the length of the fallow treatment influenced weed diversity in the subsequent maize crop. Weed communities showed higher diversity when manure from legumes fed to livestock were returned to the field than when residues are either left on or removed from the field. Management systems significantly ($P < 0.05$) influenced weed communities at 4 weeks after crop planting in each year; particularly in 2001. Consistency of association between weed species and treatments over sampling dates and years was found. After 3 years of rotational cropping, weed community diversity was significantly reduced.

S6MT09P00**CHEMICAL CONTROL OF GLYCYRRHIZA GLABRA DURING THE FALLOW YEAR IN WHEAT-CHICKPEA ROTATION**

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Glycyrrhiza glabra is the most troublesome weed in rainfed wheat-chickpea rotation in the western provinces of Iran. Absence of an effective herbicide to control this weed in chickpea crop and emergence of *G. glabra* after broadleaf herbicide application in wheat crop is the main reason why *G. glabra* infestations increase every year. A study on the effect of herbicides 2,4-D and MCPA (2+2 kg/ha), picloram (0.28kg/ha) and the combination of the above two (1.5+1.5 and 0.14 kg/ha respectively) was conducted in Kermanshah province during the fallow year to investigate their efficacy against *G. glabra*. The herbicides were applied on *G. glabra* at three phenological stages (early post emergence, bud stage and seed fill) in a complete randomised block design with three replications. Results showed that 2,4-D plus MCPA was the most effective treatment against *G. glabra* and that bud stage was the best time when the herbicides should be applied to be the most effective. Herbicide application during *G. glabra* seed fill was not as effective as the other two stages. Application of picloram alone was the least effective treatment compared with the other two at all three phenological stages.

S6MT09P00**EFFECT OF SOIL SOLARIZATION ON WEED DYNAMICS AND SEED YIELD IN MOONG BEAN (*Vigna radiata* L. (Wilezek))**

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To assess the effect of soil solarization on weed control and yield of moong bean crop, an experiment was conducted on sandy loam soil at Agronomy Research Area of CCS HAU, Hisar (India) during kharif 2002 and 2003. Experiment was replicated thrice in split plot design and consisted of three main treatments viz solarized, non solarized and stale bed preparation and three sub treatments viz. trifluralin (1.00 kg ha⁻¹), one hoeing and weedy check. After wheat harvest, the field was disked and irrigated. In the solarized treatment, soil was covered with clear polyethylene sheet of 50 µm thickness for 6 weeks (from 15 May to 3 June). Maximum temperature at different soil depths was measured daily from solarized as well as non solarized plots by LCD portable digital multi stem thermometer till the sowing of moong bean. The soil solarization with PE mulching lead to an appreciable increase in maximum soil temperature at all soil depths. At soil surface, the increase in temperature was 8.4 and 7.9 °C over non solarized plots during 2002 and 2003, respectively. Whereas, the corresponding values at 15 cm soil depth were 7 and 5.3 °C. In solarized treatment, density of annual weeds was reduced significantly over stalebed and non- solarized treatment. However, solarization provided partial control of *Cyperus rotundus*. Among weed control treatments, trifluralin provided excellent control of annual weeds. Off season soil solarization for 6 weeks integrated with trifluralin or one hoeing out-yielded all other treatments in respect of seed yield and yield attributing characters.

S6MT09P00**STUDY OF FLUMIOXAZIN IN SUNFLOWER, ONION AND GARLIC**Mária Torma¹, László Hódi², András Horn³

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The number of the herbicides registered in the studied crops is very low. In Hungary until 2003 bifenox was the only herbicide active ingredient that could be used for postemergence weed control in sunflower against dicotyledonous weeds. In 2002 experiments were carried out on small plots in three replications and in 2003 on big plots without replication using 40 g ha⁻¹ flumioxazin. Preemergence applications were made two days after sowing. The time of the postemergence sprayings were at the 4-6 leaves of sunflower and 3-4 leaves of onion and garlic. In the preemergence trials the herbicide provided good control of *Amaranthus* sp., *Chenopodium* sp., and *Datura stramonium*. The effect against *Ambrosia artemisiifolia* was moderate. No phytotoxic symptoms were observed on the tested crops. In postemergence there were differences in the efficacy of flumioxazin between the two experimental years. In 2002 the herbicide effectively controlled the annual dicot weeds. In 2003 because of the extremely dry weather the weeds developed a thick cuticle on the surface of their leaves so the herbicide effect was very limited. In sunflower, the effect of flumioxazin was improved by the addition of an adjuvant (Trend or Citowet). *Datura stramonium*, *Abutilon theophrasti*, *Chenopodium album*, and *Iva xanthiifolia* died with 90-98 % efficacy. The flumioxazin burned the leaves of sunflower. The plant recovered from the damage and no yield loss was measured. On the basis of the two year results, flumioxazin can be recommended for pre and postemergence treatments in the tested crops

S6MT09P00
EFFECTS OF WATER DEPTHS ON THE GROWTH OF RICE AND CHEMICAL CONTROL EFFICACY OF WEEDS IN PADDY FIELDS

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Studies on different water depths effects on the growth of rice and chemical control efficacy of weeds in paddy fields were conducted. Two rice cultivars (japonica rice Wuyujing No.3 and hybrid rice Shanyou No. 63) and three weeds (*Echinochloa crus-galli* L., *Cyperus difformis* L. and *Eclipta prostrata* L.) were used in the trials. The materials in the trials were treated with herbicides (acetochlor and bensulfuron-methyl + acetochlor +metsulfuron-methyl) at three different dosages and three water depths (0, 4 and 12 cm). Results indicated that more weeds were controlled by herbicides at a water depth of 4 cm than at a water depth of 0 cm. The growth of rice seedlings was remarkably suppressed by herbicides as water depth increased, but the number of tillers of rice was increased. The highest rice yield was achieved at water depth of 4 cm among all treatments. Differences in growth inhibition between two cultivars caused by interactions of water depths, dosages and herbicides have been discussed in this paper.

Key word □ water depth; weeds; paddy fields; chemical control efficacy; growth of rice.

S6MT12P00
A NEW APPROACH TO PARASITIC WEED CONTROL BASED ON INDUCIBLE EXPRESSION OF SARCOTOXIN IA IN TRANSGENIC PLANTS

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The nature of parasitic weeds makes control extremely difficult, costly or hazardous to the environment. While the potentially simplest and most effective approach to parasitic weed control – host resistance – remains an unrealized goal for agriculture, we have developed a simple genetic engineering strategy for conferring parasites resistance on a host plant. The primary component of the system is a sarcotoxin IA gene (a cecropin – type antibacterial peptide) linked to a defense-related isogene of 3-hydroxy-methylglutaryl coenzyme A reductase (HMG2) promoter. Transgenic tobacco plants expressing the sarcotoxin IA gene were grown either in polyethylene bags or in pots containing the parasitic weed seeds *Orobanch aegyptiaca*. Transgene integration into the plant genome was confirmed by PCR and Southern blot and its expression was demonstrated by reverse transcriptase RT-PCR and Western blot analysis. Results from transgenic plants indicate strong inhibition of parasite growth and increased the yield as compared to the non-transgenic plants. Most parasite tubercles attached to the transgenic root plants turned necrotic and their development was abnormal. Our results indicate that the insect gene produced in the plant cells is selectively toxic to the parasite and non-toxic to the host plant. Therefore the pending strategy is superior to other methods in that it is: effective, low cost of implementation for producers and safe for the environment.

S6MT12P00
COMPARATIVE HEPATOTOXICITY OF COMPOUNDS ASSOCIATED WITH SNAKEWEED (*GUTIERREZIA SPP.*)

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Snakeweed (SW), *Gutierrezia Spp.*, a noxious weed, grows on western rangelands in the United States and intoxicates various livestock species. The toxic compound in SW is unknown but saponins are suspected. The purpose of this study was determining the toxic compound(s) in SW. An experiment was conducted to compare hepatotoxicity of SW extracts to pure compounds known to be in SW using cultures of liver tissue slices of Female-Sprague-Dawley rats (475-500g). Treatments were ether, hexane, and ethanol extracts of SW, saponin, quercetin, α -pinene, and β -myrcene. Three rats were assigned to each treatment except hexane which had two. Rats were euthanized, livers removed, cored, and cores sliced. Slices were cultured in William's Media E at 37°C and exposed to a gas phase (95% air and 5% CO₂) in a rotating incubator. Treatments were administered at four concentrations (0, 12.5, 100, 200 μ g/mL) and tissue samples were collected at 0, 3, 6, 12, and 24 h and snap frozen in liquid nitrogen. Tissue viability was verified by intracellular potassium content and total protein content. Lactate dehydrogenase leakage was measured in medium as indication of cell death. Ether extract (P>.70), ethanol extract (P>.15), saponin (P>.30), β -myrcene (P>.65), and quercetin (P>.25) did not influence cell death. Rat livers treated with the hexane extract of SW and α -pinene had less cell death than 0 μ g/mL concentration, respectively (P<.0002, P<.03). In summary, rat livers treated with the hexane fraction of SW, which should contain essential oils, and α -pinene (essential oil) decreased cell death in rat livers.

S6MT12P00
COMPARATIVE HEPATOTOXICITY OF DIGESTED SNAKEWEED (*GUTIERREZIA SPP.*) COMPOUNDS BY THE RUMINANT

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Snakeweed (SW), a noxious weed, invades western rangelands of the United States. The toxic compound in SW is unknown, but saponins are suspected. The purpose of this study was to determine if SW digested by ruminants (ovine) were more or less toxic to liver slices than SW plant extracts. An experiment was conducted to compare hepatotoxicity of rumen and abomasum fluid of ovine using liver tissue slices of Female-Sprague-Dawley rats (475-500g). Treatments were rumen SW, rumen control (CTRL), abomasum SW, and abomasum CTRL. Six ruminally cannulated sheep were fed at 1.5% body weight for 7 d, three fed a CTRL diet and three fed a 30% SW/70% grass hay diet. On d 7, animals were euthanized, rumen and abomasum fluid collected. Three rats were assigned to each treatment. Rats were euthanized, livers removed, cored, and cores sliced. Liver slices were cultured in William's Media E at 37°C and exposed to a gas phase (95% air and 5% CO₂). Treatments were administered at 0, 12.5, 100, and 200 μ g/mL, tissue samples collected at 0, 3, 6, 12, and 24 h and frozen in liquid nitrogen. Tissue viability was verified by intracellular potassium and total protein contents. Lactate dehydrogenase leakage was measured in medium as indication of cell death. Rumen SW (P>.80), abomasum SW (P>.60), and abomasum CTRL (P>.14) did not influence cell death. Rat livers treated with rumen CTRL had less cell death than 0 μ g/mL treatment (P<.03). Rumen and abomasum fluid of SW fed ewes did not affect cell death.

S6MT12P00**DEVELOPMENT OF HOMOZYGOUS LINES WITH AUXINIC HERBICIDE RESISTANCE AND SUSCEPTIBILITY IN WILD MUSTARD (*Sinapis arvensis* L.) USING DOUBLE HAPLOID TECHNOLOGY**Mithila Jugulam¹ and J. Christopher Hall¹

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Classical genetic analyses of auxinic herbicide resistance in wild mustard indicate that resistance is controlled by single dominant gene. Wild mustard auxinic herbicide resistant (R) and susceptible (S) biotypes are genetically highly diverse and hence development of completely homozygous R and S lines of wild mustard will assist in understanding the precise role of the auxinic herbicide resistance gene(s). Homozygous lines can be developed through conventional breeding as well as *in vitro* culture and regeneration methods. Double haploid technology (*in vitro*) was used to hasten the production of homozygous lines of wild mustard. Heterozygous plants of *Sinapis arvensis* expressing picloram resistance were generated through conventional breeding and herbicide screening methods. Microspore cultures were initiated from these heterozygous plants to exploit expression of both recessive and dominant alleles. We report for the first time production of double haploid plants through pollen embryogenesis in wild mustard. The microspore-derived plant was assessed for ploidy level through flow cytometry and was found to be a spontaneous double haploid. The double haploid plant was subsequently used in genetic crosses and found to be homozygous for picloram resistance. Production of higher frequency double haploids in wild mustard will assist in uncovering the genetic basis of auxinic herbicide resistance in this species.

S6MT12P00**NUCLEAR AND CYTOPLASMIC MICROSATELLITE DIVERSITY STUDIES IN *AEGILOPS CYLINDRICA* AND ITS PROGENITORS *AE. TAUSCHII* AND *AE. MARKGRAFII***C A Mallory-Smith¹, H Gandhi¹, O Riera-Lizarazu¹, M I Vales¹, C J W Watson¹ and R S Zemetra²

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Aegilops cylindrica is an important weed species that infests 3 million hectares of cultivated land in the United States of America. *Ae. cylindrica* is also a useful source of biotic and abiotic stress resistant genes for wheat improvement. Therefore, it is important to understand the extent of genetic diversity within *Ae. cylindrica* and its progenitors for better weed management and gene utilization. Twenty chloroplast and 19 nuclear microsatellites were analyzed on 186 accessions of *Ae. cylindrica*, 17 accessions of *Ae. tauschii* and seven accessions of *Ae. markgrafii*. These accessions represent the geographical distribution of the three species and the adventive distribution for *Ae. cylindrica*. As expected, the three species were more diverse at the nuclear level than the plasmon level. Both plasmon and nuclear diversity analysis classified the accessions to their known taxonomic groups. Plasmon diversity analysis separated plasmon type C and D which corresponded to cytoplasm from *Ae. markgrafii* and *Ae. tauschii*, respectively. In accordance with earlier reports, the two types of cytoplasm, C and D, were found in *Ae. cylindrica*. However, the frequency of the C type cytoplasm was lower than the D type cytoplasm. Both cytoplasmic and nuclear diversity microsatellite markers indicated a lower level of diversity in *Ae. cylindrica* compared to *Ae. tauschii* and *Ae. markgrafii*. Microsatellite markers provided evidence that the *Ae. cylindrica* populations in the USA originated from diverse geographic sites in Central Asia.

S6MT12P00**GENETIC DIVERSITY OF *TARAXACUM OFFICINALE* IN THE UNITED STATES**Aaron S. Franssen¹, David S. Douches¹ and James J. Kells¹Michigan State University, USA, fransse1@msu.edu,
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Taraxacum officinale (common dandelion) has become a troublesome agronomic weed in several states in the United States, including Michigan. Inconsistent control of *T. officinale* with common postemergence herbicides has been observed and has led to the hypothesis that distinct biotypes of *T. officinale* exist and respond differently to herbicides. To evaluate *T. officinale* genetic diversity, mature seeds were collected from selected field populations from 16 Michigan counties and nine additional states. Individual plants were selected from field populations to represent each population. Genomic DNA was extracted from the youngest leaf tissue and screened with 10 base pair RAPD primers. Polymorphic fragments were scored as either present (+) or absent (-). Genetic distances between biotypes were determined using Nei's distance formula. Dendograms were created using the unweighted pair group method with arithmetic averages (UPGMA) cluster analysis. Genetic distance calculations and dendograms were made using NTSYSpc version 2.11L software. A total of 51 polymorphic bands were scored from nine RAPD primers. The diversity observed from the RAPD analysis indicates that *T. officinale* is highly variable. Genetic distance and geographical distance between biotypes does not appear to be highly correlated. Many of the populations were similar to others in close geographical proximity, while some populations that were separated by a great distance were more similar to each other than to adjacent populations. Several populations that appear to be genetically distant have been selected to be screened in the greenhouse for differences in sensitivity to the herbicide glyphosate.

S6MT12P00**INTROGRESSION OF A FOOT ROT RESISTANCE GENE FROM WINTER WHEAT INTO JOINTED GOATGRASS**A Perez-Jones¹, C A Mallory-Smith¹, O Riera-Lizarazu¹, C J W Watson¹, M Rehman² and R S Zemetra²

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Strawbreaker foot rot (SFR) caused by *Pseudocercospora herpotrichoides* is a disease of winter wheat (WW) (*Triticum aestivum* L.) in many wheat growing regions in the world. Resistance to SFR is conferred by a single dominant gene, *Pch1*, from *Aegilops ventricosa* that was transferred by translocation onto chromosome 7D of wheat. Madsen WW carries *Pch1* and is highly resistant to SFR. Jointed goatgrass (JGG) (*Ae. cylindrica* Host.) is a winter annual grass weed, infesting over 3,000,000 ha of WW cropland in the USA. WW and JGG share a common genome (D) and have been found to hybridize in the field. Hybrids between JGG and WW have been shown to backcross under field conditions and set seed. Since SFR resistance in WW is controlled by the *Pch1* gene on the D genome, it is theoretically possible for resistance to be transferred to JGG via backcrossing. A SFR resistant JGG population would have an ecological advantage in the presence of the disease. To evaluate the likelihood of gene introgression, two WW cultivars (Madsen and Stephens), three JGG accessions, and 15 backcross progenies (BC₂S₁ and BC₂S₂) were inoculated with *P. herpotrichoides*. The percentage of infection in Stephens, the JGG accessions, and the backcross progenies was 85% or higher except for one BC₂S₂ progeny that had only 20% infection. None of the plants of Madsen were infected. These results provide evidence for introgression of a disease resistance gene from WW to JGG that could improve the competitive advantage of the weed in the field.

S6MT12P00**MOLECULAR BASIS OF RESISTANCE TO ALS-INHIBITOR HERBICIDES IN *Scirpus mucronatus***L. Scarabel¹, M. Sattin¹ and S. Varotto²

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In Italian rice fields, repeated use of acetolactate synthase (ALS) inhibitor herbicides has led to the selection of ALS-resistant biotypes in three species. In most cases, resistance is due to a point mutation in specific highly conserved regions (domains) of the ALS gene sequence, which determines an amino acid substitution in the protein.

Two field-selected resistant biotypes of *Scirpus mucronatus* L. (Palla) (selected by bensulfuron-methyl-SU) and a third susceptible to ALS-inhibitors were considered. RT-PCR amplifications were performed to amplify cDNAs encompassing the five conserved domains of the ALS transcripts. At least three cDNA sequences were isolated by RT-PCR from resistant population 9711. The nucleotide sequence of the first clone differed from that of the susceptible population by a single point mutation at the Pro₁₉₇ codon, predicting a Pro to His substitution. This mutation could be responsible for the high level of resistance to SU observed in greenhouse experiments. The second clone showed no mutation but differed from the first by some nucleotide substitutions in the coding sequence. The third clone had a nucleotide substitution in domain B at the Trp₅₇₄ codon that determines a Trp to Leu change. Genomic Southern hybridization data support the existence of at least four ALS sequences in the genome of this species. In addition, methylation-sensitive restriction endonucleases combined with Southern blot analysis showed that some ALS alleles are methylated. Experiments are in progress to elucidate the ploidy level and to understand whether different ALS genes are differentially expressed and regulated in plant tissue during development.

S6MT12P00**FOUNTAIN GRASS (*PENNISETUM SETACEUM*) INVASIVE AND NON-INVASIVE POPULATIONS: WHAT ROLE DOES GENETIC DIVERSITY PLAY?**

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Factors that allow invasive species to become successful often remain elusive. Genetic and evolutionary processes may be key features in determining whether invasive species establish and spread. Studies of genetic diversity and evolution may give us important answers to questions about the colonization potential of species, establishment, range expansion as well as evolutionary response to new environments. Different populations of different origins might be either more or less successful in terms of genetically determined invasion pressure. Study of population genetics and especially genetic structure of invasive and non invasive populations, have potential help us to manage invasive species more effectively.

In this paper, using microsatellite DNA markers, we compared the genetic variability and population structure of *Pennisetum setaceum* (Fountain grass) populations of different origins and compared the invasion potential of the different population. We examined seven populations from areas where this species is exotic but not invasive, and growth is limited to road-sides (Southern Africa), and compared them to introduced and aggressively invasive populations in the U.S.A (3 populations from California, 2 from Florida and 5 from Hawaii). Genotypes of 510 individuals (30 individuals per population) were used to investigate the genetic differentiation, measure coefficients of inbreeding and relatedness within and between populations by calculating *F*-statistics. Comparisons of genetic patterns of exotic, but not invasive populations, and aggressively invasive populations of the same species will help to elucidate the importance of differences in genetic diversity and evolution on the invasiveness of species and populations of weeds.

S6MT20AP00**A MODEL TO PREDICT CHANGES IN LIGHT SENSITIVITY IN BURIED SEEDS OF *POLYGONUM AVICULARE* L. IMPLICATIONS FOR WEED MANAGEMENT.**D. Batlla¹ & R. Benech-Arnold¹

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The possibility of predicting the moment at which the seed-bank presents the maximum sensitivity to the light stimuli is essential for planning tillage operations to provoke the emergence of a high fraction of the seed population and, consequently, to improve the efficiency of subsequent applied control methods. The objective of this study was to develop a tool for predicting changes in light sensitivity in buried seeds of *Polygonum aviculare* in relation to soil temperature. Seeds were buried in pots and stratified at 1.6, 7 and 12 °C for 110 days. At regular intervals during stratification seeds were exhumed and exposed to light treatments establishing different Pfr/P photoequilibria. To achieve the proposed objective, changes in the germination response of the seeds to the different Pfr/P photoequilibria during stratification were related to a thermal time index which accounted for the effect of variable stratification temperature on *P. aviculare* seeds dormancy loss accumulating thermal time units under a threshold temperature for dormancy loss to occur. The index gave a good description of changes in seeds light sensitivity in relation to the temperature experienced by the buried seed-bank during winter. The model was tested against independent data and was able to predict the dynamic of changes in the germination percentage obtained for the different established Pfr/P photoequilibria. This model could be used as a tool for planning control strategies with a high impact in weed population dynamics based in the seed-bank photo-response.

Type of presentation prefer: Short oral presentation; Scientific field: Weed seed dynamics

S6MT20AP00**A SIMULATION MODEL TO PREDICT SEEDLING EMERGENCE FOR STERILE WILD OATS**E Leguizamón¹, C Fernandez-Quintanilla², JL Gonzalez-Andujar³

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Research was conducted to determine the suitability of a hydrothermal time model to predict seedling emergence of *Avena sterilis* (sterile wild oat) based on inputs of simple and easily available environmental & management data (soil type, temperature, precipitation) in winter cereal crops in Spain. Nine sets of previously published emergence data were used to formulate the model and test its adequacy. Two independent emergence data sets were used to validate the model. Constant temperature growth chamber experiments were conducted to evaluate the effects of soil water potential and seed age on the model parameters.

Within each site, a single Gompertz function could describe the emergence results observed in subsequent seasons, but differences in the parameters were observed among sets. Since there is evidence that seed fractions may not have the same germination requirements, the base water potential was modified according to the emergence period: a further calculation of hydrothermal degrees using variable water potential thresholds allowed to forecast sterile wild oat seedling emergence pattern with a single model. Further work is in progress to consider the effects of seed age and burial depth.

S6MT20AP00**ECOTYPIC VARIATION WITHIN *MALVA PARVIFLORA* POPULATIONS IN THE SOUTH-WEST AGRICULTURAL REGION OF WESTERN AUSTRALIA****P J Michael¹, K J Steadman¹ and J A Plummer²**¹Western Australian Herbicide Resistance Initiative, The University of Western Australia, 35 Stirling Hwy, Crawley, Western Australia 6009, pmichael@agric.uwa.edu.au,ksteadma@agric.uwa.edu.au; ²School of Plant Biology, The University of Western Australia, 35 Stirling Hwy, Crawley, Western Australia 6009, jplummer@cyllene.uwa.edu.au

Little is known in Australia about the ecology or biology of *Malva parviflora* L./Boiss. (small-flowered mallow). It is a weed of wasteland, crops and pastures. Small-flowered mallow can be difficult to control chemically and changing farming practices, such as minimum tillage, have facilitated its spread. A common garden experiment was initiated to observe phenotypic differences between populations collected across the south-west agricultural region of Western Australia. Little genetic variation occurred between populations due to the inbreeding nature of small-flowered mallow. However, cluster analysis revealed that northern populations flowered earlier and had heavier seeds than southern populations. Further studies were undertaken to explore the variation in seed dormancy strategies of populations from environmentally contrasting areas. Optimal breakdown of physical dormancy occurred under diurnal fluctuating temperatures, such as those experienced over summer, rather than constant temperatures. Populations in low rainfall areas had fewer dormant seeds than those in high rainfall areas, regardless of latitude.

S6MT20AP00**THE RELATIONSHIP BETWEEN SEED PRODUCTION AND BIOMASS OF *AMARANTHUS RETROFLEXUS* L.****Hanwen Ni and Xiaojing Li**

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Predicting seed production of weeds is one of key steps in studying of dynamics of seed banks. The amount of seeds produced in a field can be predicted based upon the biomass of surviving weed plants at maturity if the relationship between the seed production and biomass of the weed species is a fixed function regardless of growth conditions, herbicide injury, density, etc. A series of pot and field experiments were conducted in Beijing, China, to determine the relationship between seed production and biomass of *A. retroflexus*. The results showed that seed number per plant had a positive linear relationship with biomass per plant. Seed production per unit of biomass was constant regardless of level of environmental conditions, herbicide injury, population density, and plant size. Seed weight was constant and not affected by plant size and environmental conditions. In conclusion, the seed production of *A. retroflexus* could be predicted from its biomass.

S6MT20AP00**EFFECT OF DRY STORAGE TEMPERATURE SCARIFICATION AND LIGHT ON THE GERMINATION OF *ANTHRISCUS CAUCALIS*****R.P. Rawnsley¹ P.A. Lane¹, P.H. Brown¹ and T. Groom²**¹University of Tasmania, School of Agricultural Science, Hobart, Tasmania, 7001, Australia, rrawnsle@utas.edu.au; ²Botanical Resources Australia Pty. Ltd., Industrial Drive, Ulverstone, Tasmania 7315, Australia.

Anthriscus caucalis is a newly emerged problematic weed commonly found in pyrethrum fields of Northern Tasmania, Australia. Little is known about the seed biology of this annual Apiaceae weed and the objective of this study was to investigate the germination response of *A. caucalis* to differing storage temperatures, scarification and light. Freshly collected mature seeds of *A. caucalis* were stored under four different treatment conditions; 4°C, 20°C, 30°C and natural day/night temperatures. On eight different occasions over a 40-week period seeds were removed and the germination response tested at 15/10°C 12hr photoperiod with and without scarification and in complete darkness. There was a significant ($P < 0.001$) storage temperature, storage duration and seed treatment effect on germination, and a significant ($P < 0.001$) three-way interaction. The initial germination percentage was $15\% \pm 4.7$. This increased significantly ($P < 0.05$) with dry storage at 20°C and 30°C. Storage at 4°C resulted in no significant ($P > 0.05$) change in germination percentage while there were fluctuations in the germination of *A. caucalis* in response to exposure to natural temperatures. Scarification significantly ($P < 0.001$) increased the germination of *A. caucalis*. Incubation in complete darkness reduced the germination for those seeds stored at 4°C and 20°C. The germination response in complete darkness fluctuated with time for *A. caucalis* seeds stored at 30°C and under natural temperatures. The results of this study help explain the observed field emergence pattern of *A. caucalis*.

S6MT20AP00**Effect of the depth on the productivity and the extinction of *Oxalis latifolia* Kunth.****B. Royo & M.L. López**

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Oxalis latifolia is a bulbous species and, as so, the depths at which bulbs are buried have a direct effect on their development. We have tried to know the effect of increasing depths on the productivity of *Oxalis latifolia*, until it finally dies, by burying 5 bulbs every 4 cm from 12 to 32 cm. Initial mean weight of the bulbs was 1g. They were planted in April 2001 and harvested in October 2001. During this period the number of leaves produced by each planted bulb was counted in 14 different dates. After harvest, the apical and lateral bulbs produced by each planted bulb were weighted and the number of lateral bulbs produced was counted. Productivity was calculated with the initial, apical and lateral bulbs weight. The number of leaves developed and the productivity also allowed us to calculate each leaf's efficiency per day of activity. Results show that productivity decreases significantly ($p < 0.01$) with the increase of the depth, but 32 cm is not enough for complete extinction of *Oxalis latifolia*. The application of a lineal regression to the measured variables showed that complete extinction of the bulbs may be obtained by burying the bulbs at a depth of 33-35 cm.

S6MT20AP00

Studies on the effect of cold-warm temperatures and humidity on the activation of *common* and *cornwall* forms of *Oxalis latifolia* bulbs.

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Common and *cornwall* are the two forms of *Oxalis latifolia*, that differ both in morphology and productivity. *Common* prevails in maize fields, while *cornwall* dominates in highly disturbed areas such as orchards. This study investigates the effect of temperature and humidity on the activation of the bulbs in order to seek more differences between both forms of *Oxalis latifolia*. Knowledge about the activation conditions may also contribute to the control of the weed. 180 dormant lateral bulbs of each form were selected in terms of uniformity in late November 2002 and were kept in a fridge at +4°C. After 13, 20, 27, 41, 48 and 55 days in cold temperature, 30 bulbs of each form were taken out and put at 21°C, 15 of them were kept dry and the other 15 were moisten. Observations of the number of activated bulbs were carried out weekly. On 3rd April, those bulbs which did not show any activity were cut to see if they were dead or alive. Results show that the activation is not simultaneous in any of the forms or humidity condition and that *common* activates earlier than *cornwall*. The mean time required for the activation since the bulbs were put at 21°C is constant in *common* form, but it decreases in *cornwall* as the length of the cold period increases. In both forms, dry bulbs activate earlier than moisten ones. Finally, it seems that there is a tendency of increasing the total number of dead bulbs as the length of the cold period increases.

S6MT20AP00

WEED EMERGENCE PATTERNS OF SOME ARABLE WEEDS UNDER FIELD CONDITIONS

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When selecting herbicides it is important to take into account numbers of weed species and individuals, growth rate of the weed plants, seed production, seed shed, percentage seed germination, distribution of seed, soil seed reserves, time of germination, patterns of seedling emergence and seed longevity. Worldwide economic stress and the quest for more effective weed control put the emphasis on knowledge regarding weed emergence patterns to determine the timely application of herbicides.

The aim of this study was to gain information on the longevity and seed emergence patterns of weed seed in cultivated fields in the summer rainfall area.

To simulate cultivation practices, emergence patterns of 24 weed species, common in summer rainfall areas, were studied in a seed burial experiment. One thousand seeds of each species were randomly selected from large batches of seed collected during the previous autumn. These seeds were incorporated into previously sterilized soil during the winter. Emergence patterns of the weeds were monitored on a bi-weekly basis during the following three seasons.

Most of the weed species displayed an early summer flush characterized by high peaks. Some weeds had high initial emergence peaks followed by a decline in emergence into mid summer. In the first season only three weed species, displayed two distinct flushes. Other weeds had relatively small initial flushes but germinated well into the late summer. Total percentage emergence after three seasons indicated that not all the weed seed had emerged after initial sowing.

S6MT20AP00

WEED ESCAPE AND DELAYED WEED EMERGENCE IN GLYPHOSATE-RESISTANT SOYBEAN

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During the last decade there has taken place an important event directly related to extensive crop production systems. GM (genetic modified) crops developed with the aim of incorporating different agronomic characteristics, such as tolerance to herbicides, have been well received and very rapidly adopted by farmers in certain countries. One of the important questions about this technology is what weeds are capable to escape the herbicide action and what are the mechanisms involved in that response. During 2001 and 2002 five field experiments were conducted in soybean crops in U.S. at four Minnesota locations. The objective was to study the effect of different glyphosate treatments (one-pass glyphosate, two-pass glyphosate and standard preemergence plus one-pass glyphosate) on weed community composition, particularly to determine the identity and abundance of weeds that escaped from different treatments. Seedling emergence patterns of different weeds were also studied to identify the influence of delayed emergence on weed escapes. Overall, 14 species were recorded as weed escapes, but only *Chenopodium album* L. and *Solanum ptycanthum* Dunal were present at all locations. Higher densities of weed escapes were recorded in the one-pass glyphosate treatment than other treatments. Delayed weed emergence was the main reason of weed escapes with one-pass glyphosate. *Chenopodium album* and *Amaranthus rudis* Sauer showed a long period of emergence during the crop cycle, thereby allowing the late-emerging fractions of their populations to avoid contact with the herbicide. In contrast, *Solanum ptycanthum* only emerges late and therefore its entire seedling population may escape glyphosate treatment.

S6MT22P00

EXPERIENCES WITH TRIFLUSULFURON-METHYL RESISTANT WITLOOF CHICORY

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In the vegetable witloof chicory (*Cichorium intybus* var. *foliosum*), Asteraceae weeds frequently cause major problems. Dicot weed control options have been expanded by the registration of the foliar applied sulfonylurea triflusaluron-methyl. Although this has enabled the development of control systems with more emphasis on postemergence applications and low(er) rates, significant initial crop injury is still common. Recently, the selection of witloof chicory lines with an insensitive ALS enzyme conferring non-transgenic resistance to triflusaluron-methyl, resulted in the introduction on the market of a resistant hybrid variety ('*Mont-Blanc*'). In greenhouse bioassay experiments with triflusaluron-methyl applied preplant incorporated into a sandy loam soil, the highest concentration (512 µg/kg) did not significantly affect the pre-commercial resistant hybrid 'TR' at the foliage fresh weight level whereas the "conventional" 'Tabor' was significantly inhibited. In another pot experiment with four varieties, differential responses were recorded following application of triflusaluron-methyl (up to 15 g/ha for 'Senator' and 'Atlas' and up to 120 g/ha for 'TR' and 'Mont-Blanc') at the 1-2 leaf stage: foliage fresh weight of the resistant hybrid 'Mont-Blanc' was not negatively affected by rates of up to 120 g/ha whereas both "conventional" varieties 'Senator' and 'Atlas' were significantly inhibited (45% and 55% respectively compared to their respective untreated controls) by 5 g/ha. By growing a resistant variety such as 'Mont-Blanc', the excellent selectivity of triflusaluron-methyl may be exploited advantageously by using it from very early growth stages onwards. However, there is still a need for integration of triflusaluron with other established chicory herbicides.

S6MT22P00
HERBICIDE-TOLERANT COWPEAS FROM THE ARKANSAS
GERMPLASM

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Chemical weed control is indispensable in mechanized cowpea (*Vigna unguiculata* L.) production or in areas where manual labor is limited. Herbicide options for broadleaf weed control in cowpea are limited. Continuous use of imazethapyr (Pursuit®) has resulted in imazethapyr-resistant *Amaranthus* spp. Experiments were conducted in Arkansas and Oklahoma, USA to identify cowpea cultivars or advanced breeding lines with acceptable tolerance to alternative broadleaf herbicides. Up to 100 entries were screened for tolerance and selected lines were used in replicated trials with acifluorfen (Ultra Blazer®), 0.28 to 1.12 kg ai/ha; fomesafen (Reflex®), 0.168 to 0.672 kg ai/ha; or imazamox (Raptor), 0.034 kg ai/ha. Experiments were laid out in a split plot design with cowpea cultivar as mainplot and herbicide treatment as subplot, replicated four times. Selection of germplasm was initiated in 2001 and replicated trials were conducted in 2002 and 2003. Only lines with best yield potential and acceptable herbicide tolerance were advanced to the replicated trials. A new cultivar, Empire, released in 2003 consistently showed acceptable tolerance to acifluorfen, incurring <30% foliar injury at 0.28 kg ai/ha (commercial use rate for soybean) without any yield reduction. 'Empire' can yield higher than the commercial standard, 'Early Scarlet'. Two advanced breeding lines (00-582, 00-584), with equal or higher yield than 'Early Scarlet', showed acceptable tolerance to fomesafen. Several cowpea lines and cultivars showed good tolerance to Raptor, but several also incurred significant yield reduction. 'Early Scarlet' incurred about 15% yield reduction from Raptor treatment, but one line (01-1164) was not affected.

S6MT22P00
WEED CONTROL IN CHIVE (*ALLIUM SCHOENOPRASUM*)

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The herb crops are highly profitable in Israel; hence the area of various herbs has dramatically increased in the last several years. Herb crops are used for local consumption and are exported to Europe. The most efficient method for weed control in herbs was methyl bromide soil fumigation but its use was banned. Chive (*Allium schoenoprasum*), a small bulbous perennial, is commonly used as culinary herb to impart mild onion flavor to many foods. In our ongoing research to adapt herbicides for use in minor crops we conducted several field experiments. The experiments were conducted in commercial chive greenhouses infested with mat amaranth (*Amaranthus blitoides* S. Wats.), little hogweed (*Portulaca oleracea* L.), and painted spurge (*Euphorbia geniculata* Ortega.). Oxyfluorfen (240 g/l), pendimethalin (500 g/l), and oxadiazon (240 g/l) were post applied after chive harvesting at 0.15 l/ha, 0.15 l/ha, and 3.5 l/ha, respectively. The herbicides did not cause any visual damage to chives. Weed control efficacy of oxyfluorfen and pendimethalin was greater than oxadiazon. Oxadiazon and pendimethalin residues could be detected with GC-MS one month after application but not two months latter. Chive was oxyfluorfen-free one month after application. We suggest that effective and safe weed control in chive can be achieved with post application of 0.15 l/ha oxyfluorfen.

S6MT22P00
INTEGRATED WEED CONTROL IN DRILLED ONION

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Integrated weed management in onions needs reducing herbicide applications and connecting them with mechanical weeding treatments. Field experiments were carried out in 2002-2003 on a pseudopodsolic soil to establish a relationship between the intensity of herbicide treatments, mechanical and hand weeding endeavors on weed infestation and onion yield. Chemical and mechanical weeding were as follows: A = maximum herbicide treatment level (without mechanical and hand weeding); B = optimum herbicide treatment level [2 applications before onion emergence + oxyfluorfen (24 g.ha⁻¹; 3 times split application postemergence) + pendimethalin (990 g.ha⁻¹ at 3-4 leaves of onion)] + mechanical weeding – if needed; C = low herbicide treatment level [2 applications before onion emergence + oxyfluorfen (24 g.ha⁻¹; 3 times split application postemergence)] + 1 mechanical weeding; D = C + 3 x mechanical weedings; E = C + 2 x mechanical + 2 x hand weedings; F = Check - mechanical and hand weeding – if needed.

The results indicate that it is possible to grow drilled onion with herbicide applications only, without any mechanical treatments. On the other hand, there is also a possibility to quit herbicides and control the weeds using the mechanical and hand weeding. It seems to be that the best way is to apply herbicides at the early crop growth stages and then provide weed control by using mechanical and hand weeding methods.

S6MT22P00
SPLIT APPLICATIONS OF HERBICIDES FOR ENHANCED
WEED CONTROL IN CABBAGE SEED CROPS

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The production of high quality seed requires that cabbage seed fields be maintained as free of weeds as possible. Weed competition from autumn through early spring, when cabbage plants are small and weed growth can be high, may be the most problematic time for cabbage seed production. Trials have been conducted from 2001-2003 at the Washington State University Research and Extension Unit to evaluate split applications of several herbicides to extend the effective period of weed control. Cabbage seedlings were transplanted in early September and herbicides applied at transplanting and again approximately 4 weeks later. In 2001-02, most herbicide combinations were providing excellent weed control in cabbage at 1 month after transplanting. Combinations with napropamide were generally the poorest, except when followed by sulfentrazone, pyridate, or simazine. Simazine followed by napropamide or hand weeding followed by napropamide, clopyralid, clomazone, or simazine also were performing poorly by early October. With the exception of napropamide (53%) and simazine (73%) in 2002-03, all treatments gave very effective weed control (93 to 99%) by early October. Control from single herbicides had declined to unacceptably low levels by late April, however. Several split applications improved the level of weed control through April, especially oxyfluorfen + clomazone or simazine, sulfentrazone + sulfentrazone, clomazone, or simazine, s-metolachlor + sulfentrazone or clomazone, dimethenamid-p + sulfentrazone, napropamide, pyridate, clomazone, or simazine, clomazone + pyridate, clomazone, or simazine, and simazine + sulfentrazone, clomazone, or simazine. Cabbage injury was uniformly low (0 to 7%) in October and January.

S6MT22P00**THE INFLUENCE OF WEEDS ON HOP DEVELOPMENT AND THE QUANTITY AND QUALITY OF HOP YIELD****A Simončič**

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Between 1997 and 2001 field trials were carried out at the Slovenian Institute for Hop Research and Brewing to study the influence of the existent weeds on hop growth and the quantity and quality of hop yield. In the field trials we studied the influence of different weed species, their number and weediness duration on the quantity and quality of hop yield and development. A five-year study revealed that annual weeds such as *Stellaria media*, *Veronica* spp., *Chenopodium album* and *Amaranthus retroflexus*, regardless of their number and weediness duration, do not statistically significantly affect the quantity and quality of hop yield in the first two years, while after three years the negative effect of *Chenopodium album* and *Amaranthus retroflexus* increases, especially at high density and longer weediness duration. Weediness caused by perennial weeds, such as *Symphytum officinale*, *Rumex obtusifolius* and *Convolvulus arvensis*, impaired hop growth and resulted in lower and poorer yield quality already in the second year of research-running at high density of these weeds. Annual and perennial weeds included in the research did not statistically significantly affect the total alpha-acid content in hop regardless of the density and weediness duration, although the differences between weed-free plots and weedy plots started becoming bigger in the fourth and fifth year. In contrast to the total alpha-acids studied, the differences between certain hop samples regarding the species, density and weediness duration were recorded when chemometric methods for analysing the structure of soft hop resins were used.

S6MT22P00**RESPONSE OF DAFFODIL (*NARCISSUS TAZETTA*) TO PRE AND POST EMERGENCE HERBICIDES****T Yaacoby**

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Weed control in minor crops is a complicated task because of limited acreage, marketing and/or crop's safety. Daffodil (*Narcissus tazetta* L.) for bulbs growing season is quite a long one (ca 9 months), and major weed infestation occurs along with bulb maturation. Weeds like *Malva sylvestris*, *Sylbium marianum*, *Ammi majus* followed by *Xanthium strumarium*, *Amaranthus* spp. and *Moluccella laevis* interfere with the crop and cause severe yield losses. Methabenzthiazuron ('Tribonil') was the ultimate herbicide used in daffodils during the last thirty years in Israel, but it is now out of the market. Field experiments were conducted to evaluate the potential of various herbicides applied pre-emergence (PRE) or post-emergence (POST) for use in daffodil (cv. Ziva). Herbicide efficacy and plant response were recorded 38, 84 and 165 days after treatment (DAT) or 38 and 84 DAT of the PRE and POST treatments respectively. Isoxaben alone or in combination with pendimethalin as well as oxadiazon applied PRE provided excellent weed control of four major species; *A. retroflexus*, *X. strumarium*, *M. sylvestris* and *M. laevis*. These treatments were safe while oxyfluorfen applied PRE caused severe damage to the crop. Pendimethalin in combination with glyphosate was the best POST treatment, followed by oxadiazon and aclonifen. All these treatments were safe to the 'Ziva' daffodil and reduced weed infestation more than 90% in Lachish region, a major agricultural area in the northern Negev.

S8MT01P01**RECENTLY PATENTED AND COMMERCIALIZED FORMULATION AND ADJUVANT TECHNOLOGY****Jerry M. Green¹ and George B. Beestman²**

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Industrial research on adjuvant and formulation technology for agrochemicals has advanced rapidly in recent years. Certainly part of the progress is due to increased efforts by major pesticide producers to renew older products when patent protection is expiring and companies have fewer new actives to replace older products. Glyphosate is the best example of this trend where manufacturers introduce new formulations yearly and patents issue monthly. Many agrochemical markets are overwhelmed with 'new and improved' adjuvants and herbicide formulations. The biggest trend in the marketplace is toward combination products that "put all the good things into one product" to ensure compatibility and ease of use. Pesticide and adjuvant manufacturers are very actively patenting and commercializing improvements in adjuvant and formulation technology. These improvements will be reviewed in this paper and include adjuvants and formulations with improved chemical and physical properties, increased biological performance, improved targeting, and tailored release of actives.

S8MT01P02**THE USE OF ADJUVANTS TO OPTIMISE HERBICIDE PERFORMANCE UNDER ADVERSE CONDITIONS****P. Kudsk and S.K. Mathiassen**

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It is widely recognised that tank-mix adjuvants can improve the performance of herbicides and that adjuvant chemistry and concentration are important parameters to consider in optimising herbicide activity. It is less widely recognised that inclusion of an adjuvant may overcome the impediments imposed by variable climatic and application parameters and hence improve herbicide performance under adverse conditions and the reliability of in particular reduced herbicide doses. Adjuvants can overcome adverse conditions either as a result of a general increase in herbicide activity masking the effects of adverse conditions or as a result of a more specific effect of the adjuvant. In the first case effects are easily detectable while the more subtle effects of adjuvants observed in the last case only can be detected if a proper experimental design including several herbicide doses is applied. Adjuvants can be expected to overcome adverse effects caused by parameters directly affecting herbicide deposition and uptake, e.g. humidity, rain and application technique while adverse effects caused by parameters affecting the physiological status of plants and hence the response of weeds to a herbicide such as light intensity and temperature are less likely to be overcome by the inclusion of an adjuvant. In this presentation examples are given on how addition of adjuvants have helped to overcome adverse climatic conditions and sub-optimum application technique and the perspectives of a wider use of adjuvants for this purpose is discussed.

S8MT01P03**REDUCED LEACHING AND ENHANCED BIOLOGICAL ACTIVITY OF HERBICIDES IN CLAY-BASED FORMULATIONS**S Nir¹, O Rabinovitz¹, Y Mishael¹, Y El-Nahhal¹, T Polubesova¹, C Serban¹ and B Rubin¹¹Hebrew University of Jerusalem, Faculty of Agricultural, Food and Environmental Quality Sciences, nir1@agri.huji.ac.il

The study aimed at designing clay-based formulations which will reduce leachability and migration of widely used herbicides. Two types of slow-release formulations are described. 1. Organo-clays for hydrophobic herbicides, e.g., alachlor, metolachlor, and acetochlor. The clay-mineral, montmorillonite, becomes more hydrophobic by preadsorbing it by small organic cations, e.g., phenyltrimethylammonium (PTMA), at a loading below the cation exchange capacity (CEC), e.g., 5/8 of the CEC. Interaction between the phenyl ring of PTMA and the herbicide promotes its adsorption affinity and slows its release. 2. Micelle-clay for anionic herbicides, such as sulfometuron, sulfosulfuron, and sulfentrazone. The anionic (or neutral) herbicides bind to positively charged micelles of an organic cation with a long alkyl chain and small critical micelle concentration (CMC). The mixed micelles are adsorbed by the negatively charged montmorillonite. The optimization of slow-release formulations includes the following stages and criteria: i. Adsorption (>90% of added herbicide), ii. Release in water (less than 1-5% in 1% suspension), iii. Small degree of release upon spraying a thin layer of soil in a funnel by the herbicide formulation followed by irrigation. iv. Spraying the formulation at the top of a soil column (25 cm long) followed by irrigation (e.g., 50 mm) and tests of herbicide leaching to different soil depths analytically or by bioassay, v. Field experiments, which test for herbicidal activity and leaching. The clay-based formulations for slow release yielded reduced leaching and enhanced herbicidal activity, which makes them promising both economically and for protecting the environment.

S8MT01P04**A FUNNEL TEST - A FAST PROCEDURE FOR EVALUATING THE RELEASE RATE OF HERBICIDES FROM ORGANO-CLAY FORMULATIONS**Onn Rabinovitz¹, Yael Mishael², Shlomo Nir², Carina Serban², Baruch Rubin¹.¹R H Institute of Plant Sciences and Genetics in Agriculture, ²Seagram Center for Soil and Water Sciences, Faculty of Agricultural, Food and Environmental Sciences, The Hebrew University of Jerusalem, Rehovot 76100, Israel, Rabino@agri.huji.ac.il

Organo-clay formulations of herbicides can reduce the movement and leaching of active ingredient from application site to non-target areas. Development of a new formulation is a lengthy and expensive process, because it involves extensive tests. The objective of this study was to develop fast and reliable methods for estimating the release of herbicides from the organo-clay formulations under irrigation conditions. The herbicide formulations were applied on a thin (5 mm) sandy soil layer deposited on filter paper inside a Buchner funnel (10 cm diameter), and washed with 50 mm of water. Ten sequential fractions of the leachate were collected and herbicide concentration was determined analytically by HPLC. The active ingredients of the anionic commercial formulations of sulfometuron (Oust[®]), sulfosulfuron (Monitor[®]), and sulfentrazone (Boral[®]), were released already after the 6th or 7th wash. After the first wash, 0.4% was released from the micelle-clay formulations of these herbicides while a total of 3% to 4% was released after the 10th wash. In the hydrophobic herbicides acetochlor (Harness[®]) and alachlor (Lasso[®]) the total release of the active ingredient from commercial formulations was 50% and 100%, respectively, while the organo-clay formulations yielded a total release of 6% to 20%. By utilizing the results of funnel experiments with the knowledge about the behavior of these active ingredients in water, we could predict their movement in soil columns and under field conditions. These results enable us to improve the new organo-clay or micelle-clay formulations before testing them in field conditions.

S8MT01P05**PROPOXYCARBAZONE-NA – UPTAKE AND INFLUENCE OF GROWTH STAGE AND TANK MIXING ON THE EFFICACY ON APERA SPICA-VENTI**

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Propoxycarbazone-Na is a new sulfonylaminocarbonyl-triazolinone herbicide used for post-emergence control of several annual grasses, *Elymus repens* and some broadleaved weed species in wheat, rye and triticale.

The objective of the present study was to assess the relative contribution of soil and foliar activity of propoxycarbazone-Na and to examine the influence of growth stage and tank mixing with broadleaved weed herbicides on propoxycarbazone-Na efficacy.

The experiments were carried out as pot trials using *A. spica-venti* as test plant. The herbicides were applied in a volume of 145.4 to 157.5 L ha⁻¹ using a laboratory pot sprayer. Foliar activity only was obtained by covering the soil surface with vermiculite before spraying and soil activity only by applying the herbicide solution to the soil surface using a pipette. The fresh and dry weight results were subjected to non-linear regression analyses using a dose-response model and ED₅₀ and ED₉₀ doses were calculated.

The results revealed that that propoxycarbazone-Na is predominantly a soil active herbicide on *A. spica-venti*. The doses had to be 8 to 50 times higher when the herbicide was applied to the foliage only to obtain the same effect as for the 'overall' treatment. The growth stage significantly influenced the efficacy with doses being 1.6 to 5.6 times higher at later compared to earlier growth stages. The performance of propoxycarbazone-Na was promoted in tank mixture with EC formulations of ioxynil + bromoxynil and fluroxypyr while tribenuron and florasulam had no influence on the efficacy.

S8MT01P06**FACTORS IMPEDING COMMERCIAL SUCCESS OF SULCOTRIONE IN NORTHEAST CHINA**Z J Zhang¹ and W H Ahrens¹Shenyang Research Institute of Chemical Industry, Pesticide Bioactivity Center, Shenyang 110021, China, zongjian_Zhang@163.com, bpahrens@163.com

During 2002 and 2003, sulcotrione was sold in northeast China and applied postemergence at 450 to 600 g ai/ha in corn. However, the product is costly (\$25 to \$34 per ha) and performance has been erratic. Primary factors limiting sulcotrione efficacy in northeast China appear to be dry soil conditions during and following treatment and lack of suitable spray adjuvants. Highest postemergence sulcotrione activity is obtained under well-watered greenhouse conditions, although a dramatic adjuvant response is observed, indicating that leaf penetration of sulcotrione without adjuvant is still limiting, even when moisture is plentiful. In several years of field experiments, Quad 7 and a methylated vegetable oil adjuvant significantly increased sulcotrione efficacy. Yet even with adjuvant added, dry soil conditions often pushed the rate required for effective control beyond 400 to 600 g/ha. Adding atrazine at 500 to 1000 g ai/ha significantly improved control with sulcotrione on species such as *Commelina communis*, *Amaranthus retroflexus*, *Setaria glauca*, and *Abutilon theophrasti*. Adding 2,4-D at 400 g ae/ha or ammonium sulfate to sulcotrione also improved control of broadleaf weeds compared to sulcotrione alone. With good soil moisture, sulcotrione at 200 g ai/ha + atrazine at 1000 g ai/ha + 2,4-D at 400 g ae/ha + methylated oil adjuvant provided excellent broadspectrum weed control. The backpack sprayer equipped with a hollow cone nozzle used by Chinese peasant farmers provides non-uniform application, and commonly used spray volumes of 400 to 600 L/ha decrease herbicide efficacy as well as the enhancement effect of adjuvants.

S8MT03P01**COMMUNITY INVOLVEMENT IN BIOLOGICAL CONTROL:
EVALUATING THE STRENGTHS AND WEAKNESSES OF
DIFFERENT TECHNOLOGY TRANSFER MECHANISMS****Sarah Holland Clift¹ and Raelene Kwong^{1,2}**¹Primary Industries Research Victoria, Department of Primary Industries, P.O. Box 48 Frankston, Victoria, Australia;²Cooperative Research Centre for Australian Weed Management
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Community involvement has become increasingly valued throughout Australia as a key element of a successful biological control program. As a result, biocontrol practitioners have adopted numerous approaches that aim to take advantage of the important and diverse contributions that the community can make. The type of approach that is used will depend on factors such as the source and availability of funding, the type of weed and biocontrol agent in question, and the community's prior involvement in and knowledge of biological control. Also, environmental community groups may have vastly different motivations for controlling a weed than that of farmers or individual landowners. Therefore, deciding on the most effective way of involving the community can be difficult and requires the consideration of many overlapping factors.

This paper evaluates the effectiveness of the different community education, awareness and technology transfer methods used in the bridal creeper biological control program within Australia. The bridal creeper program has relied heavily on community involvement in the rearing, site identification, release, redistribution and monitoring of the agents. Agents have been distributed via the post, handed out at field days, reared and then released by schools and community groups or released by biocontrol practitioners themselves. We assess the strengths and weaknesses of these four distribution methods and, through this, demonstrate the need to evaluate the benefits of community involvement based on both the overall establishment and success of the agents at each site and the site manager's resultant perceptions and knowledge of biological control.

S8MT03P02**DEVELOPMENT OF PCR-DGGE FOR THE
INVESTIGATION OF SOILBORNE NATURAL ENEMIES OF
WEEDS****K I Anderson and S G Hallett**Department of Botany & Plant Pathology, Purdue University
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Soils are teeming with microbes that have the potential to be exploited in a range of different ways for the management of weeds. Resident in the soil are microbes that can accelerate the rate of decay of weed seeds, inhibit the recruitment of weed seedlings and damage or kill mature weeds. Studies of the biology of soils, however, have been hindered by the complexity of soil systems and the paucity of effective techniques. Consequently, very little work of this type has been attempted in weed science. Recently, denaturing gradient gel electrophoresis of PCR-amplified small subunit ribosomal RNA genes (PCR-DGGE) has been developed as a tool for the analysis of complex soil microbial communities. PCR-DGGE analyzes microbial taxa from DNA extracted directly from the soil, and has the advantage that it avoids the biases commonly associated with experiments using culturing methods. Notably, PCR-DGGE can reveal the presence of microbial taxa that can not be cultured on microbiological media. We have conducted a range of preliminary experiments using soil microcosms in which a range of different weed species were grown in field soil from the same source. In these microcosms, different weed species "cultured" different microbial communities in their rhizospheres. These experiments reveal the complex and dynamic nature of the soil microbial communities associated with weeds and underscore the utility of PCR-DGGE for profiling complex microbial communities. A range of applications for this technology in weed science will be discussed.

S8MT03P03**TRICHOMES: A DEFENSIVE PLANT STRUCTURE THAT
BECAME A HOST SPECIFICITY CUE FOR THE SPECIALIZED
PHYTOPHAGE GRATIANA BOLIVIANA****Daniel Gandolfo**South American Biological Control Laboratory, USDA-ARS,
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Trichomes known to play a role in water conservation, are also defensive structures against herbivores. Trichomes can act by mechanical interference or through secretion of deterrents. Solanaceae plants have a diversity of glandular and non-glandular trichomes. In fact, several studies have been conducted to transfer pest resistance associated to trichomes, from wild species to cultivated *Solanum*. However, during the evaluation of the foliage feeder *G. boliviana* as a biocontrol agent of Tropical Soda Apple (*Solanum viarum*), we found that the presence of trichomes is a requirement for a suitable host plant. The study of the walking behavior under microscope and ESEM revealed that neonate larvae walk by grasping the trichomes without touching the leaf surface. If trichomes are absent or present at low densities, the movements of the larvae are uncoordinated, and they are unable to walk and feed. Also, in standard no-choice larval developmental test some *G. boliviana* larvae were able to develop on cultivated *S. melongena* (eggplant), although with a ten fold mortality and significantly increased development time. This could be explained, at least partially, by the structure and density of the eggplant stellate trichomes. While Tropical Soda Apple stellate trichomes have a central ray perpendicular to the leaf surface and four rays radiating parallel to the leaf surface, the stellate trichomes of eggplant have eight to ten rays projecting at several angles. The high density and the structure of the eggplant stellate trichomes form an intricate web that prevents or hinders the first instars from reaching the leaf surface.

S8MT03P04**PROGRESS AND PROSPECTS FOR BIOLOGICAL
CONTROL OF SOLANUM VIARUM IN THE USA****J. Medal¹, D. Gandolfo², F. McKay², J. Cuda¹,
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Solanum viarum (Solanaceae), is an invasive perennial weed in southeastern USA. Native to South America, it was first found in south Florida in 1988, and it has already invaded more than 400,000 hectares of grasslands, agricultural, and conservation areas in eleven states. Estimates of annual production loss to Florida cattle ranchers due to *S. viarum* infestations in pastures were US \$ 11 millions in 1993. Additional losses to vegetable crops are caused by plant pathogens transmitted by insect-vectors from *S. viarum* infested plants. Recommended control tactics for *S. viarum* in pastures are based on herbicide applications combined with mowing practices. These control tactics are costly and provide a temporary solution. A classical biological control project was initiated against *S. viarum* in 1997. Field releases of the first approved biological control agent, the leaf-beetle *Gratiana boliviana* (Chrysomelidae) began in Florida in summer 2003. The establishment, dispersal, and initial impacts of the beetles are being determined. Open-field specificity tests in South America with two other potential biological control candidates (the flower bud-weevil *Anthonomus tenebrosus*, and the leaf-beetle *Metricia elatior*) corroborate their specificity and potential negative impact on *S. viarum* plant growth and reproduction. Specificity tests with two other leaf-beetles (*Gratiana graminea*, and *Platyphora* sp.) are currently underway.

S8MT03P05**BIOLOGICAL CONTROL OF IMPERATA CYLINDRICA****Fen Beed¹, Raghavan Charudattan² and Alana den Breejen²**¹International Institute of Tropical Agriculture, 08 B.P. 0932 Tri Postal, Cotonou, Republic of Benin, West Africa.F.beed@cgiar.org

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An overview will be provided of the prospects for the biological control of the rhizomatous grass *Imperata cylindrica* [(L.) Rauschel]. *Imperata cylindrica* is an undisputed target for control technologies in West Africa as it reduces crop yields and causes the abandonment of agricultural land for resource poor farmers. Biological control can provide an environmentally friendly, sustainable and selective method that will be adopted if it provides advantages over alternative control strategies. The influence of variation between biotypes of *I. cylindrica* will be considered in relation to their control by a single biological organism. The potential of fungal pathogens recovered from surveys in West Africa will be evaluated including *Colletotrichum caudatum*, *Drechslera gigantea*, *Exserohilum rostratum*, *Glomerella cingulata* and *Puccinia rufipes*. Malaysian isolates of *C. caudatum* have previously been tested as a biocontrol agent against the biotype there and isolates of *D. gigantea* and *E. rostratum* from USA were included in bioherbicide preparations against an USA biotype of *I. cylindrica*. *Puccinia rufipes* could potentially control this weed; as it is a biotroph, it is likely to act as a physiological sink to deplete the carbohydrate reserves stored in the rhizomes. It is the mobilisation of this stored carbohydrate which facilitates this weed's competitive advantage to rapidly produce leaves following disturbance to the ecosystem, such as in slash and burn agriculture. This rust pathogen has also been observed, along with other biotrophs, in South Africa, where *I. cylindrica* is not considered a weed.

S8MT03P06**TOXINS PRODUCED BY DRECHSLERA SICCANAS AS POTENTIAL NATURAL HERBICIDES****A Andolfi¹, M Fracchiolla², M C Zonno³, M Vurro³, A Motta⁴ and A Evidente¹**¹Dipartimento di Scienze del Suolo, della Pianta e dell'Ambiente, Università di Napoli Federico II, 80055 Portici, Italy; ²Dipartimento di Scienze delle Produzioni Vegetali, Università degli Studi, via Amendola 165A, 70125 Bari, Italy; ³Istituto di Scienze delle Produzioni Alimentari del CNR, Viale L. Einaudi 51, 70125 Bari, Italy; ⁴Istituto di Chimica Biomolecolare del CNR, Comprensorio Olivetti, Edificio 70, Via Campi Flegrei 34, 80078 Pozzuoli, Italy

Weedy grasses are among the worst weeds in many crops in several countries, and their management represents an increasing problem in crop protection, due to the appearance of weeds resistant to most of the available herbicides, and to the difficulties of finding new compounds with alternative sites and modes of action. This has prompted our group to start an investigation on the production of toxic metabolites by fungal pathogens of grass weeds, and to evaluate their potential as new natural herbicides, as both their native forms or as derivatives and analogues. For this purpose, many fungal pathogens were collected and their ability to produce bioactive metabolites evaluated. Among them, a strain of *Drechslera siccans*, a pathogen of oats (*Avena* sp.) and of perennial and Italian ryegrass (*Lolium perenne* and *L. multiflorum*, respectively) was particularly interesting, being able to quickly produce irregular necrotic spots on host leaves. By preliminary *in vitro* experiments the fungus proved to produce in liquid cultures lipophilic low-molecular weight metabolites causing necrotic lesions on leaves, symptoms resembling those caused by the pathogen.

This communication will describe the optimisation of the *in vitro* production of the phytotoxins produced by *D. siccans*, their isolation from the fungal culture filtrates and their chemical and biological characterisation. The possible involvement of these toxins in integrated strategies for grass weed control will be also discussed.

S8MT20AP01**SEED PRODUCTION BY ANNUAL WEEDS IN WINTER WHEAT AND OTHER ARABLE CROPS**[P J W Lutman](#), R I Hull, S E Freeman and K J WrightRothamsted Research, Harpenden, Hertfordshire, AL5 2JQ, UK, peter.lutman@bbsrc.ac.uk

As farming systems in the UK and elsewhere in Europe move away from prophylactic weed control towards more targeted approaches to weed management, the need for a better understanding of weed population dynamics increases. The critical parameters required are the levels of seed production and the longevity of the seeds. The main aim of this work was to quantify seed production and to explore the allometric relationship between seed production and plant dry weight to see if this value could be used as a surrogate for seed numbers. Over the past 6 years we have recorded seed production and plant dry weight for 16 different annual arable weeds. The robustness of the relationship between plant weight and seed number has been tested by collecting data from several seasons and sites, and by exploring the effects of changing crop agronomy, e.g., seeding rate and nutrition. Much of the work has focussed on weeds in winter wheat, but information also has been collected from other crops and from weeds growing on their own. Overall, there is a strong linear relationship between plant weight and seed number. In general, the relationship for individual weeds does not seem to vary greatly between crops but there is evidence that weeds growing in the absence of the crop do behave differently. The strongest relationship in the research seems to be between log₁₀ plant weight and log₁₀ seed numbers. Results from a sample of the 16 weed species will be presented and some of the 'problems' discussed.

S8MT20AP02**RE-INFESTATION POTENTIAL OF NASSELLA TRICHOTOMA UNDER A 'NO-SEEDING' MANAGEMENT STRATEGY**[S L Lamoureux](#), and G W BourdôtAgResearch Ltd, PO Box 60 Lincoln New Zealand, shona.lamoureux@agresearch.co.nz; graeme.bourdott@agresearch.co.nz

As part of an effort to optimise the management strategy for *Nassella trichotoma* Nees. in New Zealand, experiments were established to determine which life history stages most influence the plant's persistence and spread. In this paper we use the results of one of these experiments, the longevity of seed in the seed bank, to explore the future re-infestation potential of *Nassella trichotoma* under a hypothetical 'no-seeding' management regime. Mesh bags, each containing fifty *N. trichotoma* seeds mixed with sterilized soil, were buried just under the turf layer on shady and sunny aspects at each of three sites in North Canterbury. Bags were exhumed annually over five years and the viability of the seeds was ascertained using 2, 3, 5-triphenyl tetrazolium chloride. Double exponential decay models best fitted the data implying that some seeds of *N. trichotoma* have a higher probability than others of surviving long periods of time in the soil. Assuming an initial soil seed bank size of 40,000 seeds per hectare and an annual establishment rate of seedlings from the seed bank of 0.0128, the models revealed that no-seeding regimes would need to be in place at the sites of the experiments 4 to 8 years to reduce the re-infestation potential of *N. trichotoma* to below one plant per hectare. Eleven to 23 years were predicted for re-infestation potentials of below one plant per 100 hectares. Such re-infestation potentials may be unachievable in a management strategy for *N. trichotoma* as a consequence of the difficulties of preventing seeding.

S8MT20AP03

Weed seed bank response to crop rotation and tillage at TYGERHOEK, South Africa

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As the weed seed bank is the primary source of future weed infestations, it could indicate shifts in weed populations because of crop production practices. It is also important to evaluate whether modification of the cropping system to crop rotation under conservation tillage might result in increased weed problems which would counteract the expected beneficial effects on soil fertility. A long-term field study was initiated in 2000 to determine weed seed bank composition and to assess weed seedling densities after each year's crop rotation. The four-year cycles for crop rotations consisted of wheat monoculture, wheat – barley, wheat – medic – barley and lupines – wheat – canola – barley. Sampling of each plot was done with soil cores. The weed seed bank was analysed using the seedling emergence method in a glasshouse. Results indicated a significant increase in the number of seedlings of *Erodium moschatum* in no-till systems. With regard to crop rotation, the number of seedlings of *Lolium temulentum* was significantly greater in plots under wheat monoculture and wheat – barley. The crop rotation containing lupines showed a significant increase in *Fumaria muralis* in subsequent years. It can be concluded that no tillage could increase the abundance of certain weed species, but the fate thereof will be determined in the next four-year crop rotation cycle of this study.

S8MT20AP04

MODELING EMERGENCE OF TROPICAL WEEDS

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Weed control is a major production cost in most crops in tropical cropping systems. Due to competing demands on time during the growing season family labor is often not available when weeds are most damaging to crops. Weeds could be managed better if farmers understood their emergence patterns. Emergence models were developed for two important weeds in cropping systems of Nigeria and other tropical areas. These species were *Ageratum conyzoides*, and *Imperata cylindrica*. The models were developed using the soil hydrothermal time concept and five years of seedling emergence data for *Ageratum* at Ibadan, and two years of *Imperata* shoot emergence data at Umudike. Hydrothermal time was calculated from soil temperature and soil water potential, which was simulated with the SHAW model using weather data collected at the two locations. For each species a Weibull function was fitted to cumulative percentage emergence and hydrothermal time. The Weibull functions that best described the emergence of *Ageratum* and *Imperata* were $Y = 100 * [1 - e^{-0.0054 * HTT^{1.4288}}]$ and $Y = 100 * [1 - e^{-0.00023 * HTT^{2.8575}}]$, respectively. The model for *Ageratum* simulated emergence adequately at Umudike ($r^2 = 0.85$), and Los Banos, Philippines ($r^2 = 0.89$). The *Imperata* model adequately simulated emergence in corn/cassava plots weeded twice and five times at Ibadan. The model for *Ageratum* may be most useful in tropical locations where conditions approximate those in Nigeria. Additionally, the cogongrass model has some merit and may help to set the stage for further analysis on emergence patterns and management of *Imperata*.

S8MT20AP05

Plant Phenology to predict weed emergence

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Phenology is the study of periodic biological events. Two phenological events are correlated if they regularly coincide or follow one another in time. If we can detect easily recognizable phases in common plants that precede or coincide with weed emergence, these plants could be used as indicators. Weed emergence is usually difficult to detect, particularly in turf, and the use of phenological indicators provides an alternative approach to predict the time when a weed appears and, consequently, this could guide management decisions. A study was undertaken to determine whether the phenological phases of some plants could serve as reliable indicators of time of weed emergence in turf. Six common shrubs (*Crataegus monogyna* Jacq., *Forsythia viridissima* Lindl., *Sambucus nigra* L., *Syringa vulgaris* L., *Rosa* sp., and *Ziziphus jujuba* Miller) and four important annual weed species (*Digitaria sanguinalis* [L.] Scop., *Eleusine indica* [L.] Gaertner, *Setaria glauca* [L.] Beauv., *Setaria viridis* [L.] Beauv.) were observed from 1999 to 2003 in Veneto, northern Italy. The Wielgolaski's GDD method (1999) was used to predict the beginning of each phase and the correlation between this event and weed emergence was verified. *Syringa* and *Forsythia* seemed to be the best indicators. There was a quite close correspondence between the first appearance of *D. sanguinalis* emergence and *Syringa* flowering, and emergence of *S. glauca* and *S. viridis* were predicted well in relation to both the end of *Forsythia* flowering and the start of *Syringa* flowering.

S8MT20AP06

DORMANCY BREAKING OF WILD OAT (*AVENA FATUA* L.) SEEDS UNDER VARYING LEVELS OF TEMPERATURE, GA₃ AND KNO₃

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Dormancy is the failure of seeds to germinate under favourable conditions. This trait is of adaptive significance for weeds, as it allows them persist in agro-ecosystems. Several chemicals inducing germination in weeds have been identified. Hence, laboratory studies on wild oat seeds were undertaken at NWFP Agricultural University Peshawar, Pakistan, to investigate dormancy breaking by using a range of GA₃ and KNO₃ treatments from 0 to 800 ppm, with increments of 200 ppm, and exposure to 20, 25 or 30 °C temperature regimes. Experimental design was completely randomized with split plots. Temperatures were assigned to main-plots, while chemicals and their concentrations were allotted to sub-plots. Each sub-plot comprised a single petri-dish with 35 seeds. The germination percentage data were subjected to ANOVA, and the means were separated by the SNK test. The analyses revealed significant effects on germination of temperatures, chemicals, concentrations and their interactions. The highest germination (85%) was recorded at 20 °C as compared to only 5%, germination in 30 °C. GA₃ was more effective in inducing germination (52%) than KNO₃ (39%). The chemical x rate interaction revealed highest germination (61%) under GA₃ applied at 600 ppm, which was statistically comparable with other rates of GA₃, but higher than all concentrations of KNO₃ and untreated checks. The interaction of temperature x chemicals x rates was manifested by the highest germination observed (95%) and GA₃ was applied at 800 ppm and seeds subjected to 20 °C. This treatment was, however, statistically at par with the other concentrations of GA₃ exposed either to 20 ° or 25 °C.

S11MT02P01**Overview of water weed problems in the developing world****Ricardo Labrada¹****Food & Agriculture Organization, Rome
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Water weeds are becoming a serious problem all over the tropical and sub-tropical world. The most important species is water hyacinth (*Eichhornia crassipes*), which was introduced from South America into several countries of North and Central America, the Caribbean, Africa, South and South East (SE) Asia. This plant is seriously affecting large water bodies in Africa; Mexico, Central America and the Caribbean; and South and SE Asia. The stretches of river infested by the weed (excluding the Pacific region) are about 7171 km worldwide, while more than 29 000 km² of other inland waterways are also infested. The floating *Salvinia molesta* (water fern) and *Pistia stratiotes* (water lettuce) and the submerged *Hydrilla verticillata* have also invaded several water bodies, the first two in Africa, while the latter is important in North and Central America. Rooting *Typha* spp. is also of concern in water bodies of dry areas in Africa. Biocontrol, through the release of the weevils *Cyrtobagous salviniae* and *Neohydronomus affinis*, has proved to be effective in the short term for the elimination of water fern and water lettuce, respectively. Integrated management is required to reduce water hyacinth, consisting of the release of the weevils *Neochetina* spp. combined with manual/mechanical removal and/or rational use of low toxicity herbicides. For *Typha*, the only strategy available is physical removal; for *Hydrilla* chemical control is the current method used although some biocontrol agents are still being evaluated.

S11MT02P02**MANAGING WATER HYACINTH INFESTATION – THE UGANDA EXPERIENCE****James A. Ogwang, PhD**

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Water hyacinth, *Eichhornia crassipes* invaded Uganda and was first spotted in Lake Kyoga in 1988. The weed rapidly spread to cover most of the major water bodies reaching Lake Victoria in 1989. At the peak of its infestation in 1998, water hyacinth infestation coverage of L.Victoria was estimated at 12,000 ha – 4,000 of which occurred on the Ugandan side of the lake, 2,000 in Tanzania and 6,000 in Kenya.

Water hyacinth caused serious socio-economic, health and industrial problems in the lake region. The weed also impacted on diversity – reducing spawning habitats for fish.

In Uganda, an integrated approach was adopted involving mechanical removal, biological control agents while use of herbicides was deferred after an environmental impact assessment in 1996. Biological control using weevils *Neochetina eichhorniae* and *N. bruchi*, was adopted as the cheapest and safe methods. The weevils were reared using rearing facilities set along the shores of the affected water bodies. Fishermen were trained and integrated to speed up the release of the bioagents. By 2000, the weed biomass had all but collapsed under heavy damage by the bioagents which are credited for one of the most spectacular cases of successful biological control of a weed in the world. Although the use of an integrated management strategy significantly reduced water hyacinth infestation in Lakes Victoria and Kyoga, recent surveys indicate a recurrence of the weed. Significance of the weed resurgence is discussed.

Keywords: Water hyacinth, intergrated management, resurgence, *Neochetina bruchi*, *Neochetina eichhorniae*, Lake Victoria and Lake Kyoga.

S11MT04P01**BEYOND JUST WEED CONTROL: SOCIO-ECONOMIC FACTORS INFLUENCING THE ADOPTION OF WEED MANAGEMENT PRACTICES****R S Llewellyn**

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In modern cropping systems throughout the world, heavy reliance on herbicides has often led to widespread herbicide resistance. However, even where resistance problems have become most serious, growers usually have several herbicide options still available and continue to rely heavily on herbicides. To minimise further development of herbicide resistance, growers are being encouraged to invest more in the use of integrated weed management (IWM) practices. This paper explores the socio-economic factors influencing the decision to adopt IWM practices and a more conservative approach to herbicide use. The main objective is to identify opportunities for extension and research to improve weed management decision-making. Drawing on results from several surveys of Australian grain growers, the management of herbicides and resistance is presented as a resource conservation decision, with growers having to select the optimal use of the herbicide resource and the more costly non-herbicide practices over time. Factors that may influence this decision include perceptions relating to the exhaustibility of available herbicides, the likelihood of gaining resistance from external sources via seed or pollen movement, and the economic value of practices within the total farming system (*i.e.*, the value beyond simple weed control efficacy). The resource management approach to herbicide resistance is shown to be useful for understanding IWM adoption decisions in regions with both emerging and established herbicide resistance problems. Although several socio-economic factors act against investment in the conservation of herbicide susceptibility, opportunities to target extension to increase IWM adoption are identified.

S11MT04P02**SOCIO-ECONOMIC ASPECTS OF WEED CONTROL IN EAST EUROPEAN COUNTRIES****L Stefanović¹ and M Simić¹**

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Land reform and farm privatization are important components of ex-socialist economies in transition. Cultural, economic, and human experiences in these countries vary greatly. Transition had many negative impacts, especially on rural development. During reform in the 1990s, most agricultural land was abandoned. Privatization of agriculture has led to high unemployment, especially for rural women.

The agriculture sector predominates in transition economies. The agricultural profile of these countries is very different from that in western Europe. Use of natural resources in Europe is diverse, due to varying landscapes, biodiversity, cultivation practices, production and productivity, rural communities, and technical knowledge of farmers. Life on the farm is strongly dependent on farm and family size, economic situation, and level of mechanization. The situation in eastern European countries has been more difficult than in the rest of the continent. During the first seven years of transition, agricultural production fell by one third.

The transfer of land ownership from state to private hands was accompanied by changes in the farming system, including changes in crop rotation, fertilization practices, tillage, mechanization, and use of farm chemicals. Farmers were often confronted with economic difficulties that resulted in limited use of chemicals. Fields were heavily infested with weeds. Changes in weed species composition during this period are well documented. Currently, the level of weed control remains low in eastern Europe, with the exception of a few countries. Results of research projects, partially financed by the state, are rarely adopted by farmers.

S11MT08P01**Herbicide Resistance due to AMINO ACID CHANGES in Herbicide Target Sites****C Preston**

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Herbicide resistance in weeds can be endowed by any of a number of possible mechanisms. Target site insensitivity is the most commonly reported mechanism of herbicide resistance. Target site resistance involving a single nucleotide change and usually dominant genetics is easily selected. In addition, target site changes often provide high levels of resistance that are easily measured. Lastly, target site changes are generally simple to measure in the laboratory and often the first, and only, mechanism examined. The ability to detect mutations endowing resistance using rapid molecular techniques has made it even simpler to detect target site mutations. Target site mutations endowing herbicide resistance in weeds are known for Photosystem II, acetolactate synthase, acetyl coenzyme A carboxylase, tubulin polymerisation and 5-enolpyruvyl-3-shikimate phosphate synthase-inhibiting herbicides, as well as for auxinic herbicides. For some herbicide target sites only a few mutations the endow resistance have been found, whereas for others many have been discovered. In some cases selection with a specific herbicide, or group of herbicides, appears to always result in the selection of the same mutation, such as is seen with selection by triazine herbicides. The same is not true for other target sites, such as acetolactate synthase. This paper will review current knowledge about target site mutations endowing herbicide resistance and discuss how herbicide use patterns may contribute to selection for target site mutations.

S11MT08P02**P450 AND GST ENDOWED HERBICIDE RESISTANCE****R. De Prado and M.D. Osuna**

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Evolved resistance to herbicides in weed species is a significant and increasing problem in world agriculture. We will emphasise the crucial role of cytochrome P450 and GST enzymes in endowing herbicide resistance, in some cases across several dissimilar herbicide chemistries. Where herbicide resistance is endowed by herbicide metabolism in resistant weed biotypes it is important to establish the exact basis of resistance. Herbicide biotransformation may be due to one or more of multiple processes, collectively known as metabolism. Hall's group (2003) definition is useful: "the biotransformation of an organic compound that is not used as an energy source or as a constitutive element of the organism". The more important reactions of the metabolism detoxification pathways include oxidation, reduction, hydrolysis, and conjugation. These reactions are involved in a three-phase process: In phase I of metabolism, herbicides are transformed through oxidation, reduction or hydrolysis to produce metabolites which may or may not retain herbicide toxicity. Phase II involves conjugation of a herbicide or herbicide metabolite with a sugar, amino acid, or glutathione, which increases the water solubility and reduces toxicity compared with the parent herbicide. Phase III involves conversion of phase II metabolites into non-toxic secondary conjugates. Among the group of oxidative and conjugative enzymes, the most extensively studied in crops and weeds resistant to herbicides are the Cyt P450 and GST enzymes, which are the most important enzymes in phase I and II of metabolism, respectively.

S11MT17P01**MODELING SPATIAL AND TEMPORAL DYNAMICS OF WEED POPULATIONS UNDER THE INFLUENCE OF SITE-SPECIFIC WEED CONTROL- A NEW APPROACH****D. Dicke¹, R. Gerhards¹, A. Büchse² and K. Hurle³**

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Experiments were conducted on five arable fields to study the spatial and temporal dynamics of weed populations in a four year crop rotation and in continuous maize under the influence of site-specific weed control from 1998 until 2003. The objective of the study was to adapt a weed population model created by BÜCHSE and HURLE 2003 to forecast weed population dynamics based on previous years weed distribution maps. For weed mapping, a regular 15 * 7,5 m grid was established in all fields. Weed seedling density was counted before and after post-emergent herbicide application and before harvest in a 0,4 m² quadrat frame placed at all grid intersection points. Seed production of surviving weeds and seed mortality by predation and fatal germination was assessed in field studies. Data that were needed for the model and not assessed in the experiments were taken from literature. All data were entered in the weed population model.

The results showed that areas of the rotation fields that were not sprayed or that received a reduced herbicide dose did not increase in weed seedling density. However, weed seedling density has increased in continuous maize during the period of study. Results could be explained by the model and predictions of the model often corresponded to the assessed data. Therefore, modeling can help to reduce the time and costs for sampling weed distributions in the field. The knowledge of weed seedling populations dynamics can also be transferred to fields where Precision Farming has not been practised yet.

S11MT17P02**SPATIAL VARIABILITY OF THE WEED SEEDBANK IN NEW ZEALAND CROPPING SOILS****A Rahman¹, T K James¹, J M Mellsop¹ and N Grbavac²**

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Estimates of weed seedbank in the soil have considerable potential for predicting future weed infestations. With advance knowledge of the future composition and density of weeds in a field, they could be managed better through integrated and effective control strategies. Unfortunately, the distribution of weeds within fields is often spatially aggregated or patchy and this, in conjunction with various cultural factors results in seedbanks that are spatially heterogeneous. We have conducted field studies over several growing seasons to gain a better understanding of the weed seed distribution in New Zealand arable soils and to assist in development of reliable sampling methods. Vertical variability in distribution of weed seeds was studied by collecting soils samples to 15 cm depth along 100 m transects and enumerating by seed extraction method. The mean seed numbers for most species showed an exponential decline with depth (P<0.01). The horizontal variability was investigated by collecting samples to 5 cm depth on a 50 cm grid pattern. Although there was some indication of localized clumping, samples taken at least 1 m apart were shown to be statistically independent. In separate studies, no significant differences were found in the number of seeds or seedlings between samples collected from inner and outer (20 m wide corresponding to headland planting area) areas of fields. Samples from the outer areas, however, grew seedlings of significantly more species. Our studies suggest that approximately 25 cores, each 25 mm diameter, on a diagonal transect, may provide sufficient sized sample for arable fields.

**S11MT20CP01
SPATIAL VARIABILITY IN WEED POPULATIONS RELATED
TO NATURAL AND MANAGEMENT ECOLOGICAL FACTORS**

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Climate and soil are the major ecological determinants of the structure of weed communities at the regional and landscape scales. Land use history is also an important factor controlling the distribution of weeds in cultural mosaics. Within fields, spatial distribution is dependant on specific characteristics of weeds, i.e life cycle and growth and reproductive characteristics, which interact with cultural practices, such as, soil tillage, crop sowing, chemical control practices and crop harvesting. In some ecological scenarios seed predation, plant attack by herbivores and diseases also may become factors that determine weeds' distribution patterns. Therefore, spatial variability in weed populations should be studied taking into account a spatial-temporal scale hierarchy. Change patterns of the corresponding ecological factors to which weed species are sensitive have to be identified. In this paper we review the current literature on variability of biotic and abiotic factors and their interactions that result in spatial variability of weeds at different scales.

**S11MT20CP02
MECHANISMS CONTRIBUTING TO VARIABILITY IN WILD
OAT (*AVENA FATUA* L.) EMERGENCE ACROSS DIVERSE
LANDSCAPES**

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Primary dormancy prevents germination until environmental conditions are suitable for plant growth and development. In wild oat in Eastern Washington, seeds that over-winter are exposed to fluctuations in soil temperature and moisture. These fluctuations reduce primary dormancy, enabling germination in the early spring. However, several abiotic factors, such as landscape position, plant litter and the depth of seed burial, alter the magnitude of soil temperature fluctuations and may slow dormancy release and the rate of emergence. These effects are further compounded by the fact that seed banks are composed of seeds varying in age that may not respond uniformly to germination cues. Consequently, the emergence phenology of many herbaceous plant species can vary both spatially and temporally. The objectives of the study were to examine how these factors altered the pattern of wild oat emergence and to quantify the relationship between seedling emergence and soil temperature and moisture across a diverse landscape. Preliminary results indicate that temperature drives both dormancy release and the rate of emergence. In addition, our results suggest that the emergence phenology of wild oat will vary with seed age. We are developing a wild oat emergence model that accounts for variability in dormancy release and the timing of emergence, as influenced by over-wintering thermal accumulation. Our goal is to predict wild oat emergence across a diverse landscapes.

**S11MT25P01
COOL-SEASON TURFGRASS: WEED MANAGEMENT
STRATEGIES**

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Weeds invade cool-season turfgrass environments (*Agrostis stolonifera*, *Festuca arundinacea*, *Festuca rubra*, *Lolium perenne*, and *Poa pratensis*) and persist under various management conditions. Some of the common weeds are *Digitaria sanguinalis*, *Digitaria ischaemum*, *Elusine indica*, *Poa annua*, *Setaria glauca*, *Setaria viridis*, *Capsella bursa-pastoris*, *Medicago lupine*, *Polygonum aviculare*, *Plantago major*, *Plantago lanceolata*, *Stellaria media*, *Taraxacum officinale*, *Trifolium arvense*, *Veronica arvensis*, and *Viola arvensis*. The management of these weeds can be challenging because of the weed complex that occurs. A successful management program integrates both cultural practices (mowing height, frequency of irrigation and fertilization) and various chemical control strategies. Type I strategy refers to preemergence control of annual grass weeds. Bensulide, dithiopyr, pendimethalin, proflaminate, and oxadiazon are recommended for such control. Type II strategy involves a preemergence treatment (as mentioned above) followed by a sequential application of either preemergence or postemergence (dithiopyr, fenoxaprop, and quinclorac) treatments. Type III strategy focuses on postemergence control of either broadleaf weeds, annual grass weeds or both. The timing of application in relation to weed growth stage is very important in effective weed control. Postemergence treatments are desirable in early spring or early fall for broadleaf weeds, while grass weeds are targeted at the 2- to 4-leaf stage (early spring). Postemergence treatments for grass weeds include fenoxaprop, quinclorac, or MSMA. Products such as Confront, Millennium Ultra, PowerZone, SpeedZone, Trimec Classic, and TurflonD are recommended for effective postemergence control of these broadleaf weeds.

**S11MT25P02
WEED MANAGEMENT IN WARM-SEASON TURFGRASS**

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Weeds are a major problem faced by turfgrass managers regardless of whether they work with golf courses, residential turf, industrial sites, sports turf or parks. In warm-season turfgrass areas, this problem is exacerbated by long, sometimes year-round, growing seasons. Maintaining a healthy, vigorously growing turf that minimizes voids is the first step in a cost effective, environmentally sound weed management program. Even with optimum turfgrass growth, however, herbicides are often needed to provide a level of weed control acceptable to those utilizing the turfgrass areas. In warm-season turfgrass, multiple applications are often necessary to provided season-long control, especially for the most common and troublesome species such as *Digitaria* spp. , *Cyperus* spp. In general, preemergence applications of dinitroaniline or similar weed spectrum herbicides are applied before germination of annual grass species. This initial treatment is usually followed 40 to 60 days later by a second application of the same herbicide. Recently, several Aceto-Lactate Synthase (ALS)-inhibiting herbicides have been labeled in the U.S. for postemergence control of several problem species including *Cyperus* spp., *Eleusine indica*, (goosegrass), *Poa annua*, (annual bluegrass), *Diodia virginiana* (Virginia buttonweed) and *Panicum repens* (torpedograss). While *Cynodon dactylon* L. x *C. transvaalensis* (hybrid bermudagrass) and *Zoysia* spp. (zoysiagrass) tolerate these new herbicides, most of the other warm-season turfgrass species do not.

S13MT02P01
**BIOCONTROL OF WATERHYACINTH IN MEXICO BY USING
INSECTS AND PLANT PATHOGENS**

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In Mexico, more than 40,000 ha of dams, lakes, channels and drains are infested with waterhyacinth. Chemical and mechanical control methods have been used to manage this weed; those methods are expensive and unsatisfactory as repeated applications are needed (Gutiérrez et al. 1994). In order to evaluate other methods of control, two host-specific herbivorous weevil species (*Neochetina* spp; Coleoptera: Curculionidae) in combination with Mexican indigenous pathogens were used for waterhyacinth control in a dam in México. A total of 9,800 insects were released and two applications of a mixture of *C. piaropi* and *A. zonatum* (mexican indigenous fungi) were carried out. After two months from the first insect release, all leaves of waterhyacinth showed adult feeding scars. Concerning pathogens affect, after two weeks of the first application, the disease spread to infect most of the waterhyacinth in the area (approximately 3 ha.) One month after the establishment of insects and pathogens, a reduction of 71.40% on fresh weight, 41.10% on number of plants per square meter, 36.36% on the number of leaves per plant and 17.85% on the number of new leaves was observed. Three months later, the dam was complete cleaned. The combine action of insects-pathogens, growth cycle of waterhyacinth and the weather contributed together towards waterhyacinth control.

S13MT02P02
**MANAGEMENT OF WATER FERN (*SALVINIA MOLESTA*)
IN SENEGAL AND MAURITANIA**

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In 1999 Senegal and Mauritania faced an invasion of water fern (*Salvinia molesta*) which heavily infested over than 18,000 ha of Senegal River. Such an infestation became an extremely serious problem and threat to agriculture, fisheries, human health, transportation and the environment. Biological control of salvinia was implemented using its natural enemy, the weevil *Cyrtobagous salviniae*. Funding and technical support were provided by FAO through a 13-month TCP agreement. The main objectives of the assistance were: to set up two rearing units (one in each affected country); to massively release the insect; to monitor the weed infestation and the insect establishment; and to conduct an awareness campaign for the water fern biological control among the riparian populations. Each country received an initial insect colony of 1,250 weevils. Rearing process provided 60,000 weevils released in 270 sites. Local populations were involved in the program, and effectiveness of the release was measured using three parameters: invasion level, damage and fresh weight of salvinia. In all monitored sites, attacked salvinia buds by the weevils reached 100%. Affected plants lost its fleshy green plant vigor and died. Salvinia invasiveness decreased within relatively short period of time. By the end of the program, more than 95% of water plans were free of salvinia. Six months after the end of the project, the Senegal river and its tributaries were free of *Salvinia molesta*. Riparian populations participated with enthusiasm in the development of the project, particularly in weevil release campaigns.

S13MT02P03
**INTEGRATED CONTROL OF HYDRILLA IN THE UNITED
STATES**

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For the past 30 years, the management of hydrilla in the United States has relied mainly on the use of grass carp as well as chemical and mechanical control technologies. These technologies provide, at best, short-term control at a prohibitively high cost. In addition, implementing these strategies does not normally take into consideration other factors within the ecosystem, such as nutrient inputs and native plant diversity, which may be influencing the formation of economically important hydrilla infestations. Recently, two new technologies have emerged that offer the possibility of combining all available techniques into an integrated ecosystem management approach to hydrilla control. These new technologies include host-specific insect agents, specifically, two species of leaf-mining flies, *Hydrellia pakistanae* and *H. balciunasi*, and an ecosystem approach where stable native aquatic plant communities are established in an effort to exclude or inhibit the formation of large infestations of hydrilla. The development of an integrated, ecosystem approach to hydrilla management, where all aspects of the environment from nutrient loading to native plant community structure are taken into consideration, represents a significant advance over more traditional management methods. This presentation will examine the promise of these new technologies, alone and in combination, with more traditional existing methods, for managing hydrilla within an ecosystem context.

S13MT02P04
**AQUATIC WEED MANAGEMENT IN AUSTRALIA:
SUSTAINABILITY IS PARAMOUNT**

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The emphasis in Australia for the management of aquatic weeds has been to develop sustainable techniques, integrated strategies, and to conduct research to underpin their development. Testament to the success of this approach is the contribution Australian work has made to aquatic weeds management in numerous other countries. To achieve sustainability, (encompassing affordability, practicability and environmental acceptability), biological control has been and continues to be used as the base technique. This paper discusses current research and management activities for aquatic weeds in Australia, with emphasis on biological control, and the systems that are in place that support these activities. The main target weeds are: the emergent weed alligator weed (*Alternanthera philoxeroides*), the submerged weed cabomba (*Cabomba caroliniana*), and the two floating weeds, salvinia (*Salvinia molesta*), and water hyacinth (*Eichhornia crassipes*).

**S13MT04P01
INNOVATIVE APPROACHES TO WEED SCIENCE EXTENSION**

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New and innovative approaches to Weed Science Extension include Decision Support Systems (DSS) and various web based applications. WeedSOFT[®] is a Windows based weed management DSS developed for use in seven North Central states. The regionalization effort was supported by USDA CSREES Ramp Award 2001-61101-11100. This effort resulted in each cooperating state having a version of WeedSOFT[®] that addresses its unique soil and climatic conditions, weed species, and crop production practices. This regional project involved Illinois, Indiana, Kansas, Michigan, Missouri, Nebraska, and Wisconsin. WeedSOFT[®] consists of three modules, Advisor, EnviroFX, and WeedVIEW. Advisor provides a bioeconomic assessment of preemergence, postemergence, and pre + postemergence weed management strategies in several crops. EnviroFX supports site and herbicide specific assessment of groundwater contamination potential. WeedVIEW provides visual images as an aid in weed identification. Plans for the future include a GPS based weed mapper module in WeedSOFT[®].

WeedSOFT[®] is useful in a teaching environment. Learning modules addressing postemergence application timing, weed seedbanks, environmental factors, and crop growth stages have been included in the 2004 version of WeedSOFT[®].

Web based extension educational resources include web pages and internet lessons. These approaches provide educational opportunity at the convenience of place-bound learners. They allow each learner to proceed at an individual pace. A suite of crop and weed science internet lessons has been developed at the University of Nebraska and can be accessed at <http://croptechonology.unl.edu>.

**S13MT04P03
HERBICIDE RESISTANCE MANAGEMENT EXTENSION IN WESTERN AUSTRALIA**

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For numerous reasons, herbicide resistance has a strong presence in Australia's major grain producing state, Western Australia. The first case of resistance was confirmed in the early 1980's and has expanded enormously over the past two decades in the Western Australia grain belt. Currently resistance exists across seven different modes of action (including glyphosate) in *Lolium rigidum*, and resistance is rapidly increasing in *Raphanus raphanistrum*. Campaigns by the Department of Agriculture in the early 1990's, recorded 96% grower awareness about the risk of herbicide resistance. Although the efforts of extension have helped improve farmer knowledge about herbicide use and various integrated weed management practices, farmers have generally continued to select for the most common types of resistance such as *Lolium rigidum* resistance to ACCase and ALS herbicides. To further enhance education against selection for resistance, compulsory herbicide group labelling began on all herbicide products in 1996. By 1998, a grower survey reported an 85% awareness of herbicide mode of action grouping and considered mode of action an important herbicide characteristic. However, over 70% of Western Australia's paddocks now contain a herbicide resistant *Lolium rigidum* population. As the use of herbicides continues to increase, extension has focused on managing resistant populations and preserving the remaining herbicide resource. One of the methods used to help achieve this goal is the development of the RIM (Resistance and Integrated Management) bioeconomic model which is workshopped with growers and advisors to evaluate the long-term value of crop rotation and various weed control options.

**S13MT04P02
WEED SCIENCE EXTENSION IN SOUTH AFRICA**

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The majority of recognised weeds in Southern Africa are introduced and are annuals affecting mainly crop production or are perennial shrubs and trees invading indigenous environments and plantations. Generally the economic importance of a species has determined the priority of research on biology and control measures, with results then disseminated by research and extension services to the landowner.

The extension service in each province is organized into regions, each subdivided into districts which are further divided into wards. The target is to have at least one extension officer per ward. Each province has a central administration with technical support staff.

Much of the basic research is undertaken by specialist institutes within the government Agricultural Research Council or by universities or privately funded organisations specialising in commercial crops such as sugar and timber. These latter organisations generally transfer weed science research results through their extension or advisory organisation to producers, with the aim of more efficient production or protection of indigenous biodiversity. Weed science courses are held regularly.

Companies under Crop Life have played a significant role in developing weed control systems based mostly on herbicides. Information days and courses convey the technology to the extension officers and farmers.

Legislation designating the classification of weeds is in place as well as making control of certain species mandatory. The extension officers play a major role in conveying this information to land owners. All herbicides are regulated by legislation.

**S13MT04P04
IMPROVING FOOD SECURITY THROUGH STRIGA AND SOIL FERTILITY MANAGEMENT IN LOWLAND MAIZE: A PARTICIPATORY DEVELOPMENT PROCESS**

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Lowland tropical maize (0-1000 metres above sea level) comprising 18% of maize production in eastern and southern Africa, often is characterised by declining productivity. In the Muheza District of northeast Tanzania, village workshops confirmed that maize is the most important crop, but production has declined from over four to less than half a tonne per ha within living memory. The main reasons identified by participants were declining soil fertility, increasing *Striga asiatica* and stem-borer infestations, as well as increased drought and deforestation and a lack of improved seed. Although farmers have developed coping strategies for these constraints, they have done little to arrest yield decline and poverty has increased. As part of a participatory research and development process involving key stakeholders, farmers selected options for on-farm testing. This included *Striga* and soil fertility management using leguminous green manure cover crops (*Mucuna*, *Canivalia*, and sunhemp), as well as *Striga* tolerant maize varieties and methods to control stem-borer control. Results after one year (two seasons) indicate that maize yields can be increased by more than 100% when following a green manure crop. Although alternative legume choices are few, *Canivalia* was preferred by farmers due to its drought tolerance, low labour requirement for incorporation, resistance to insects and diseases, improvement in soil structure and soil moisture holding capacity, and a reduction in *Striga* infestation in the subsequent maize crop. Concerns with the *Canivalia* green manure system were the loss of a cropping season and disapproval of non-adopting neighbours.

S13MT08P01**PARAQUAT RESISTANCE OF CONYZA CANADENSIS (L.) CRONQ.**

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Among the herbicide resistance mechanisms the Pq resistance of weeds is probably the less well understood. Numerous hypotheses have been evolved on possible mechanisms of Pq resistance: sequestration of Pq, its limited translocation within the plants or enhanced activity of oxygen radical detoxifying enzymes were also proposed in different resistant species.

In populations of horseweed (*Conyza canadensis* /L./ Cronq.), which otherwise caused great troubles in Hungarian vineyards, Pq resistance evolved 18-20 years ago independently in different locations. Some biotype showed atrazine resistance, too. Since that time the mechanism of resistance has extensively been studied here in the cooperation of two research groups. This review gives an overview on this work with special regard to the results of recent molecular approaches.

On the basis of our results we assume that sequestration mechanism plays a crucial role in the resistance mechanism. Our studies using transporter inhibitors (CCCP, DCCD, TPP and vanadate) showed that probably not directly energized antiporters can play a role in paraquat sequestration. Gene expression studies (DDRT-PCR) affirmed our hypothesis that EmrE-like gene differentially expressed in resistant and sensitive biotypes and may contribute to the resistance. The effect of Pq, menadione and S-methylmethionine on the gene expression level of putative transporters, with RT-PCR and real time PCR has also been studied.

S13MT08P02**LOW RATES OF DICLOFOP-METHYL RAPIDLY SELECT FOR HERBICIDE RESISTANCE IN LOLIUM RIGIDUM.**

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There has been much conjecture, supported by little empirical research, suggesting that low herbicide rates may rapidly select for economic levels of herbicide resistance. In 2000, the response of the herbicide susceptible *Lolium rigidum* biotype, VLR 1, to low rates of diclofop-methyl (0, 38, 75, 113, 188 and 375 g a.i. ha⁻¹) was established under glasshouse conditions. Dose response data were described by a log-logistic regression model. Thirty five percent (52 individuals) of the screened VLR 1 seedlings survived the 38 g a.i. ha⁻¹ rate of herbicide. These survivors were grown to maturity, bulk crossed and seed was collected. In 2001, the dose response of the parent VLR 1 biotype and the low dose selected subset of VLR 1 were compared. Log-logistic models identified a significant increase in the LD₅₀ of the low dose selected subset, confirming the heritability of the low dose response and the potential for low herbicide rates to increase the herbicide resistance status of *L. rigidum* populations. Two further cycles of recurrent selection have resulted in a 16-fold increase in the LD₅₀ for diclofop-methyl of the selected compared with the original VLR 1 biotype. Additionally, selection with low rates of diclofop-methyl has resulted in cross-resistance to other ACCase herbicides and to the chemically dissimilar ALS-inhibiting herbicide, imazethapyr. In vitro studies of ACCase enzyme inhibition have confirmed that resistance is due to a non target site mechanism. These results confirm the ability of low herbicide rates to rapidly select for economic levels of resistance.

S13MT08P03**GLYPHOSATE RESISTANCE MANAGEMENT IN USA-SYNGENTA PERSPECTIVES**

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Changes in the use of glyphosate with the introduction of Roundup Ready® crops in the mid-90s has meant exposure of a whole new "genetic pool" to the herbicide. Although weed population shifts and resistance have been observed before, following locally intense glyphosate use, the recent widespread adoption of homogeneous weed control methods, particularly in cotton and soybeans, has led to a burgeoning resistance problem. Despite the low frequency of resistance to glyphosate in natural weed populations, the characteristics of those weed species developing resistance are such that their spread is inevitable, unless appropriate management is undertaken. It has become apparent through our monitoring programs, surveys and experimental work that weed populations are changing. There is a pressing need for diversification of control methods to delay the onset and manage the development of glyphosate resistance. The use of integrated weed management techniques, such as alternating modes of action will be necessary to ensure preservation of this important tool and sustain its use in North American agriculture.

S13MT08P04**MULTIPLE HERBICIDE RESISTANCE IN WILD RADISH (RAPHANUS RAPHANISTRUM) POPULATIONS IN WESTERN AUSTRALIA**

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There is an increasing frequency of herbicide resistance in populations of wild radish collected from the Western Australian wheatbelt. Resistance to the acetolactate synthase (ALS) inhibiting herbicides has become common place (>20% of populations). Triazine herbicide resistance and resistance to the phytoene desaturase inhibiting herbicide, diflufenican has also been identified separately in several populations. In recent seasons there have been widespread reports of phenoxy herbicide failure on wild radish populations. Several of these populations were thoroughly screened in a series of whole plant population response studies with the aim of establishing herbicide resistance profiles. Population responses were contrasted in a series of herbicide cross resistance screens and dose response studies conducted over a three year period at the University of Western Australia. Six populations were found to be resistant to the phenoxy herbicides 2,4-D and MCPA at up to 4 times the recommended field application rates. There was more than 50 percent survival at these very high application rates in four of the populations studied. The six phenoxy resistant populations were also simultaneously resistant to a range of ALS inhibiting herbicides. Additionally, two of these populations were also resistant to a phytoene desaturase inhibiting herbicide. The mechanism of resistance to the ALS inhibiting herbicides in several wild radish populations has been previously been identified as resulting from an altered target site. Therefore indications are that these populations have developed at least two mechanisms endowing herbicide resistance across the phenoxy herbicide, ALS inhibiting and phytoene desaturase inhibiting herbicide chemistries.

S13MT08P05
RESISTANCE TO THREE MODE-OF-ACTION CHEMISTRIES IN TALL WATERHEMP [*AMARANTHUS TUBERCULATUS* (MOQ.) SAUER]

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A tall waterhemp [*Amaranthus tuberculatus* (Moq.) Sauer] population with resistance to multiple herbicides was recently identified in Adams County, Illinois, U.S.A. Greenhouse studies were conducted to confirm and quantify the responses of this tall waterhemp population, designated ACR, to various mode-of-action chemistries when compared to a herbicide-susceptible population. The ACR population was able to survive postemergence applications of herbicides that inhibit protoporphyrinogen oxidase (PPO), acetolactate synthase (ALS), or photosystem II (PSII). In fact, individual tall waterhemp plants from the ACR population survived treatment with a herbicide mixture containing lactofen at 175 g ai ha⁻¹, imazamox at 44 g ae ha⁻¹, and atrazine at 1000 g ai ha⁻¹. Treatment of herbicide-susceptible tall waterhemp plants with similar rates of lactofen, imazamox, or atrazine provided excellent control. Contrary to results obtained with previously mentioned herbicides, the ACR population was not resistant to glyphosate or paraquat. Preliminary observations indicate that resistances to inhibitors of PPO, ALS, and PSII are conferred by separate mechanisms. Tall waterhemp is one of only several weed species that have evolved resistance to three or more mode-of-action chemistries, and poses a significant loss of options for postemergence control of tall waterhemp in soybean production.

S13MT17P01
SENSOR BASED WEED DETECTION AND VARIABLE RATE HERBICIDE SPRAYING IN REAL TIME

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The use of production inputs and the input of biocides into the environment could be reduced by variable rate application of herbicides according to the weed occurrence. Fast small-scale information about the weed distribution can be delivered by use of sensors for automatic weed detection. At the Institute of Agricultural Engineering Bornim (ATB) an optoelectronic weed sensor was developed, which was used in the past 4 years in farmers fields of cereals and pea for a variable rate herbicide spraying in real time with common application speeds. Large scale field strip trials with a sensor operated field sprayer were conducted to quantify herbicide savings, yield and preharvest late weed occurrence compared to common practiced uniform spraying. In 13 fields of winter wheat, winter rye, triticale, summer barley and pea herbicide savings on the average of 25 % were achieved. For assessment of the effectiveness of the sensor based spraying variety and abundance of the weeds were recorded in grid sampling before spraying and before harvesting at the same sampling points. A higher late weed occurrence could not be obtained in the variable rate sprayed plots. By measuring the volume flow the application rate at each sampling point was recorded. The abundance of late occurring weeds was independent of the application rate at the sampling points. Two strips per plot were harvested by a combine harvester with a yield logger. On an average equivalent yield levels were obtained in the variable rate plots in comparison to the uniform plots.

S13MT17P02
APPLYING MULTISPECTRAL AERIAL IMAGERY TO WEED SPECIES DIFFERENTIATION

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A field experiment was implemented in 2002 to differentiate six common Mississippi weeds, soybean [*Glycine max* (L.) Merr.], and soil using multispectral aerial imagery. The weed species chosen were hemp sesbania [*Sesbania exaltata* (Raf.) Rybd. ex. A. W. Hill], prickly sida [*Sida spinosa* L.], sicklepod [*Senna obtusifolia* (L.) Irwin and Barnaby], smallflower morningglory [*Jacquemontia tamnifolia* (L.) Griseb.], palmleaf morningglory [*Ipomoea wrightii* Gray], and pitted morningglory [*Ipomoea lacunosa* L.]. Experimental units were 4 x 4 m replicated four times, which were dissected into 16 1-m subunits. Within each subunit, weed species were planted to densities reflecting 50, 100, and 200% of published yield loss thresholds. Multispectral aerial images with 0.5-m spectral resolution were acquired July 18, August 10 and 21, and September 6 and 28, 2002. Supervised classification analysis techniques were used to determine classification accuracy assessments. Images acquired in July and September produced the highest overall classifications accuracies. All classification accuracies for these images were greater than 83%, which can be attributed to fewer classes being classified in these images. Overall classification accuracies were 49 and 64% for the images collected August 10 and 21, respectively. Overall classifications decreased due to an increased number of classes being misclassified and mixed pixel misclassification along the plot borders.

S13MT17P03
SIMULATION OF WEED SAMPLING STRATEGIES

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For the site-specific application of Pesticides, and Herbicides in particular, High Resolution Maps are required. So far, Weeds are mapped by interpolation between the sampling locations in an arable field. Little is known about the adequacy, quality and reliability for the intended purpose of the Weed Maps regarding the sampling resolution and the sampling scheme applied. Based upon a complete survey of Weeds in subsets of several arable fields that has been achieved by the developed Weedscanner technique described in another publication a simulation of sampling densities and strategies was performed in this study. A custom simulation software was implemented in order to test different sampling densities, quadrat sizes for counting and sampling schemes such as regular sampling and random sampling. The errors of the simulated sampling were calculated according to the reference area for the specific sampling proposal for the particular population investigated. The results clearly indicate that further knowledge on the Weeds's spatial distribution is necessary in order to perform the highest possible adequacy in sampling schemes and resolutions. Nevertheless, the results reveal large errors and uncertainties resulting from sparse sampling. The question of whether or not spatial interpolators are capable of improving the results of sparse sampling will be discussed based on a plausible example.

S13MT17P04**HERBICIDES EFFECT ON WEED FLORA AND GRAIN YIELD OF ZERO VS. CONVENTIONAL TILLAGE WHEAT**N U Khan¹, S U Khan¹ and G Hassan²¹ *Plant Physiology & Weed Management, Agricultural Research Institute D.I.Khan 29020 Pakistan, E-mail: nukmarwat@hotmail.com.*² *Department of Weed Science, NWFP Agricultural University Peshawar Pakistan.*

Cultural as well as chemical weed control is a basic requirement for improved cropping system. Herbicides were evaluated in zero vs. conventional tillage wheat planted in a triplicated split-plot arrangement in rice-based cropping system at Agricultural Research Institute D.I.Khan, Pakistan. Herbicides viz; Bromoxynil + MCPA (Buctril-M) and Carfentrazone-ethyl + Isoproturon (Affinity) were applied in wheat. Weed flora observed was *Convolvulus arvensis*, *Rumex dentatus*, *Medicago denticulata* and *Melilotus indica*. Weed density revealed significant differences for tillage operations, herbicides and their interaction. In grain yield, herbicides exhibited significant differences but the tillage practices and their interaction were non-significant. Conventional tillage showed lesser weed infestation than no tilled plots. On average, tillage plots showed lesser weed infestation than no till plots. In interaction, herbicides under either tillage regime have shown significant decrease in weed flora against weedy check. Buctril-M produced higher grain yield (3068 kg ha⁻¹). It was at par with Affinity (2822 kg ha⁻¹). There was no significant difference in yield of zero- and conventional tillage plots. Weedy check has shown the lowest yield. In the end of crop season, *Conyza bonariensis* was appeared with heavy infestation only in zero tillage plots but absolutely no such weed plant was observed in tilled plots. It may be due to conserving of weed seed bank in zero tillage regimes but in conventional tillage the weed seeds were exposed to the unfavorable environment at germination stage. Zero tillage with herbicides was found more economical by saving time and land preparation expenditure.

S13MT17P06**DOMINANT WEED SPECIES OF POTATO CROPS IN MOUNTAIN-CONTINENTAL PART OF MONTENEGRO**Stešević Danijela¹, Jovović Zoran²¹ *University of Montenegro, Faculty of Sciences, Biology Department, Cetinjski put bb, Podgorica, SCG, denist@cg.yu*² *University of Montenegro, Biotechnical Institute- Kralja Nikole bb, Podgorica, SCG, jovovic@cg.yu*

Yield loss from weeds are huge and diverse and they reflects themselves the best way through decrease of quantity and very often through decrease of gotten product's quality. Because of a plasticity of its genotype and high adaptability on different environmental conditions weeds become a powerful competitors to cultivated plants. So, getting know with the biology and ecology of dominant weed species present the base of successful weed control.

Our investigations were carried in period 1998-2000, on potato crops not treated with herbicides. We registered 57 weed species that belongs to 35 floral elements. These numbers speak about great richness and diversity of potato crop's weed flora. List of dominant weed species is formed on weedness estimation and it comprise 7 species: *Convolvulus arvensis* (21.6%), *Anthemis arvensis* (9.9%), *Sinapis arvensis* (6.5%), *Bilderdickya convolvulus* (6.0%), *Galeopsis tetrahit* (5.6%), *Chenopodium album* (5.3%) and *Fumaria officinalis* (5.1%). *Convolvulus arvensis* was shown as the most dangerous weed in potato crops of investigated region. It's perennial, with strong, deep and on several levels horizontally branched root with ability of vegetative reproduction (among with seeds). Phenologically observed it belongs to spring-winter group of weeds and it express the biggest abundance in 2nd and 3rd estimation. Other weed species are annuals with typical phenology.

Having in mind all mentioned particularities of potato crop's weeds of investigated area, we conclude that with regular choice, in time and consequent weed prevention, extraordinary results in weed control can be achieved. It would minimize lost of yield and tuber production.

S13MT17P05**STUDY OF CANOPY ARCHITECTURE OF WHEAT IN COMPETITION WITH WEEDS**Hossein Najafi¹ and Hamid Rahimian Mashhadi²¹ *Plant Pests and Diseases Research Institute,**Weed Research Dept., Tehran, Iran, B.P. 19395; najafiamir@yahoo.com; and ²Agronomy Department, Faculty of Agriculture, Tehran University, Tehran, Iran.*

Cruciferous weeds are among the most troublesome weeds that cause considerable grain yield reduction in Iranian wheat fields. In order to determine the effects of weed competition on wheat canopy architecture, an experiment was conducted in Iran(2001). Treatments included three weeds (*Sinapis arvensis*, *Rapistrum rogosum* and *Descurainia Sophia*) at five densities (0, 4, 8, 16 and 32 plantsm⁻² for *Sinapis arvensis* L. and *Rapistrum rogosum*, and 0, 16, 32, 64 and 128 plantsm⁻² for *Descurainia Sophia*). A randomized complete block design with four replications in an additive series technique was employed as the experimental design. Increasing weed density, significantly reduced the height and leaf area of wheat. In addition, in comparison with control, leaf area of wheat was move distributed at the top of plant. Change in vertical distribution were primarily associated with increases in the proportion of leaf area and dry matter in the upper segment of the wheat. Weeds with different morphologies showed different effects in canopy structure of Wheat. *Descurainia* had a more open canopy than the other weeds, and was a consistently weak competitor. Wheat biomass highly correlated with the *Sinapis* and *Rapistrum* biomass, leaf area and light interception ability. In compare to *Descurainia*, *Sinapis* canopy was similar in structure and leaf area distribution to *Rapistrum*.

S13MT20CP01**WEED EMERGENCE AND GROWTH AS INFLUENCED BY LANDSCAPE POSITION**

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Field research was conducted in a 16 ha soybean field at the Agricultural Ecology Research Farm, Southern Research and Outreach Center, University of Minnesota, to characterize the extent of spatial variability in weed emergence and growth across a field-sized landscape. Weed density and height data were obtained weekly from ten research sites in 2000. Research site locations were selected based on hillslope position, aspect, slope, and soil taxonomy. Sites included two summit sites, five backslope sites, and three toeslope sites. Soil physical and chemical properties were collected at each location along with a detailed analysis of primary and secondary terrain attributes to enhance our understanding of factors contributing to differences in weed emergence and growth. A statistical model was developed for conducting spatial analysis of weed emergence and growth patterns in time and space. We modelled growth coefficients of traditional emergence curves as multivariate spatial processes designed to capture multi-resolution variation. Macro- and micro-level variation was obtained through a coregionalized model. Spatial variation in intercept and slope processes can be seen at micro- and macro-level scales. For emergence of *Setaria* spp. (foxtails), sand, potassium, and profile darkness index were the only significant covariates. We will discuss how this type of analysis can enhance our understanding of weed emergence and growth across field landscapes and how choice of covariates is important. We also will argue that understanding the role of environment in regulating weed emergence and growth may require the use of integrator variables that describe complex processes.

S13MT20CP02
SPATIAL VARIABILITY OF WEEDS AFFECTS ESTIMATION OF INFESTATION

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Estimation of average density of weeds is important both for the surveillance of weed abundance and diversity and for planning an appropriate weed control strategy. Several quantitative methods have been developed for these purposes. Some methods, such as the Braun-Blanquet method, are based on subjective estimation of plant cover where data depend on the individual observer. These methods have the advantage of being fast to conduct, which is important if large areas have to be surveyed. Other methods are based on more precise measurements, e.g. counting plants per unit area. The data obtained by this method do not depend on the observer, but the approach is very time consuming and thereby limits the possibility of surveying large areas. Frequency analysis is sometimes used instead. In a frequency analysis, only the presence of a species is observed in each survey plot. This method is much faster than counting, but one does not obtain an estimate of the average weed density. In this paper the relation between average weed density of a field and the frequencies obtained is estimated. Additionally, spatial variability of weeds in relation to choice of botanical analysis and use of statistical methods, such as kriging and co-kriging, are discussed.

S13MT20CP03
ANALYSIS OF THE SPECIFIC AND FUNCTIONAL STRUCTURE OF WEED COMMUNITIES IN THE ROLLING PAMPA: TEMPORAL AND SPATIAL APPROACHES

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Agricultural activities performed during the last 80 years in the Rolling Pampa of Argentina affected the propagule availability, soil resources and physical space, all of which changed specific and functional structures of these communities. We studied shifts in weed richness and functional composition in the central Rolling Pampa. We evaluated temporal variation using historical records of wheat, flax and corn fields, and recent surveys of soybean fields. We also examined spatial variation, analyzing a set of surveys conducted recently in wheat and soybean fields, and data from factorial field experiments that included different crops and management. We evaluated species constancy, richness and function (morphotypes and physiotypes). Data were analysed with multivariate procedures. Agriculture reduced original (grassland) richness by 117 species. On a temporal scale, weed species richness increased at a rate of 0.42 species per year from 1926 to 1999, accompanying an enlargement (19%) of the cultivated area. Functional groups producing secondary metabolites with biological activity were maintained on both spatial and temporal scales. Since 1997, soybean weed species richness decreased at a rate of 5 species per year ($r^2 = 0.80$), accompanying the rise (12%) between 1997 and 2003 of the land area in no-tillage and the wide adoption of transgenic crops resistant to glyphosate. On a spatial scale, the results from the soybean, corn and wheat surveys, as well as wheat-coriander and corn-tagetes field experiments, showed that among all the management variables considered (crop yield, tillage, weed management, fertilization), the main factor that discriminates among communities was the number of annual cropping cycles, which is related positively to soil degradation.

S15MT02P00
USING WATER HYACINTH TO PRODUCE ORGANIC FERTILIZER

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Water hyacinth (*Eichhornia crassipes*) continues to cause serious problems in many provinces of East-southern China, and lose more than RMB 5 billion yuan a year. A great deal of fund has been applied to manage this weed. From 2001 to now, studies on using water hyacinth to produce organic fertilizer was conducted, and fancy results were obtained. In the fertilizer plant in Shanghai, 50 ton water hyacinth was treated a day according to the formulation of 95% water hyacinth + 5% manure. In the 28-30 day fermentation, the high temperature (≥ 50 °C) would keep more than 15 days. As a result the organic fertilizer product is characterized by pH 7.2, total N, P, K content ≥ 7.0 , organic matter content $\geq 45\%$, thus according to national standard of China. In addition, heavy metal content of Cu, Cr, As and Hg in fertilizer was tested, that showed the fertilizer product is safe to environment according to the standard involved.

Key words: water hyacinth, organic fertilizer

S15MT02P00
COMPETITIVE INTERACTION BETWEEN TWO WEEDS: WATER HYACINTH (*EICHHORNIA CRASSIPES* [MART.] SOLMS.) AND ALLIGATOR WEED (*ALTERNANTHERA PHILOXEROIDES* [MART.] GRISEB)

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For the past five to six years alligator weed was found naturally growing on the live substrate of *Eichhornia* and suppress its growth and eventually killing it. We tested this process in the controlled laboratory conditions by incubating the two weeds in pure and mixed stocks. Even small proportions of alligator weed inhibited the growth of *Eichhornia* within 15-20 days; latter showed stunted growth and the leaves turned yellow and died in about 30 days. On the other hand alligator weed grew better in the presence of *Eichhornia* than in the pure stocks. The inhibitory effect of alligator was found to be due to water soluble leachates that suppresses the uptake of nutrients by the roots of *Eichhornia* plants. We discuss the possible methods of controlling *Eichhornia* using this inhibitory process of alligator weed.

S15MT02P00**ERADICATION OF HYDRILLA (*HYDRILLA VERTICILLATA*) FROM CALIFORNIA WATERWAYS BY THE CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE, 2003 STATUS AND UPDATE****J Robert Leavitt¹, Larry Bezark¹, Nathan Dechoretz¹, and Ross O'Connell¹**¹California Department of Food and Agriculture, 1220 N Street, Sacramento, California 95814, rleavitt@cdfa.ca.gov

Starting soon after hydrilla was first discovered in a small lake in Marysville, California in 1976, the California Department of Food and Agriculture (CDFA) has maintained an interior and exterior quarantine prohibiting the sale of hydrilla within the state, and has carried out an intensive program to survey and eradicate this invasive, noxious aquatic weed. In total, hydrilla has been detected in 28 locations in 17 counties. Three of these infestations have been the monoecious form. Infestations have ranged from small ornamental and farm ponds of less than one acre, to 26 miles of the Chowchilla River, to over 600 miles of canal in the Imperial Irrigation District, to parts of 43,000-acre Clear Lake. It is generally considered likely that most, if not all, of these infestations started with infested aquaria, infested ornamental plants, or other human activities. The eradication program uses integrated pest management, the principal methods of which have been hand and mechanical removal of plants and tubers, biological control using the triploid grass carp (*Ctenopharyngodon idella*), drawdown and soil treatment with metam-sodium, and chemical control with copper and fluridone aquatic herbicides. The original infestation in Marysville was declared eradicated in 1984. Currently there are eight infestations remaining in eight counties. In 2003, plants were detected at only two locations in the Imperial Irrigation District and only one plant was found in Clear Lake. No plants were detected along the Chowchilla River in 2003. Plant counts are zero or declining rapidly in the other five infestations.

S15MT02P00**USE OF HYPERSPECTRAL IMAGERY TO MAP AQUATIC WEEDS IN CALIFORNIA'S SACRAMENTO-SAN JOAQUIN RIVER DELTA****Melinda Mulitsch¹, Susan Ustin¹, Marcia Carlock², Robert Leavitt³, Larry Bezark³, Nathan Dechoretz³, and David Kratville³**¹California Space Institute Center for Excellence, University of California Davis, One Shields Avenue, Davis, California 95616, mjmulitsch@ucdavis.edu; ²California Department of Boating and Waterways, 2000 Evergreen Street, Sacramento, California 95815, mcarlock@dbw.ca.gov; ³California Department of Food and Agriculture, 1220 "N" Street, Sacramento, California 95814, rleavitt@cdfa.ca.gov

The University of California, the California Department of Boating and Waterways, and the California Department of Food and Agriculture cooperated on a pilot project to map weeds in the Sacramento-San Joaquin River Delta in California in 2003 using hyperspectral imagery. The target weeds were water hyacinth (*Eichhornia crassipes*), Brazilian waterweed (*Egeria densa*), and perennial peppergrass (*Lepidium latifolium*). The methods used were a hyperspectral sensor on an aircraft platform, hand-held hyperspectral sensors on boat and truck platforms, and hand-held sensors on laboratory grown plants. The sensors captured 126 discrete bands of electromagnetic radiation in the visible, near infrared, and short wave infrared wavelengths (400 to 2500 nanometers). A total of ten flight lines covering approximately 400 square kilometers were acquired. Data were analyzed using spectral mixture analysis for the aquatic weeds, and mixture tuned matched filtering for the perennial peppergrass. There was sufficient spectral resolution to discriminate between all the target weeds. Spatial resolution was nine square meters (pixel size). Fractional gray-scale images of the distribution of each weed were produced and superimposed on true color images of the flight lines. The technique was able to identify and quantify water hyacinth in mixed stands of cattails (*Typha* spp.), tules (*Scirpus* spp.), water primrose (*Ludwigia peploides*), and pennywort (*Hydrocotyle ranunculoides*); and also to identify and quantify perennial peppergrass in surrounding vegetation. Brazilian waterweed was also mapped. Based on laboratory spectra, it may be possible to discriminate between Brazilian waterweed and other submersed vegetation in the field, but more research is needed.

S15MT02P00**INTEGRATED MANAGEMENT OF WATER HYACINTH WITH *FUSARIUM PALLIDOROSEUM* AND CASHEW NUT SHELL LIQUID****A. Naseema, R. Praveena, Ancy M. Salim, C. K. Peethambaran and****S. Balakrishnan**Department of Plant Pathology, College of Agriculture, Vellayani, 695522, Kerala, India, e-mail: shikhana@eth.net

Water hyacinth [*Eichhornia crassipes* (Martius-Solms) Laubach] is the most invasive aquatic weed. This investigation was done to develop a strategy for the integrated management of water hyacinth involving a mycoherbicide and cashew nut shell liquid (CNSL). Studies conducted at College of Agriculture, Vellayani, Kerala, India, showed *Fusarium pallidoroseum* is an efficient pathogen of water hyacinth. Forty per cent WP formulation of *F. pallidoroseum* was tested on the weed under controlled conditions in glass house, in tanks and natural conditions (infested lake). The CNSL was sprayed to weaken the weed before applying pathogen. In glass house 97.78 and 82.22 per cent damages were recorded on applying 40 per cent WP formulation at five per cent and ten per cent respectively on weeds pre-sprayed with two per cent CNSL, while the killing was better with higher concentration of CNSL (four per cent) in tanks. In the infested lake, on applying five per cent WP formulation (pre-sprayed with five per cent CNSL), weeds developed typical blighting symptoms on the fourth day with 83.4 – 94.5 per cent intensity of damage and sank to the bottom by seventh day onwards. The product formulation and CNSL at this concentration were safe to other aquatic flora and fauna. The spores in the WP remained viable up to five weeks at room temperature (28± 4° C) and under refrigeration (4° C) up to four months.

S15MT04P00**ECONOMICS OF CONTROL AND IMPACT OF SPREAD OF WEEDY RICE (*ORYZA SATIVA* L.) IN MALAYSIA****B B Baki¹, M Azmi² and A B Mislamah³**¹Institute of Biological Sciences, University of Malaya, Kuala Lumpur, Malaysia, baki@um.edu.my; ²Rice Research Centre, MARDI Kepala Batas, Seberang Prai, Penang, Malaysia, azminan@mardi.my; ³Crop Protection Division, Department of Agriculture, Jalan Gallagher, Kuala Lumpur, Malaysia, mislamah@yahoo.com

The readily shattering, invasive weedy rices (*Oryza sativa* L.) inflict serious yield and quality losses on commercial rice in Malaysian rice fields. Field surveys were conducted from 1999 to 2002 to assess the extent of spread and infestation of weedy rice in selected farm blocks in the rice growing areas of Tanjung Karang, MADA, and Besut. The extent of weedy rice infestation varied with season and from field to field. Infestations ranged from 1 to 100%, although most farm blocks experienced 5 to 20% infestations. Differences in agronomic practices, control measures, and water availability were among the factors contributing to significant differences in degree of weedy rice infestation which correlated with crop yield loss. We conducted partition analyses on the economics of weed control operations in direct-seeded rice fields in Malaysia. Labour for the herbicide-based weed control operations averaged MYR 187/ha, representing 7.5% of the total cost of production. Land preparation required MYR 469/ha (18.8% of production costs) and herbicides averaged MYR 261/ha (10.5% of production costs). Net income averaged MYR 2,726/ha. With a 35% field infestation, weedy rices caused yield losses of 50 to 60% (3.20 to 3.84 tons/ha per season) valued at MYR 2,816 to 3,379/ha per season. With national average weedy rice infestations of 5%, average national yield at 6.2 tons/ha, and a guaranteed price of MYR 850/ton, a loss of 64,880 tons of rice yield valued at MYR 55,150,550 per season or MYR 137,876,375 per year may occur due to weedy rice infestations in Malaysia.

S15MT04P00**PERCEPTION OF FARMERS IN BENIN, WEST AFRICA TOWARDS *IMPERATA CYLINDRICA*****S Ayeni¹, A Avocanh¹ and F Beed¹**¹*International Institute of Tropical Agriculture, 08 B.P. 0932 Tri Postal, Cotonou, Republic of Benin, asidjc@yahoo.fr, A.avocanh@cgiar.org, F.beed@cgiar.org*

Questionnaires and sampling techniques were developed to assess the distribution, problems caused by, and the efficacy of control methods for *Imperata cylindrica* (L.) Raeuschel. One hundred farmers were interviewed from each of the three agro-ecological zones of Benin. These differ in climate, especially annual rainfall, and in crops cultivated. *I. cylindrica* was the most serious weed in the high and medium rainfall zones but was less prevalent in the arid zone. In all zones, the recent intensification of agricultural land use caused a reduction in the use of fallow and cover crops, resulting in increased incidence and severity of *I. cylindrica*. Significant yield losses due to *I. cylindrica* infestation were reported for all crops, including cassava, cotton, cowpea, maize, millet, peanut, sorghum, and yam. Furthermore, the clearance of vegetation by "slash and burn" agriculture encouraged rapid leaf growth from rhizomes to create dense stands of *I. cylindrica* that virtually eliminated other species. Such areas were frequently abandoned because existing control methods were ineffective. Weeding by hand caused cuts due to sharp leaf margins and leaf tips occasionally caused injury leading to blindness. Frequent ploughing can break rhizome sections into pieces sufficiently small to avoid plant regeneration, but was considered too time and labour intensive. Of the 300 farmers surveyed, none used chemical herbicides, due to high cost. This study showed the need to develop sustainable methods of *I. cylindrica* control for resource poor farmers.

S15MT04P00**A WEB-SUPPORTED SYSTEM TO ESTIMATE *SORGHUM HALEPENSE* AND *CYNODON DACTYLON* SPROUT EMERGENCE DYNAMICS IN THE ARGENTINE PAMPAS****D de Abellevera¹ and E H Satorre¹**¹*Cátedra de Cerealicultura, Facultad de Agronomía, Universidad de Buenos Aires, Argentina, deabelle@agro.uba.ar*

Various models that predict weed population dynamics under field conditions have been developed and may be used to improve weed management decisions in the Pampas of Argentina. *Sorghum halepense* and *Cynodon dactylon* commonly occur in this region. The ecophysiology of these weed species has been extensively studied and their phenological development can be predicted using models based on daily air temperature. This knowledge enables implementation of more efficient control methods by determining critical periods for survival of these species. Some models, however, require complex calculations that can be especially cumbersome when daily calculations are required. We intend to make available to farmers some of these models by a calculation system hosted on a web server that can be accessed via the internet. The system uses a PostgreSQL² database accessed through a PHP³ system, both of which are installed in the server. This application allows users (i) to load into the database their own meteorological data, (ii) to make calculations needed to estimate *S. halepense* and *C. dactylon* time of emergence, and (iii) to determine the phenological state of the weeds in their fields. The system also allows prediction of weed growth dynamics by loading temperature values estimated by the user or from meteorological history data loaded in the database. Farmers may also gain access to output generated by other farmers in a regional map of weed emergence generated dynamically. The system can be observed at: <http://www.agro.uba.ar/epg/malezas/index.php>

²POSTGRE-SQL: Object-relational database management system (ORDBMS) based on POSTGRES. <http://www.postgresql.org>³PHP: Hypertext Preprocessor. <http://www.php.net>**S15MT04P00****ECONOMIC BENEFIT OF STRATEGIES FOR LONG TERM MANAGEMENT OF ANNUAL GRASS WEEDS IN TEMPERATE AUSTRALIAN GRAZING SYSTEMS****R E Jones¹ and P M Dowling¹**¹*NSW Agriculture and CRC for Australian Weed Management, Orange Agricultural Institute, Orange NSW 2800, Australia, randall.jones@agric.nsw.gov.au, peter.dowling@agric.nsw.gov.au*

Annual grass weeds impose significant costs to the Australian grazing industry by reducing pasture production and lowering stocking rates. The replacement of perennial grass species by undesirable annual grass weeds also results in various external environmental costs such as increased deep drainage resulting in greater potential for development of salinity and increased runoff of silt-laden water into rivers and streams. The objective of this paper is to present a resource economic framework suitable for evaluation of dynamic weed problems in livestock grazing systems. We report on a bioeconomic analysis that specifically evaluates the economic benefit of technologies that increase perennial grass composition of a grazing system in the NSW Central Tablelands, Australia. The management strategies examined were fertiliser application and a rest period from summer grazing. The study used a combination of simulation and dynamic programming models, with the state of the system represented by variables for perennial grass composition and soil fertility. The analysis demonstrates the biological feasibility of reducing annual grass weed infestations by increasing the density of perennial pasture species. However, long-term economic benefits are maximised at a 50% perennial grass composition, which is significantly less than what is biologically attainable and that maximises short-term benefits. A change in landholder preferences to reduce annual grass weeds and increase perennial composition must rely on a clear demonstration of the long-term economic benefits of such a change. The resource economic framework presented in this paper is an important contribution towards achieving this goal.

S15MT04P00**WEED WARRIORS – WHAT IS IT GOOD FOR?****R M Kwong^{1,2}, M M McArthur^{1,2}, M K McCarthy¹ and C M Hallett¹**¹*Department of Primary Industries, PO Box 48, Frankston, Australia, rae.kwong@dpi.vic.gov.au;* ²*Cooperative Research Centre for Australian Weed Management*

Weed Warriors is an extension program that aims to empower and actively engage school students and the wider community in local weed management programs.

Weed Warriors was developed in 1994 involving only 10 schools. By 2002 it had extended across the state of Victoria, initiating a groundswell that expanded the program nationally in 2003. Hundreds of schools across Australia have now participated in the program targeting a range of weed species.

With the expansion of Weed Warriors the objectives of the program and the methods of delivery have evolved. This evolution has been largely based on 'gut-feeling' rather than on a formal evaluation driving the decision making process. It is timely at this stage of re-development, to reflect back on Weed Warriors and to clarify a number of key questions. What are the short and longer-term objectives of the program? Are the activities of the program likely to bring about the desired outcomes? How can we build in a process of data collection so that an evaluation of the State-based program can lead to an improvement in the national program?

This paper deconstructs the state-based Weed Warriors program and uses an extension tool known as 'program logic' to identify the cause-effect relationships between program outputs and ultimate outcomes. We also illustrate how the framework is used to subsequently evaluate the logic behind the project and to guide the collection of data for evidence of program impact.

S15MT04P00
TRAINING PROGRAMS FOR IMPROVING WATERWAY WEED CONTROL IN MEXICO

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An on-going weed infestation problem in the Mexican irrigation infrastructure has forced researchers, technicians, and users to maintain training and technology transfer programs in order to better control and manage the situation. However the results of some training programs have not been completely satisfactory due to a tendency to teach general weed control solutions that fail to take into account the occurrence of different weed species. Furthermore, there is a widespread lack of knowledge regarding the weed species prevailing in various regions, together with frequent personnel changes at institutions, a lack of on-going farmer training, and substandard management of irrigation water. In addressing this complex situation, it seemed prudent to use a workshop format to train technicians and users, providing them with an integrated concept of national problems related to weeds and water management as well as the actions needed for preservation of irrigation resources. Technical and educational programs were established by the government in an effort to improve the environment. The initial trainees later trained other users, including them in participatory workshops, and striving to instill in them a social conscience regarding the importance of preserving the environment. In conclusion, achieving sustainable development through appropriate management of resources will require education and technology transfer into all of society.

S15MT04P00
ECONOMICS OF WEED CONTROL IN LENTILS

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Weeds are an important constraint in lentil production (*Lens culinaris* Medik.). Hand weeding and herbicides are two common methods of weed control. Hand weeding is labor intensive and can be costly. In order to compare costs of hand weeding and chemical weed control in lentils, a field experiment was conducted in 2001 in Karaj, Iran, with two different economic models. The treatments included herbicides, hand weeding, and a weedy check. The experimental design was a randomized complete block with four replicates per treatment. According to the models, costs of hand weeding and chemical weed control were 15.5% and 3%, respectively, of the total per hectare value of the lentil yield. Hand weeding proved to be expensive and time consuming, and caused mechanical injury to the crop. Chemical weed control was less expensive and saved time compared to hand weeding.

S15MT04P00
ECONOMIC BENEFITS OF RESEARCH INTO MANAGEMENT OF VULPIA IN THE PASTURE AREAS OF SOUTHEASTERN AUSTRALIA

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Pasture weeds impose substantial economic losses on Australia's grazing industry by reducing pasture production, contaminating produce, and injuring livestock. Some weed species are costly to manage and may impose external costs through spread. Research on pasture weeds in the temperate regions of southeastern Australia has been publicly funded for many years and there is increasing pressure to evaluate the benefits of that research investment. This paper reports an economic evaluation of the long term benefits to Australia of publicly funded research on management of the pasture weed *Vulpia*, the major annual grass weed of temperate pastures in southeastern Australia. Using a combination of simulation and economic surplus modelling, a 20-year stochastic benefit-cost analysis demonstrated that reducing the impact of *Vulpia* in temperate pastures potentially can produce benefits to the Australian wool industry with a mean net present value of \$58.3 million and a mean benefit-cost ratio of 33:1. Several other benefit-cost results were generated for various expectations related to the research results and the adoption of its outcomes. Temperate pasture zone wool producers captured most of the benefits while wool producers elsewhere in Australia suffered losses from *Vulpia* reductions in the temperate pasture zones because of reduced wool prices. Such economic evaluations assist in the development and promotion of improved pasture weed management practices and help to justify the involvement of the livestock industry and government in the weed research process where it can be demonstrated that public benefits outweigh public costs.

S15MT04P00
EVALUATING THE IMPACT OF WEEDS IN WINTER CROPPING SYSTEMS ON THE AUSTRALIAN ECONOMY

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Australian winter cereal and oilseed producers have identified weeds as their main crop management problem. The annual economic loss attributed to these weeds is estimated at \$1.279 billion. Losses of this magnitude are large enough to significantly impact the Australian national economy. This impact was evaluated using a multi-regional computable general equilibrium (CGE) model of the Australian economy to simulate the economic effect of eliminating these weed losses. Impacts were simulated by imposing a productivity gain that was equivalent to the economic cost estimate, and were measured in terms of value changes in major macroeconomic variables at the state and national levels. The simulation generated a total annual increase in gross domestic product (GDP) of \$1.454 billion which was 0.28% of the national GDP in 1996-97. Other value changes resulted in changes in other important macroeconomic variables such as aggregate consumption, employment, and export-import volumes. Significant differences were observed in the value changes in different states. The results demonstrated that the economic effects of rural production problems such as weeds are not confined to the agricultural sector. This type of analysis expands the availability of economic information regarding the effect of weeds on agricultural production and supports the concept of public funding for research into improved weed management.

S15MT04P00**SPRAY TUTOR: COMPUTER BASED TRAINING FOR SPRAY DRIFT MANAGEMENT**

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Spray tutor is an interactive cd-based software package containing a comprehensive training programme intended to illustrate and train users (through the growsafe[®] courses operated by the new zealand agrichemical education trust) in the causes and effects of spray drift. It reflects new zealand industry codes of practice, regulatory requirements, and performance guidelines for safe, effective, and responsible agrichemical application.

Spray tutor captures the expertise of a range of experts in aerial and ground based spray application. It is compiled in four parts: causes of spray drift, factors influencing spray drift, drift minimization, and drift management. The first two sections are largely instructive, with brief explanations for an extensive range of relevant factors, influences, and effects of spray drift. The last two parts are quite different in that they primarily use interactive simulations of the factors affecting drift. These include different application methods (hand held, ground, and aerial) and deal with different pesticide use sectors including arable and pastoral farming, forestry (land preparation, release, and health), and horticulture (market gardening and orchards) as well as amenity and turf management.

S15MT08P00**TRACING RESISTANCE TO PYRIDAZINONE AND THIOCARBAMATE HERBICIDES**

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pyramin and betanal (AM) are the major herbicides belongs to pyridazinone and thiocarbamates that are used in sugar beet cropping of Khorasan province where is the most important area for this crop in Iran. But there have been numerous increasing reports claiming unsatisfied chemical weed control using these two herbicides during last several years. The prime objective of this study was to confirm evolution of resistance to these two herbicide family in weed flora in the area. *Amaranthus retroflexus* and *Chenopodium album* Seeds were collected from two Suspected fields and along with Susceptible ones were exposed to pyramin and betanal AM from two different sources i.e. original as well as local formulated products. The field experiment was carried out at the farm of khorasan Agricultural Research Center during growing season of 2003. It was laid out in a randomized complete block design. No-spray treatment was included in the experiment. Each treatment replicated thrice. Results revealed that source of product significantly effected weed control level while no significant differences were detected among sources of seeds. Therefore it may be concluded that there is no new case of herbicide resistance but it is inefficient local formulation, which is involved in ineffective weed control.

S15MT08P00**CROSS RESISTANCE TO HERBICIDES INHIBITING ACETYL COENZYME-A CARBOXYLASE IN *ROTTBOELLIA COCHINCHINENSIS* BIOTYPES FROM SANTA CRUZ, BOLIVIA**

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Bioassays were conducted to evaluate the response of itchgrass (*Rottboellia cochinchinensis*) populations associated with soybean production from the northern zone of Santa Cruz state, Bolivia. Populations were selected because of their deficient response to commercial applications of aryloxyphenoxypropanoate (APP) and cyclohexanedione (CHD) herbicides. Greenhouse bioassays were carried out from May to October 2003, at Chapingo University, Mexico, to determine the dose-response to selected grass herbicides and to estimate growth inhibition (GR₅₀) values based on above-ground fresh weight. Herbicides used were fluzifop-p-butyl, haloxyfop-R-methyl (APPs), clethodim, and sethoxydim (CHDs). Varying levels of resistance were found to all grass-killer herbicides and cross-resistance among graminicides was confirmed. Resistant populations were those exposed to an intensive and repetitive use of herbicides, particularly fluzifop-p-butyl, in the past few years. This is the first account of graminicide cross resistance in itchgrass reported in Latin America.

S15MT08P00**TESTING RESISTANCE OF JOHNSONGRASS (*SORGHUM HALEPENSE*) TO NICOSULFURON**

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Johnsongrass (*Sorghum halepense* (L.) Pers.) is the major perennial grassy weed in some parts of Serbia. Crops may heavily be infested and due to only a few efficient herbicides johnsongrass may provoke serious damages to crop production. In 2002 johnsongrass population survived the application of herbicides in the locality of Zemun Polje. This locality is known to have been treated with ALS (acetolactate synthase) inhibitors for years which may be considered the main cause of herbicide resistance. Resistance was tested during 2003. Seeds were used from the same locality (population considered to be resistant to sulfonylurea- R). The control were johnsongrass seeds from the locality known to have never been herbicide treated (known to be sulfonylurea susceptible population-S). Resistance was tested in a controlled environment chamber using whole-plant bioassay. The following parameters were monitored: height, fresh and dry weight of R and S plants. Damages were visually estimated. These parameters were recorded before herbicide application and on the 7, 14 and 21 day after treatment. The data were statistically computed using analysis of variance. It may be concluded that the poor efficacy of the herbicide in the R population was not due to resistance.

S15MT08P00**RESISTANCE PATTERNS TO ALS-INHIBITORS IN *CYPERUS DIFFORMIS* AND *SCHOENOPLECTUS MUCRONATUS*****R Busi, F Vidotto and A Ferrero**

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Resistance to ALS-inhibitor herbicides in populations of *Cyperus difformis* L. (smallflower umbrella sedge) and *Schoenoplectus mucronatus* (L.) Palla (rice bulrush) have been reported in several rice areas of the world. To investigate the common traits of *C. difformis* and *S. mucronatus* resistant to ALS-inhibitors in Italy, California and Spain, a joined research program involving Universities from these countries has been developed. The resistance has been studied both at the whole plant, target-site and biomolecular level. This contribution reports preliminary results of a study carried out at the whole plant (greenhouse) and target-site (*in vitro* on ALS) level on populations collected in Italian rice fields. The following ALS-inhibitors were tested: bensulfuron-methyl, halosulfuron, cinosulfuron, imazamox, and bispyribac-sodium. *C. difformis* showed cross-resistance to all the tested herbicides, except halosulfuron, both in greenhouse and laboratory experiments. In *S. mucronatus* simple resistance was found to bensulfuron-methyl, halosulfuron and cinosulfuron. In both species, resistance was found to herbicides which has never been used in Italian paddies (imazamox and bispyribac-sodium for *C. difformis*, halosulfuron for *S. mucronatus*). The results pointed out the presence of different patterns of resistance in the two species. Simple and cross-resistance to ALS-inhibitors can be regarded as realistic constraints for developing molecules.

S15MT08P00**DEVELOPMENT OF A EUROPEAN DATABASE FOR THE EVOLUTION FOLLOW-UP OF RESISTANT BLACK-GRASS (*Alopecurus myosuroides* huds.) POPULATIONS IN CEREAL CROPS****J-P. Claude, A. Didier, P. Favier and P.P. Thalinger
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A test to screen rapidly seeds or seedlings coming from fields where black-grass resistance to herbicides is suspected has been used to study more than 650 populations between 1999 and 2003, coming from European countries. Results obtained with the following herbicides (fenoxaprop-P-ethyl, clodinafop-propargyl, sethoxydim, chlortoluron, flupyrsulfuron-methyl, mesosulfuron+iodosulfuron, propoxycarbazone) have been consolidated into a database allowing to follow the evolution of the mechanisms involved in black-grass resistance. Two major types of mechanisms have been identified: a) target site resistance to ACCase inhibitors, b) metabolic resistance leading to various spectrum of cross-resistance between actives independently of their mode of action. The overall picture of resistance appeared to be stable over these five years with pure ACCase target site resistance staying low at +/- 5% of the populations, pure metabolic being constant around 70% and mixed populations (target site + metabolic resistance) being at 25%. The overall picture of metabolic resistance doesn't show any sign of evolution of the average level recorded for the actives tested. Nevertheless a trend in the evolution of ACCase target site resistance inside the populations having metabolic resistance (mixed populations) can be seen in the United-Kingdom unlike the other countries like France where mixed populations are stable. These differences can partly be explained by major differences in the agronomic practices. These findings regarding the "global" picture don't preclude possible evolutions at field parcel level. Follow-up of black-grass populations and the development of this database are part of the stewardship policy set by DuPont in the management of sulfonylurea herbicide resistance.

S15MT08P00**CROSS RESISTANCE OF RYEGRASS TO GLYPHOSATE, PARAQUAT AND HALOXYFOP-R METHYL ESTER IN THE WESTERN CAPE****F.H. Eksteen, A.L.P. Cairns and P.J. Pieterse**

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Ryegrass (*Lolium spp.*) is a common weed in cereals, orchards and vines in the Western Cape. Resistance of the weed to ACCase and ALS inhibitors in cereals is widespread. During the last few years several reports of poor control of the weed in perennial crops by glyphosate, and paraquat have been received. These reports were investigated and field trials were conducted on suspected resistant material with glyphosate and later with paraquat. These trials confirmed that at several localities ryegrass biotypes were resistant to these herbicides. Seed from five localities were subsequently collected and the resultant seedlings grown in pots under glasshouse conditions. Dose-response trials using dosage rates of up to 7.2 kg ha⁻¹ ae glyphosate and 4.0 kg a.i. paraquat were carried out with a pneumatically driven pot sprayer. Glyphosate and paraquat were applied at total volumes of 200 and 400 L ha⁻¹ respectively. Two of the biotypes showed resistance to glyphosate but not to paraquat. The other three biotypes showed various degrees of cross-resistance to both herbicides. Cloned material of one of these cross-resistant biotypes was also found to be resistant to the ACCase inhibitor, haloxyfop-R methyl ester. All plants sprayed with a dosage rate of up to 270g a.i. ha⁻¹ (equivalent to 5 times the maximum registered dosage rate) survived the treatment. The management of these resistant populations of ryegrass with a view to their elimination is discussed.

Key words: paraquat, glyphosate, cross-resistance, *Lolium spp.*

S15MT08P00**MECHANISM OF RESISTANCE TO QUINCLORAC IN SMOOTH CRABGRASS (*DIGITARIA ISCHAEMUM*)****I Abdallah¹, A J Fischer², C L Elmore², and M E Saltveit²**

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A biotype of smooth crabgrass from a turf site in Tulare County exhibited resistance to quinclorac. When quinclorac was tested on this site for the first time in the mid eighties, there was already a significant proportion of the smooth crabgrass population that was not controlled by this herbicide. Dose response studies conducted on whole plants treated in postemergence with quinclorac confirmed the strong resistance of this biotype to quinclorac, and suggested a possible target-site mediated mechanism of resistance. When treated with quinclorac a susceptible (S) smooth crabgrass biotype responded with increased ethylene production. This increase was minimal in the resistant (R) biotype. Parallel to the increase in ethylene production, there was a buildup of cyanide in tissues of the S biotype; cyanide is a co-product of ethylene biosynthesis. This increase in tissue cyanide reduced smooth crabgrass growth, and the effect was the same whether a given cyanide concentration resulted from quinclorac treatment of from an external KCN application. Pre-treatment of plants with the ACC synthase inhibitor AVG prior to quinclorac application resulted in less ethylene and cyanide production and higher smooth crabgrass growth than when plants were treated with quinclorac only. These data suggest a target site-based mechanism of resistance involving the accumulation of cyanide derived from stimulated ACC synthesis (a precursor of ethylene). In resistant smooth crabgrass a stimulation of ethylene and cyanide biosynthesis is not elicited by quinclorac.

S15MT08P00**STRATEGIC CONCEPTS FOR HERBICIDE RESISTANCE MANAGEMENT IN CALIFORNIA RICE****A J Fischer, J E Hill**University of California, Davis, CA, ajfischer@ucdavis.edu,
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California rice is largely mono-cropped on heavy clay soils, mostly unsuitable for growing other crops. Aerial water seeding has been the principle method of stand establishment, adopted for ease of planting as well as weed suppression. However, weeds adapted to the water-seeded and continuously flooded system have now become the most serious production problem. Although flooding provides considerable weed suppression, some problematic weeds such as the watergrasses (*Echinochloa oryzoides* (Ard.) Fritsch and *Echinochloa phyllopogon* (Stapf) Koss.), sedges (particularly *Schoenoplectus mucronatus* (L.) Palla syn. *Scirpus mucronatus* L. and *Cyperus difformis* L.), and broadleaf weeds (*Ammannia auriculata* Wild. and *A. coccinea* Rottb.) are only partially controlled by flooding and thus weed control is strongly herbicide-dependent. Herbicide resistance, resulting from the continuous use of a few available herbicides, is threatening the viability of chemical control, and restrictions to herbicide registration limit the availability of new compounds. Innovative concepts for integrated weed management in California rice will rely heavily upon breaking weed cycles through rotation of stand establishment methods, alternating herbicides modes of action, as well as effective crop interference to reduce herbicide use.

S15MT08P00**THE EFFECTS OF DIFFERENT PRE-TREATMENTS ON THE GERMINATION OF RESISTANT AND SUSCEPTIBLE POPULATIONS OF *BROMUS DIANDRUS*****J H P Fourie and P J Pieterse**Department of Agronomy, University of Stellenbosch, Private Bag X1,
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The occurrence of herbicide resistance in *Bromus diandrus* in South Africa is increasing. The question that arises with resistant populations is whether they are less fit than non resistant populations. Dormancy and vigor of the seed can influence fitness. An experiment with gibberellic acid and ammonia was done to determine the effect thereof on the germination of three populations with different levels of resistance. Seed of three different *B. diandrus* populations were treated with gibberellic acid and ammonia approximately 2 weeks after harvesting. The gibberellic acid concentrations were 0; 0,065; 0,125; 0,25; 0,5; 1 and 2 mM. Ammonia treatments included seeds that were fumigated for 0, 10; 20; 30; 40; 50 and 60 minutes respectively. After aerating for three days the seeds were germinated in petri dishes at 20°C, in the dark, for three weeks. Seeds were evaluated for germination every three days. The ammonia experiment was repeated three weeks later and a cold treatment of 5 days at 4 °C after aeration was included. Initial results showed that gibberellic acid increased total germination and germination rate of all populations when evaluated after 21 days. The ammonia treatments did not significantly increase germination percentage and germination rate after three weeks, but did so after 51 days in two resistant populations. Cold treatments had a significant positive effect on germination percentage and germination rate of the two resistant populations. The susceptible population, which was collected from natural vegetation, did not seem to have the same dormancy characteristics of the two resistant populations collected from wheat fields.

S15MT08P00**Farmer Perceptions on Herbicide Resistance and Proposed Herbicide Use to Control Annual Ryegrass in South Australia****Dawn Hawthorn-Jackson¹, Christopher Preston¹ and Robert Davidson²**

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Annual ryegrass (*Lolium rigidum*) is a widespread weed in the southern Australian wheatbelt. Extensive use of herbicides to control this weed has resulted in the evolution of herbicide resistance in many populations. Herbicide resistance significantly complicates weed management in cropping systems. A survey of grain grower use of herbicides, perceptions of resistance and strategies to manage *L. rigidum* was conducted in South Australia. The survey highlighted the continued reliance by grain growers on herbicides as the main form of management for *L. rigidum*. A high percentage of growers reported resistance to ACCase-inhibiting herbicides and consequently relatively few growers propose to use aryloxyphenoxypropionate herbicides in 2003. However, growers intend to continue using a variety of herbicides with other modes of action. A high percentage of growers perceive resistance to chlorsulfuron or triasulfuron and trifluralin. Resistance to ALS-inhibiting herbicides is not unexpected, however, the perception of extensive resistance to trifluralin is intriguing. Growers reporting trifluralin resistance propose to rely more on doubleknock, crop topping, stubble burning, autumn tickle and delayed seeding in 2003 compared to growers without trifluralin resistance. These management strategies are commonly used by growers to manage large *L. rigidum* populations. Thus, growers with trifluralin resistance may simply have more *L. rigidum* and are therefore more likely to encounter poor performance of trifluralin. Alternatively, there may be significant undetected trifluralin resistance in fields in South Australia. The extent and importance of trifluralin resistance in *L. rigidum* needs further investigation.

S15MT08P00**POTENTIAL MANAGEMENT ALTERNATIVE FOR LITTLESEED CANARYGRASS (*PHALARIS MINOR* RETZ.) IN WHEAT FIELDS****Inderjit, Harleen Kaur and Prasanta C. Bhowmik¹**Department of Botany, University of Delhi, Delhi 110007, India, email (Inderjit): allelopathy@satyam.net.in; ¹Department of Plant and Soil Sciences, University of Massachusetts, Amherst, MA 01003, USA, email: pbbhowmik@pssci.umass.edu

Littleseed canarygrass (*Phalaris minor* Retz.) is an invasive weed in wheat fields. It is a major weed in Latin America and probably invaded India through the import of Mexican wheat. Wheat production has declined after the invasion of littleseed canarygrass. Littleseed canarygrass is an annual grass, and is a dominant weed of wheat fields in Northern India. Currently, this species has been adapted to a specific habitat under rice-wheat cropping systems in India. This species can cause 30 to 80% reduction in wheat yield. This annual weed has developed resistance to the commonly used herbicide isoproturon. There is a need to find an alternate herbicide to control littleseed canarygrass. We explored the potential use of isoxaflutole, a pre-emergence herbicide, to control littleseed canarygrass. Greenhouse studies were carried out to determine the phytotoxicity of isoxaflutole in relation to shoot height, fresh shoot biomass and leaf chlorophyll concentration of wheat and littleseed canarygrass. Electron microscopy was used to examine any damage to leaf chloroplast at cellular level. Results indicate that isoxaflutole (0.5 mg/L) significantly reduced the shoot height of littleseed canarygrass, but no significant reduction in the shoot height of wheat was observed when compared to control. None of the selected concentrations of isoxaflutole altered soil chemistry in relation to either pH, organic matter or inorganic ions. While untreated littleseed canarygrass leaves had elongated chloroplast, starch grains and small number of plastoglobuli; treated littleseed canarygrass leaves had swollen chloroplast, large number of plastoglobuli, and a lack of starch grains. Our research data indicate potential use of isoxaflutole for effective control of littleseed canarygrass in wheat.

S15MT08P00**PARAQUAT RESISTANCE AND POLYAMINE TRANSPORTERS****B Jóri, D Lásztity, V Soós, I Rác, Z Szigeti***Department of Plant Physiology, Eötvös Loránd University, 1117 Budapest, Pázmány Péter sétány 1/C; bjori@freemail.hu*

Non-selective herbicide paraquat and polyamines share similar intramolecular charge distribution, thus polyamine transporters are supposed to play role in the paraquat resistance of different organisms. Large family of transporters can remove paraquat and other xenobiotics in an energy dependent process and decrease their concentration near their target. According to literary data PotE polyamine transporters are responsible for paraquat resistance in bacteria. In plants, however, these transport mechanisms are mostly undiscovered. In our work we tried to identify a polyamine transporter in sensitive and resistant biotypes of horseweed (*Conyza canadensis* (L) Cronq) and in rape (*Brassica napus*) using *in silico* and molecular methods. With the EMBOSS program using more matrices during the alignment method we searched homologues similar to PotE, and we found a putative cationic amino acid transporter among the data of The Arabidopsis Information Resource. We tried to predict characteristic features of the protein, and we planned PCR primers. These primers were used in our molecular experiments on horseweed and rape. We also studied the effect of paraquat, menadione and S-methylmethionine on the gene expression level of our putative transporters with RT-PCR and Northern-blotting. PotE homologues were identified in sensitive and resistant biotypes of horseweed as well as in rape. According to our results paraquat and S-methylmethionine enhanced the expression level of two proteins: our PotE homologue and a protein with high similarity to lipoxigenase, while their expression was not influenced by menadione.

S15MT08P00**DERIVED CAPS: A SIMPLE METHOD TO DETECT A CRITICAL POINT MUTATION IN THE ACCASE TARGET GENE CONFERRING GRAMINICIDE RESISTANCE IN MONOCOT WEEDS****Shiv Shankhar Kaundun & John Windass***Syngenta, Bioscience, Molecular Genetics and Cellular Biology, Jealott's Hill International Research Center, Bracknell RG42 6EY, UK*

Herbicide resistance can result from a number of mechanisms including target site modification, detoxification through enhanced metabolism, over-expression of the target enzyme, reduced absorption and translocation amongst others.

In this respect, a major point mutation in the ACCase gene causing an amino acid change from isoleucine to leucine (I1781L), has been shown to confer graminicide resistance to most FOP and DIM herbicides in *Lolium* ssp., *Alopecurus myosuroides*, *Avena fatua* and *Setaria viridis*. This change results from the substitution of an adenine residue by a thymine or cytosine at position 5341 in *A. myosuroides* and at a homologous position in the other three species. The I1781L mutation can be detected using allele specific assays that are, however, very dependent on the conservation of nucleotide sequence flanking the causative single nucleotide polymorphism (SNP). Such assays cannot however distinguish between homozygotes and heterozygotes in a single PCR reaction. Here we present an alternative Derived Cleaved Amplified Polymorphic sequence (dCAPS) method to detect the I1781L mutation. This dCAPS approach has proved to be very simple, economical, highly transferable from species to species and can fully distinguish between homozygote Leu/Leu 1781 and heterozygote Ile/Leu 1781 resistant plants, thus providing an accurate measure of the frequency of the dominant Leu allele in a given population.

S15MT08P00**DETERMINATION OF *ABUTILON THEOPHRASTI* MEDIC. ATRAZINE RESISTANCE****B. Konstantinovic, M. Meseldzija, Bo. Konstantinovic***Faculty of Agriculture, Department for Environmental and Plant Protection TrgD. Obradovica 8, 21 000 Novi Sad, SCG brankok@poli.ns.ac.yu, majia@poli.ns.ac.yu*

Long lasting use of herbicides with similar mode of action enabled control of susceptible weeds, but also spread of resistant ones. Resistance should be considered as possible cause in cases when herbicides, even after multiple applications of the recommended rates show no visible effects. The aim of the work was to study occurrence of *Abutilon theophrasti* Medic. atrazine resistance. This triazine herbicide, the inhibitor of photosynthesis in photosystem II has been widely used in Yugoslavia since 1966. Seeds were collected during 2002 in various localities of Vojvodina, with a long history atrazine use. For reference, a susceptible population was collected from an area that was free of herbicide treatment.

During 2002 and 2003, studies were performed in laboratory by Petri dishes bioassays (Clay and Underwood, 1990), and whole plant studies (Moss, 1995). Assays were set up in four replications with a range of atrazine concentrations, e.g. 0.0, 0.5, 0.75, 1.0, 1.25, 1.5, and 2.0 kg a.i.ha⁻¹. Germination energy assessment, foliage fresh weigh and plant height were measured after two to eight weeks from the onset of the experiment. DNA was extracted from the samples and PCR analysis was performed.

By the comparison of the studied samples with susceptible standard it was determined that *Abutilon theophrasti* Medic population from locality Zabalj evolved atrazine resistance. This means that resistant biotype must be controlled by using herbicides with alternative modes of action.

S15MT08P00**HERBICIDE-RESISTANT WEEDS IN CEREAL CROPS IN GREECE.****E. Kotoula-Syka¹, C. Afentouli², I. Georgoulas³***¹Democritus University of Thrace, Dept. of Agricultural Development, Pantazidou 193 Orestiada 68200, Greece E-mail kotoulaeleni@yahoo.gr, ²Technological Educational Institution of Thessaloniki, Greece, ³National Agricultural Research Foundation, Plant Protection Institute, Thessaloniki, P.O. Box 324 Themi, 570 01 Greece.*

In Greece, chlorsulfuron was used for many years to control broad-leaf weeds whereas diclofop-methyl was heavily used for grass weed control in winter cereals. Recently, failures in control of several populations of major weeds were reported in Greece. The objectives of this research were to investigate the possibility of resistance evolution in various populations of *Papaver rhoeas* to chlorsulfuron, and of *Lolium rigidum*, *Phalaris brachystachys* and *Avena sterilis* to grass herbicides and to elucidate the mechanisms of resistance. Plant response to these herbicides was evaluated in pot experiments and laboratory studies. We found that *L. rigidum* is multiple-resistance to ACCase inhibitors due to an altered target site, and to chlorsulfuron due to enhanced detoxification. A population of *P. rhoeas* was found to be resistant to chlorsulfuron (altered target site). However all *P. rhoeas* populations were susceptible to imazamox and tolerant to imazapic, but R plants were cross-resistant to imazethapyr. Eight biotypes of *P. brachystachys*, were examined for resistance to ACCase inhibitors and seven of them indicated resistance to fenoxaprop-ethyl. In contrast all eight biotypes were susceptible to tralkoxydim and clodinafop-propargyl. Continuous use of isoproturon resulted in heavy infestation with *A. sterilis* that tolerates high rates of isoproturon while being susceptible to ACCase inhibitors used. Practically the selective control of multiple-resistant *L. rigidum* with ACCase and ALS inhibitors is a difficult task, whereas control of the resistant *P. rhoeas*, *P. brachystachys* and *A. sterilis* can be achieved by alternative selective herbicides.

S15MT08P00
TISSUE CULTURE PROPAGATION OF 2,4-D RESISTANT WILD RADISH

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Raphanus raphanistrum L. (wild radish) is one of the most detrimental weeds in wheat growing areas in Australia with expenditure for the control of this weed approximately A\$40 million annually. Control of this weed is mainly achieved by spraying with the auxinic herbicide 2,4-D. Farmers in Western Australia have recently reported the emergence of resistance to 2,4-D in wild radish. Currently there is limited knowledge about the molecular basis of resistance to 2,4-D in wild radish and we are seeking to understand the precise biochemical and genetic mechanisms that endow resistance to this herbicide.

The starting phase of these studies involves spraying wild radish plants with varying concentrations of 2,4-D in order to assess the degree of resistance or tolerance to this herbicide. This technique is, however, destructive and these experiments would result in loss of both resistant and susceptible plants. Hence there is a need to maintain clonal material to enable molecular and biochemical analysis of clonal material from individual plants which have been assessed by treatment with herbicide. As wild radish is an obligate outbreeder, all individuals within a population will be genetically distinct and therefore, study of the molecular basis of the resistance trait is complicated by this genetic heterogeneity within the populations. Hence, a study of the feasibility of propagating wild radish lines by tissue culture was undertaken.

The present investigation reports the successful propagation of both resistant and susceptible lines of wild radish by micropropagation. To our knowledge, successful propagation of wild radish by tissue culture has not been reported before.

S15MT08P00
CURRENT STATUS AND CONTROL OF SULFONYLUREA RESISTANT WEEDS OCCURRING IN RICE FIELDS OF KOREA

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The widespread and diverse sulfonylurea(SU) resistance problem has found in Korea, where bensulfuron and pyrazosulfuron of the SU herbicides have been used continuously as so-called "one-shot" formulations since 1989. Six SU resistant biotypes of *Monochoria korsakowii*, *Monochoria vaginalis*, *Lindernia dubia*, *Scirpus juncooides*, *Rotala indica* and *Cyperus difformis* as of 2003 have confirmed in paddy fields in Korea. These SU-resistant weeds have been mainly identified in Jeonnam and chungnam provinces practicing extensively wet-seeded culture, however, farmer complaints to control effect of SU have been provoking from the others. Up to now, the resistance to SU has been usually checked by herbicide treatment to seedlings. This treatment technique is time consuming and not very practical. Therefore we have developed rapid and practical diagnosis which allow easy detection of the SU resistant weeds within a population. In the pot experiment under wet-seeded rice and infant seedling culture with machine, several herbicides having different mechanisms of action from SU herbicides, such as mefenacet, pyrazolate, and thiobencarb had excellent controlling effects on the resistant weeds. The resistant weeds survived from the rice fields treated with SU herbicide-based mixtures could effectively be controlled by soil application of butachlor+pyrazolate GR or by foliar application of the mixtures of bentazone SL and 2,4-D SL.

S15MT08P00
THE OCCURRENCE OF HERBICIDE RESISTANT ALOPECURUS MYOSUROIDES(BLACK-GRASS) IN ENGLAND

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Alopecurus myosuroides is the most important herbicide-resistant weed in Europe and occurs in at least 10 countries. In the UK, black-grass resistant due an enhanced metabolism mechanism was first identified in 1982. Populations with target-site resistance to ACCase inhibitors were subsequently identified in 1991. Screening tests showed that resistance occurs widely, with >1000 cases by 2002, but the frequency of occurrence was unknown. Consequently, a survey of randomly selected farms was done to determine the current incidence of resistance to herbicides and to identify which mechanisms (enhanced metabolism or ACCase target-site resistance) are involved. Black-grass seed samples were collected in summer 2002 from randomly selected farms and tested for resistance in glasshouse pot and laboratory Petri-dish assays.

The survey indicated that resistance occurs on virtually all farms that use herbicides regularly to control black-grass. Target site (ACCCase) resistance was positively identified on 40% of farms and a further 40% showed some evidence of its presence at a low frequency. Molecular studies in both the UK and France have started to identify the mutations responsible for ACCCase target site resistance. At least two mutations have been identified so far, but one of these, an isoleucine/leucine substitution appears to be the commonest. Interestingly, this mutation has also been found in at least three other resistant grass-weeds elsewhere in the world.

S15MT08P00
DEVELOPMENT PATTERNS OF HERBICIDE RESISTANCE ON A FARM IN THE MEDITERRANEAN WHEAT PRODUCING AREA IN SOUTH AFRICA

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Herbicide resistance is a worldwide problem disrupting conventional chemical control programmes. Development of herbicide resistance is a selection process caused by repeated use of the same herbicide or herbicides with the same mode of action. In this paper, patterns of development of herbicide resistance on a farm in the mediterranean wheat producing area of South Africa are considered. Firstly, the rate of resistance development was investigated by applying the same herbicide in the same plots at the recommended rate for a period of three consecutive years. Four different herbicides viz. iodosulfuron, diclofop-methyl, clodinafop propargyl and imazamox were used in the study. Field counts of surviving *Lolium* spp. plants were done four weeks after application. Results indicated that efficacy of all the applied herbicides was consistently lower in the years following the first year. However, resistance was already present in the first year. The results of the third season could have been compromised by the fact that it was an extremely dry season. In another study, varying levels of resistance was observed in *Lolium* spp. occurring in fields subjected to different treatments in a long-term rotational cropping system trial that was running for seven years. The resistance patterns are discussed with reference to the rotational crop sequence as well as history of herbicide use.

S15MT08P00

**QUANTIFYING THE INCIDENCE OF HERBICIDE RESISTANCE
IN SOUTH AFRICA.**

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Resistance of weeds to herbicides has developed in most countries in the world and South Africa is no exception. The incidence of herbicide resistance in South Africa is increasing, but little data is available to quantify the increase in occurrence of resistance. In this study the incidence of suspected and confirmed herbicide resistance was investigated by making use of literature reports, surveys and databases of relevant research institutions. More information on resistance was obtained by making use of questionnaires and by greenhouse testing of suspected resistant weed populations. The questionnaires were distributed to agrochemical companies to obtain a clearer picture of the incidence of suspected herbicide resistance in the winter rainfall area of the Western Cape Province. Seed samples obtained from suspected resistant weed populations were germinated and the resulting seedlings were subjected to spraying with different herbicides at different doses. The treatments were replicated three to four times and mortality of the seedlings was evaluated four weeks after date of application. Results from the questionnaires indicated that there was a steady increase in the number of suspected resistance cases in the area surveyed and more than 230 suspected cases occurred in 2000. Results from the greenhouse tests indicated that more than 80% of the samples tested exhibited resistance to herbicides. These results is a clear indication that herbicide resistance in South Africa are increasing and that everybody in the industry should implement strategies aimed at curbing the rate of spread of this problem.

S15MT08P00

**DOMINANCE OF THE HERBICIDE RESISTANCE
IN TREATED AND UNTREATED AREAS**

F Roux and X Reboud

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The fate of resistance alleles under selection depends on their selective advantage or disadvantage (cost) in the presence or the absence of pesticides in the environment, as well as the dominance (i.e. the fitness of heterozygous RS individuals compared to resistant RR and sensitive SS homozygous individuals) of these effects. The dominance toward herbicide resistance and the fitness impairment have been the subject of much research. Despite the importance of the dominance of the resistance cost on the evolution of resistance, no study has been specially designed to measure the dominance of resistance costs. By analysing morphological characters and simple fitness components, the cost associated with each of eight herbicide resistance alleles (acetolactate synthase, cellulose synthase and auxin-induced target genes) was studied here in the model plant *Arabidopsis thaliana*. The use of allele-specific PCR to discriminate between heterozygous and homozygous plants was used to provide insights into the dominance of the resistance cost, a parameter rarely described. Morphological characters appear more sensitive than fitness (seed production) as 6 versus 4 differences between resistant and sensitive homozygous plants were detected, respectively. Dominance levels for the fitness cost varied greatly from recessivity (*csr1-1*, *ixr1-2* and *axr1-3*), to dominance (*axr2-1*), to underdominance (*aux1-7*). Furthermore, the dominance level of the herbicide resistance trait did not predict the dominance level of the cost of resistance. According to the results of theoretical predictions, the different resistances analysed here would thus have varying probabilities of success under field conditions.

S15MT08P00

**RESISTANCE OF *CHRYSANTHEMUM CORONARIUM* TO ALS
INHIBITING HERBICIDES IN ISRAEL**

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Chrysanthemum coronarium L., an annual Compositae weed, a Mediterranean weed that infests many crops in the Middle East countries. In Israel, it is considered as a serious weed of rain fed cereals and pulses that competes vigorously with crops and cause significant yield losses. Sulfonylurea (SU) herbicides are used efficiently and intensively since the mid 80's to control broad-leaf weeds in wheat. In 2001 the first SU-resistant biotype of *C. coronarium* was identified in Gilat experimental farm, and later a second biotype was reported in Be'eri, Israel where these herbicides were applied repeatedly for more than 10 years. Dose-response experiments at the whole-plant level have revealed that the resistant (R) biotype was highly resistant (>>10 fold relative to the wild-type susceptible(S) to SU herbicides including: tribenuron, iodosulfuron, chlorsulfuron and sulfometuron. However, moderate resistance (<10 fold) has been found to other acetolactate synthase (ALS) inhibiting herbicides imazethapyr and flumetsulam, and almost no resistance to pyriithobac and propoxycarbazone-Na. Comparison of ALS sensitivity between enzyme extracted from R and S biotypes have confirmed the whole-plant observations, indicating that the resistance is due to an alteration in the target site (ALS). Region A and region B of the ALS gene known to vary in ALS-resistant biotypes were amplified and sequenced. Two amino acid substitutions were found in region A of resistant *C. coronarium* (numbering based on *Arabidopsis* ALS). In Gilat biotype, proline₁₉₇ was substituted to threonine and in Be'eri biotype from proline₁₉₇ to serine.

S15MT08P00

**IS MALATHION A USEFUL TOOL TO INFER THE
CHLORSULFURON-RESISTANCE MECHANISM IN MULTI-
RESISTANT ITALIAN POPULATIONS OF *LOLIUM* SPP?**

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Ten years after the finding of the first diclofop-resistant population, *Lolium* spp is now the grass weed showing the fastest evolving herbicide resistance in Italy. To date, more than seventy populations have been confirmed as being resistant to ACCase inhibitors and it is estimated that more than 20,000 ha are infested. Several of these populations have also shown multiple resistance to ALS-inhibitor herbicides, which may be due to increased herbicide metabolism. The synergistic effect of the organophosphate insecticide malathion with chlorsulfuron has been used to test this hypothesis. The response of seven *Lolium* spp populations (two of them susceptible) to various ACCase and ALS inhibitors was characterised by greenhouse dose-response experiments which demonstrated various patterns and levels of resistance. The resistance index to chlorsulfuron was always below 10. In the same populations, the influence of malathion on chlorsulfuron herbicidal efficacy was verified in growth-room experiments including three temperature regimes or seven herbicide doses. The effect of malathion was influenced by temperature regime. In all cases (susceptible and resistant populations), malathion significantly increased herbicide efficacy. Relative potencies ($R=ED_{50\text{chlor}}/ED_{50\text{chlor+malat}}$) ranged from 2.41 for a susceptible population, to 4.21 for the population showing the highest resistance. A sigmoidal increasing relationship was found between ED_{50} in the absence of malathion and relative herbicide potency with malathion.

S15MT08P00**CULTIVAR AND PLANTING DATE AFFECT GENE FLOW BETWEEN CLEARFIELD® RICE AND RED RICE****V K Shivrain¹, N R Burgos¹, and S N Rajguru¹**¹University of Arkansas, 1366 W Altheimer Dr., Fayetteville, AR, USA 72704, vks4@uark.edu, nburgos@uark.edu, srajgur@uark.edu

Red rice (*O. sativa* L.) is a major weed problem in rice growing areas of the southern U.S. Herbicide-resistant Clearfield® (CL) rice now offers an excellent option for red rice control. This technology, however, accentuates the risk of gene flow. Experiments were conducted at the Rice Research and Extension Center, Stuttgart, AR, USA in 2002 and 2003 to evaluate the effects of cultivar and planting date on the extent of natural outcrossing between CL rice and Stuttgart strawhull red rice. The First experiment was planted in April and the second in May 2002. CL cultivars CL 161 and CL 121 were planted in circles, 10 m in diameter, with three replications. Natural red rice population was maintained in the outer concentric circle, 20 m in diameter. There was synchronization in flowering between red rice and CL rice. At maturity CL rice was removed from the inner circles and red rice was allowed to shatter. In summer 2003, volunteer red rice were sprayed with Newpath®. Survivors were counted, characterized morphologically, and leaf tissues were collected for DNA analysis. SSR primer RM 180 was used to verify hybridization between red rice and Clearfield® rice. Outcrossing was higher with CL161 (0.008%) than with CL121 (0.004%) and higher when rice was planted in late May than in late April. Resistant red rice hybrids were located within 10 m from CL rice. Thus far, there was no indication that red rice hybrids would be more weedy than the red rice parent, except for the presence of herbicide-resistance trait.

S15MT08P00**MOLECULAR BASIS FOR DIVERSE LEVEL OF HERBICIDE MULTIPLE-RESISTANCE IN PROSTRATE PIGWEED (AMARANTHUS BLITOIDES)****M Sibony and B Rubin**

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Multiple-resistant prostrate pigweed (*Amaranthus blitoides*) populations that exhibit resistance to both, sulfonyleurea and triazine, were detected in several locations in Israel. The response of individual plants in these populations varied when exposed to ALS inhibiting herbicides. Molecular analyses have shown that the population from 'Ganot' is a mixture of two biotypes: SuRA/TR with a mutation in domain A (Pro₁₉₇ to Ser) and SuRB/TR in which the mutation was in domain B (Trp₅₇₄ to Leu). Whole plant studies revealed that the mutation in domain A lead to resistance to all ALS inhibitors but not to imidazolinone herbicides, whereas the mutation in domain B lead to higher resistance to all ALS inhibitors tested including imidazolinones. The two biotypes are multiple-resistant with additional single mutation in the chloroplastic *psbA* gene (Ser₂₆₄ to Gly). We demonstrate here, that individual plants within a population, which were exposed to a similar selection pressure, may confer multiple resistance and different pattern of cross-resistance, due to different point mutations. This unique phenomenon renders rational planning of preventive weed management difficult. The data also indicate the importance of molecular analyses as an essential part of herbicide-resistance weed management.

S15MT08P00**NOVEL ASPECTS OF THE PARAQUAT RESISTANCE OF CONYZA CANADENSIS (L.) CRONQ.****V. Soós¹, Z. Szigeti, B. Jóri, I. Rácz, Z. Bratek, D. Lásztity**

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Paraquat (Pq) is a foliage-active bipyridyl herbicide, which exerts its phytotoxic effect by diverting electrons from PSI to molecular oxygen and generating toxic oxygen forms. Extensive use of Pq containing herbicides has led to the worldwide incidence of resistant biotypes including weeds as well as cultivated plants. Numerous hypotheses have been evolved on possible reasons for the Pq resistance. Inhibited translocation, binding of Pq to the cell wall, its sequestration to the vacuoles, or enhanced activity of oxygen radical detoxifying enzymes were proposed as mechanisms of resistance.

On the basis of our former findings, we assume that sequestration mechanism plays a crucial role in the resistance of horseweed *Conyza canadensis* (L.) Cronq. We studied the effect of transporter inhibitors (CCCP, DCCD, TPP and vanadate) on the decrease of functional activity (characterised by variable fluorescence, Fv/Fm) which is caused by paraquat in order to reveal the possible roles of different types of transporters in the resistance mechanism. Results show the participation of not directly energized antiporters in paraquat sequestration. We examined a paraquat inducible protein similar to EmrE of *E. coli* which presumably functions by carrying paraquat to a metabolically inactive compartment. Gene expression studies (DDRT-PCR) affirmed our hypothesis that EmrE-like gene differentially expressed in resistant and sensitive biotypes and may contribute to the resistance. Furthermore we observed and sequenced a wide range of genes including ferritin which are expressed to paraquat threatment. Identification of these genes is under way.

S15MT08P00**RESPONSE OF THE ATRAZINE-RESISTANT COMMON RAGWEED POPULATIONS (AMBROSIA ARTEMISIIFOLIA L. SYN. A. ELATIOR) TO OTHER TRIAZINES IN HUNGARY**Sz. Tóth Csantavéri¹, F. Hartmann¹, L. Gracza¹, L. Szentey², Á. Tóth³, Zs. Hoffmanné⁴¹Plant Protection and Soil Conservation Service of County Komárom-Esztergom, H-2891 Tata, Pf. 50 Hungary, csantaveri@freemail.hu²Ministry of Agriculture, Plant Health and Soil Conservation Department, H-1860 Budapest, Pf 1. Hungary³Plant Protection and Soil Conservation Service, Budapest H-1519, Pf. 340, Hungary⁴Plant Protection and Soil Conservation Service of County Somogy, H- Kaposvar, Pf. 55. Hungary**Introduction**

The common ragweed was a botanical curiosity in Hungary at the beginning of the last century. Nowadays it is one of the most common-problem weed. Although there are many reasons for the ragweed's significant propagation, we only tested the herbicide-resistance.

Material and methods

The suspicion that ragweed may have an atrazine-resistance was discussed at the beginning of the 90's. The atrazine-resistant biotype of ragweed was first identified in 1993 from seed samples of 1992. We monitored the appearance and spread of the atrazine-resistant biotype of ragweed in more than a ten-year-long period. Every year we make a map of the ragweed's spreading in Hungary. In our actual experiment we were investigating for the atrazine-resistant ragweed's response to other triazines. The investigated substances were: metribuzine, prometryn, terbutryn, terbuthylazin.

Results and discussion

The seed samples, which were previously proved to be atrazine-resistance, behaved differently against other triazines.

S15MT08P00**RESISTANCE TO DICLOFOP-METHYL IN LOLIUM MULTIFLORUM: SELECTION HISTORY AND TRADEOFFS BETWEEN RESISTANCE AND GROWTH**

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Continuous use of herbicide has promoted the appearance of resistant populations in *Lolium multiflorum*. There is uncertainty concerning fitness responses of herbicide resistant and susceptible biotypes. The objective of this study was to evaluate 1) the effect of selection history on the level of herbicide resistance and 2) the tradeoffs between herbicide resistance and growth. A population of *Lolium multiflorum* was grown during four years and subjected to 8 selection histories: grown as a monoculture (L) or in mixture with a related species (*F. Festuca rubra*) under four levels of herbicide. *F. rubra* is naturally resistant to the herbicide, and potentially capable of crossing with *L. multiflorum*. Plants were sprayed every year with diclofop-methyl herbicide at 2240 gr ai ha⁻¹ (2x), 1120 gr ai ha⁻¹ (label dose, x), 560 gr ai ha⁻¹ (0.5 x) or left unsprayed (control, 0x). Herbicide lethal dose 50 (LD₅₀) was calculated for each selected population using a standard probit approach. Vegetative and reproductive biomass outputs of plants under field conditions and without herbicide pressure were evaluated in two subsequent years. The LD₅₀ varied between 32.86 gr ai ha⁻¹ and 772.30 gr ai ha⁻¹. Cluster analysis of the survival rates showed three different groups according with the increasing herbicide-resistance level exhibited (0xL, 0xF, 1xF – 1xL, 2xF, 0.5xL – 0.5xL, 2xL). Vegetative biomass production was similar among *L. multiflorum* populations but differed between years. However, reproductive biomass showed both, year and population (resistance level) effects, with no significant interaction. Within each year the group with intermediate resistance level exhibited the lowest reproductive biomass values.

S15MT08P00**A MUTATION CONFERS MONOCHORIA VAGINALIS RESISTANCE TO SULFONYLUREAS THAT TARGET ACETOLACTATE SYNTHASE**

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Evolution by herbicide resistant weeds is one way to evade death and competition from invaders, whether natural or artificial. The widespread evolution of herbicide resistance has threatened weed management worldwide. Identification of the molecular mechanism of herbicide resistance has been attempted using various approaches. Here, we cloned and sequenced fragments encoding ALS genes from biotypes of *Monochoria vaginalis* susceptible (S) and resistant (R) to sulfonylurea (SU)-herbicide. The nucleotide sequences of the 39bp Domain A region for R *M. vaginalis* biotype differed from that of the S biotype by a single nucleotide substitution at variable Pro codon of Domain A (CCT to TCT), predicting a Pro in the S but a Ser in the R biotype. No nucleotide differences between S and R *M. vaginalis* were observed in Domain D. We suggest that the amino acid substitution at Domain A region is responsible for resistance to SU-herbicides in *M. vaginalis*.

S15MT08P00**ECOLOGICAL FITNESS IN A MULTIPLE HERBICIDE RESISTANT *LOLIUM RIGIDUM* POPULATION: SEED DORMANCY, GERMINATION AND SEEDLING ESTABLISHMENT IN METABOLISM- VS. TARGET-SITE BASED-RESISTANT INDIVIDUALS**

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A series of experiments were carried out in controlled and field conditions to study seed dormancy release and germination and seedling emergence in *L. rigidum* phenotypes possessing target-site and non-target site mechanisms of herbicide resistance. Discrete lines composed of herbicide susceptible (S) and metabolism-based (M) and target site-based (T) resistant individuals, obtained from a multiple-resistant population (SLR31) were used in the comparative experiments. Phenotype T had the highest base temperature (T_b) for germination and required significantly more time to reach 50% emergence (T_{E50}) in relation to S and M phenotypes. The loss of dormancy release, total germination and seedling emergence was equal among the phenotypes after-ripened either in the field or in constant environment (20°C), and exposed to germinate under alternating 25/15°C with 12-hourly photoperiod. However, ACCase mutant seeds incubated either over a range of constant temperatures with 12-hourly photoperiod or fluctuating temperature and darkness, displayed respectively a markedly lower total germination and seedling emergence in relation to the other phenotypes S and M. When after-ripened in the field both resistant phenotypes germinated less than the susceptible phenotype when exposed to either constant temperatures or dark conditions. Seedling emergence from deep burial (8cm) in soil promoted significantly higher fatal germination in S (38%) and M (53%) phenotypes compared to T (10%). The results of this work suggest that germination and emergence patterns between herbicide susceptible and resistant *L. rigidum* phenotypes may potentially be exploited to design management strategies for attenuating resistance.

S15MT17P00**WEEDY RICE (*ORYZA SATIVA* L.) INFESTATION AND YIELD TRENDS IN THE SAWAH SEMPADAN RICE GRANARY, MALAYSIA: A GIS APPROACH**

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Weedy rice, an off-type of *Oryza sativa* L. is an aggressive weed in the irrigated rice ecosystems in Malaysia. Sawah Sempadan, an area of about 3200 hectares was selected to assess the trends in weedy rice infestation and rice yields for five years, commencing in 1996. Each sampling point, randomly chosen in each farm block of Sawah Sempadan was recorded using the geographical positioning system (GPS) tools. The data were analysed for percentage of severity, relative densities, relative frequencies, while other related spatial data, and the degree of weedy rice infestation were mapped out using the GIS approach. Measurable season- and location-mediated variations were registered signifying heterogeneities in spatial distribution and aggregation of weedy rice in the Sawah Sempadan granary. Intrinsic and extrinsic factors contributed to their spatial dynamics of weedy rice in the granary. In 1996 and 1997, weedy rice displayed both clumped and aggregated distribution patterns, whilst in 2000 to 2002, the scourge showed gradual random distribution patterns. Rice yields were negatively correlated with the degree of weedy rice infestation in the fields surveyed. We recorded yields ranging from 3 tons in 1996, gradually increasing to 8 - 9 tons in 2002, indicating significant decrease in the degree of weedy rice infestation in the fields surveyed due to effective control measures by farmers, and continuous extension services provided by the government agencies inculcating awareness the dangers of weedy rice infestation on rice yields.

S15MT17P00**THE IMPACT OF DIFFERENT WAYS OF WEED CONTROL ON THE WEEDNESS AND THE POTATO SEED CROP YIELD NEAR PLJEVLJA**Jovović Zoran¹, Momirović Nebojša², Stešević Danijela³¹Biotechnical Institute - Podgorica²Faculty of agriculture, Beograd³Faculty of Sciences - Podgorica, Biology Department

In a period 1998-2000. in agroecological conditions of Vrljja (Pljevlja district) we investigated efficiency of different ways of weed control on potato crop weedness and tuber production. Weed control was done:

1. with herbicide combination: metribuzin + fluazifop-p-butyl (0,8 kg/ha + 2,5 l/ha, ACWG), which was shown, for the mountain region of Montenegro, as most efficient one,
2. and by mechanical way of treatment which include intertillage and rotation.

Control variant wasn't treated with herbicides or cultivated. Tested sort was Condor, very productive and stabile sort in concrete agroecological conditions.

During three years long investigations of potato crop agrophytocenosis 45 weed species were registered, among which: *Convolvulus arvensis* (9,96 ind/m², or 16,7%), *Anthemis arvensis* (5,55 ind/m², 9,3%) *Bilderdykia convolvulus* (5,34 ind/m², 9,0%), *Sinapis arvensis* (3,79 ind/m², 6,4%), *Galeopsis tetrahit* (3,38 ind/m², 5,7%) and *Agropyron repens* (3,25 ind/m², or 5,5%) were most abundant.

Application of herbicide combination: metribuzin + fluazifop-p-butyl achieved a very high efficiency in weed control during every estimation and year of investigation. Average efficiency of herbicide application for whole experiment was established at range 94- for number and 86- for weed biomass.

Mechanical way of treatment showed very low effect in weed control in investigated region. Efficiency was lower than 40. Its' effect was expressed better on biomass

Obtained results shows that in investigated area mechanical way of treatment can't compete with chemical one and that solution of problem lies in system composed of lower herbicide concentration and adequate mechanized technique, combined system that can achieve results similar to application of full chemical dose.

S15MT17P00**A GROWTH AND COMPETITION MODEL FOR A WEED MANAGEMENT DECISION SUPPORT SYSTEM (WMSS)**

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A decision support system (DSS) is being developed to aid weed control decision making in winter cereal crops in the United Kingdom (Weed Management Support System (WMSS)). This biological model has to meet the requirements of a decision model, which will call upon the biological model to find optimal weed control measures to maximise economic return.

The growth and competition model is based upon the Wageningen INTERCOM model. The model iterates the growth of each weed species and the crop on a daily basis from the day of seedling emergence to the point of canopy closure. Spread in time of seedling emergence is simulated by assuming the weed emergence of each species occurs as eight discrete cohorts. For each day, dry matter increment due to photosynthesis is calculated from the daily light integral and the vertical distribution of leaves within the entire community. Photosynthates are converted to dry matter and used to generate new green area for further interception of light. This simulation runs only to the point of canopy closure, to minimise the run time requirements of the DSS. The green area of the weed relative to that of the crop is taken as a measure of crop yield loss.

Herbicides are assumed to reduce yield loss by destroying weed green area. The green area destruction at the time of application is assumed to occur at the time of canopy closure.

Despite these simplifying assumptions, the model appears to give adequate predictions of yield loss for the DSS.

S15MT17P00**STUDY OF QUALITY AND QUANTITY OF LIGHT IN COMPETITION BETWEEN WHEAT AND CRUSIFEROUS WEEDS**Hossein Najafi¹ and Hamid Rahimian Mashhadi²¹ Plant Pests and Diseases Research Institute,

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Plant that grow underneath or within a canopy are not only exposed to a reduced amount of PPFD but they also received a different quality of light. In order to study of light competition in mix canopy of wheat and weeds, two experiments were conducted in Iran(2001) and Canada(2002).The treatments of field study included three Cruciferous weeds: *Sinapis arvensis*, *Rapistrum rogosum* (at 0, 4, 8, 16 and 32 plantsm⁻²) and *Descurainia Sophia* (at 0, 16, 32, 64 and 128 plantsm⁻²). Randomized complete block design with four replications in an additive series technique was employed as the experiment design. In growth cabinet study, we used a model system to examine how canopies of species differed in light-interception abilities. Wheat, *Sinapis arvensis* and *Descurainia Sophia* were grown as "targets", surrounded by neighbors of a single species. Plants were grown in pots, with one target plant and three neighbor's plants. Results suggested that *Sinapis arvensis* and *Rapistrum rogosum* had more effect on PPFD and red: far-red(R: FR) ratio. Increasing weed density, significantly reduced light transmission. As canopy-transmitted PPFD declined, total dry matter accumulation decreased. In addition, with increase in leaf area of mix canopy, the quality and quantity of light changed. At low densities the main effect was an increase in far-red irradiance caused by shading, while at higher densities the predominant effect was the decrease in red irradiance caused by absorption. The R: FR ratio decreased with density of weeds.

S15MT17P00**WEED INFESTATION DETECTED THROUGH SATELLITE IMAGES**M. F. A. Oliveira², A. Ricci Jr.², M. S. Simões², P. J. Christof

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The presence of weeds in sugarcane crops is a very usual problem, which causes yield reduction. This research, which was conducted in a Sugar Mill located in northwest of São Paulo state/Brazil with two sugarcane varieties, analyzed the detection of weed spots inside sugarcane fields, through ETM+/Landsat 7 images. The trial consisted to let 8 plots of 1 ha, without weed control inside the field and compares the spectral response of its biomass canopy and the areas without weeds. Thus, two satellite spatial resolutions were tested, 30 and 15 meters. The Normalized Difference Vegetation Index (NDVI) - a vegetation index which relates the reflectance of B3 and B4 bands (red and infra-red bands) of ETM+/ Landsat 7 with the biomass canopy - was able to detect the difference between the none controlled areas and the areas with weed control. NDVI values ranged 0,424 - 0,527 (weed + sugarcane) and 0,304 - 0,355 (weed controlled areas) in the 30 meters spatial resolution; 0,435 - 0,523 (weed + sugarcane) and 0,317 - 0,356 (weed controlled areas) in the 15 meters spatial resolution. A statistical analysis showed a significant difference of 5% level Tukey test, between the infested areas and none infested areas, proving the feasibility of this method. Therefore, the areas with the larger amount of biomass had presented higher NDVI values than the areas with less biomass. Thus, the satellite images are an efficient tool to detect weed spots inside the sugarcane crop and are an excellent method to assist the management.

S15MT20CP00**DEVELOPMENT OF SCOTCH BROOM IN THE FRENCH MASSIF CENTRAL PASTURES****B. Prévosto¹, C. Picon-Cochard², D. Orth³**¹ Cemagref, Applied Ecology of Woodlands Team, 24 Av des Landais, BP 50085, 63172 Aubière cedex, France e-mail : bernard.prevosto@cemagref.fr² INRA, Grassland Ecosystem Research, 234 av du Brézet, 63039 Clermont-Ferrand Cédex 09, France e-mail: picon@clermont.inra.fr³ ENITAC [Agricultural Practices and Landscape Team, 63370 Lempdes, France, e-mail : orth@enitac.fr]

Scotch broom (*Cytisus scoparius* L.) is a commonly colonizing species in the insufficiently grazed pastures of the French Massif Central. By decreasing pasture value and altering initial flora composition broom is considered as an important weed. Our study aims at characterizing broom recruitment in grazed pastures and its development after grazing cessation in relation to the above and below ground resources. Broom seedlings recruitment and dimensions were investigated for 5 years in 37 grazed and ungrazed plots in different vegetation composition. Results showed that grazing favored seedlings emergence but has a detrimental effect on both survival and growth. Broom seedling aerial and below-ground development was studied in the field and in controlled conditions by testing the respective impact of aerial and below-ground competitions induced by grass. From these experiments, growth and survival of broom seedlings were strongly reduced when transmitted light reached values below 20%, while below-ground competition did not interact with aerial competition. Thus light availability was found as a major determinant of survival of broom seedlings in extensive grassland. Broom demography after grazing cessation was assessed by studying 11 stands according to an age gradient. Three main stages were distinguished: the initiation stage characterized by a high density of seedlings, the stem exclusion stage characterized by an important increase in size and a drastic reduction of the density due to intraspecific competition and the senescent stage due to ageing.

S15MT20CP00**EFFECTS OF GRAZING STRATEGIES ON SERRATED TUSsock (*NASSELLA TRICHOTOMA*) SEEDLING DENSITY IN AN IMPROVED PHALARIS AND SUB-CLOVER PASTURE****A R Barritt^{1,4}, P W G Sale¹, L Miller² and D A McLaren^{3,4}**¹La Trobe University, Department of Agricultural Science, Bundoora, Vic. 3086, Australia, abarritt@students.latrobe.edu.au;²Catchment and Agriculture Services, Department of Primary Industries, Agriculture Victoria, Little Malop Street, Geelong, Vic. 3220, Australia, lisa.miller@dpi.vic.gov.au; ³Primary Industries Research Victoria (PIRVic), Department of Primary Industries, Frankston Centre, PO Box 48, Frankston 3199, Australia, david.mclaren@dpi.vic.gov.au; ⁴CRC for Australian Weed Management

A field experiment was initiated in an improved pasture to determine how different grazing practices affected seedling survival of *Nassella trichotoma* (Nees) Arech. (serrated tussock). Treatments included different combinations of set stocking, spelling pasture, heavy grazing, or mowing at different times of the year. The study site was considered a relatively closed system as the two sides facing prevailing winds had 3- to 4-m high windbreaks, and the upwind source of *N. trichotoma* seed was eliminated in 1999 when the neighbouring paddock, which had a dense infestation of mature *N. trichotoma*, was ploughed. Seedling numbers declined for all treatments over the summer/autumn of 2000/2001. Regular mowing in spring was the only treatment where the basal area of *N. trichotoma* seedlings remained relatively constant over the dry summer/autumn of 2001, compared to a 75% decline in the basal area for the other treatments over this period. The findings indicate that the spelling of pasture during spring may be effective in minimizing seedling survival of *N. trichotoma*, due to the increased competition by resident pasture species. The decline of *N. trichotoma* seedlings in all treatments, as well as in the control, coincided with the cessation of seed import from the adjacent paddock.

S15MT20CP00**LEAF ANATOMY AND ITS RELATION TO THE ECOPHYSIOLOGY OF 30 WEED SPECIES OF DIFFERENT SEASONAL PERFORMANCES****G M FAHMY¹, A K HEGAZY², M I A ALI² and N H GOMAA³**¹Department of Biological Sciences, Faculty of Science, University of Qatar, P. O. Box 2713, Doha, Qatar, fahmy_2000eg@yahoo.com;²Department of Botany, Faculty of Science, University of Cairo, Giza 12613, Egypt, akhegazy@hotmail.com; ³Department of Botany, Faculty of Science, University of Cairo, Beni-Suef Branch, Beni-Suef, Egypt, nhgomaa@yahoo.com

The present work demonstrates the leaf anatomy of 30 weed species belonging to 16 families of angiosperms. The weeds were collected from the summer and winter crops of the old cultivated land. The species include 12 summer weeds, 12 winter weeds and 6 all-year weeds. The species were obtained from the field crops of Beni-Suef governorate which is located at about 120 km south of Cairo in the Nile Valley of Egypt. Some anatomical differences were observed between the leaves of the different weed groups. Such differences may be related to the seasonal variations in climate. Compared to winter weeds, the investigated summer weeds possess higher stomatal and trichome densities as well as higher leaf specific conductivity (LSC). There is a positive correlation between the ratio of mesophyll cells area/leaf or leaflet area and the thickness of lamina. The values of the calculated hydraulic conductance (*Kh*) of tracheary elements supplying the transpiring areas, laminal area and stomatal spacing of the summer weeds are lower than those of the winter weeds. For all-year weeds with either winter or summer affinity, the stomatal density is generally higher in summer than in winter season. In general, the laminal area, *Kh*, and number of tracheary elements of petiole or petiolule are significantly higher in winter than in summer season for the studied all-year weeds with winter affinity. On the other hand, the all-year weeds with summer affinity show an opposite behaviour.

S15MT20CP00**INDIVIDUAL AND POPULATION RESPONSES TO ABIOTIC STRESSES IN ITALIAN RYEGRASS****M A Martinez-Ghersa¹, S R Radosevich², D Olszyk³ and C M Ghersa¹**¹IFEVA, Departamento de Recursos Naturales y Ambiente, Facultad de Agronomía, Universidad de Buenos Aires, Av. San Martín 4453, Buenos Aires 1417DSE, Argentina, martinez@ifeva.edu.ar; ²Department of Forest Science, Oregon State University, Corvallis, OR, USA; and ³Environmental Protection Agency, National Health and Environmental Effects Research Laboratory, Western Ecology Division, Corvallis, OR, USA

Expected environmental changes will alter productivity of agroecosystems and influence the distribution of agricultural pests. In addition to the natural factors that cause stress, humans introduce chemical pesticides into the agricultural environment. Weeds persist in stress-dominated environments, despite efforts to eradicate them. This is because plants shift resources between yield and survival. The objective of this research was to assess the impact of three anthropogenic stresses (herbicide, UVB light and ozone) and their interactions on individual Italian ryegrass ontogeny and reproduction. The potential evolutionary effect of these stresses and combinations also was addressed. Individual responses to herbicide were modified by levels of tropospheric ozone and UVB light. Plants were capable of growth and reproductive compensation under all stress factors. Compensation occurred at the individual level through modification of growth and carbon allocation to different organs, and at the population level through modification of birth and death rates and density-dependence responses. Interaction of stresses resulted in an increase of relative contribution of smaller individuals in the population to the next generation.

S15MT20CP00
ECHINOCHLOA CRUS-GALLI IN MAIZE CROPS IN POLAND

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Echinochloa crus-galli (L.) P. Beauv. is a serious weed in Polish maize fields. This paper will review briefly the research conducted on this weed in Poland. Triazine herbicides have been applied for 50 years in Poland for weed control in maize and, as a result, infestations of *E. crus-galli* have increased. Research conducted from 1975 to 2000 in Poland used the Braun-Blanquet survey method to help determine the geographic extent of *E. crus-galli* infestation in different crops and soils. The competitive relationship between *E. crus-galli* and maize also was studied. The critical period for maize damage by *E. crus-galli* is at the 2-4 leaf stage. A resistant biotype of *E. crus-galli* in southwestern Poland evolved as a negative consequence of repeated triazine use. Studies of triazine resistance were conducted in 1999 to 2001 using bioassays and fluorescence measurements. Preferred methods for control of *E. crus-galli* are with rimsulfuron and nicosulfuron. However, these herbicides cannot be applied commonly because some varieties of maize are sensitive to sulfonylurea herbicides. In 1992 to 2001, 140 hybrids of maize were tested and among them 22 hybrids were sensitive to nicosulfuron and 25 were sensitive to rimsulfuron.

S15MT20CP00
IMPACTS OF WILLOW (*SALIX X RUBENS*) INVASION ON RIPARIAN BIRD ASSEMBLAGES

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Although woody plant invasions threaten riparian zones worldwide, surprisingly little is known about their impacts on higher trophic orders, such as birds. This study investigated the impacts of invasive willows on diurnal bird assemblages from spring through summer along the lower Tarago River in southern Victoria. Bird species richness, species and foraging guild composition, the abundance and diversity of invertebrates, and the vegetation structure were compared along river corridors lined with native woody species, the invasive white-crack willow (*Salix x rubens*), or cleared of woody vegetation. Overall, 70 bird species from 14 foraging guilds were observed, of which the superb fairy-wren (25% of all bird records), grey fantail (17%), brown thornbill (14%) and white-browed scrub wren (7%) were most abundant. Native sections had significantly more birds, more bird species and a greater diversity of foraging guilds than either cleared or willow-invaded sections, with woodland-dependent bird species being almost twice as abundant along native sections. Willow-invaded sections provided significantly fewer branch invertebrates and a simpler habitat structure than native sections. Willow invasion directly into the native riparian zone is likely to reduce markedly the abundance and variety of birds. Also, its spread into previously cleared areas is unlikely to facilitate many woodland dependent species.

S15MT20CP00
GENETIC DIVERSITY AND LATE GERMINATION MAY CONTRIBUTE TO WEEDINESS OF BIENNIAL WORMWOOD (*ARTEMISIA BIENNIS* WILLD.)

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Biennial wormwood is native to North America and has become an important weed of several crops in the northern Great Plains of the USA and Canada. Our objectives were to study genetic diversity and variability in germination among several biennial wormwood populations. Intersimple sequence repeat (ISSR) genetic diversity studies were conducted using biennial wormwood seed harvested from seven locations. These populations were later planted in a common garden and harvested seeds used in germination studies. Seeds from the biennial wormwood populations were incubated on a thermogradient plate providing a temperature range of 5 to 41 C, and a diurnal temperature fluctuation of 0 to 36 C. The total genetic diversity of six biennial wormwood populations was $H_T = 0.40$, with 22% of this diversity among populations ($G_{ST} = 0.22$). Estimated gene flow among biennial wormwood populations was low ($Nm = 0.9$), and high levels of differentiation may be due, in part, to low levels of genetic exchange among biennial wormwood populations. Though variable, germination among biennial wormwood populations was generally highest when seeds were exposed to 37 C or greater, with a temperature fluctuation of 24 C or greater. Increased germination with high temperatures and diurnal fluctuations is consistent with relatively late biennial wormwood seedling emergence in the spring and possible avoidance of early-season weed management. High genetic diversity among biennial wormwood populations is consistent with adaptation to local environments, perhaps contributing to variation in germination.

S15MT20CP00
CONTRASTING ROOTING BEHAVIOUR IN A RANGE OF UK WEED AND CROP SPECIES AND THE IMPLICATIONS FOR GROWTH IN MIXTURES

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The outcome of competition between crops and weeds depends on aboveground competition for light and belowground competition for water and nutrients. However, much less is known about belowground competition than that aboveground. In this project the rooting behaviour of several UK weed and crop species was studied in a series of experiments over a 4 year period. Non-destructive, minirhizotron, measurements were made as well as destructive samples using large volume soil cores. These experiments provided data on rooting depth over the course of the season, on the vertical distribution of root biomass and on root length at maturity. Rooting behaviour was dramatically different between species. There was a tendency for crop species (winter wheat, *Triticum aestivum* L.; and oilseed rape, *Brassica napus* L.) to be both deeper rooted and have much lower proportion of total root length near the soil surface than any of the weed species (*Alopecurus myosuroides* Huds., *Galium aparine* L. and *Stellaria media* [L.] Vill./Cyr.). The implications of these contrasting rooting behaviours, with respect to soil moisture uptake, on the growth of the species in mixtures was explored using data from neutron probe tubes that were used in some of the field trials. Trends in soil moisture uptake with depth reflected the root distribution findings. Those species, with a greater proportion of total root length deeper in the soil profile, were able to extract available soil water from greater depths in the soil profile than other species. These findings have implications for the predictions of weed and crop growth, and they demonstrate the importance of the inclusion of root distribution in more mechanistic models.

S15MT20CP00
NECTAR PRODUCTION OF SOME MELLIFEROUS PLANTS IN BELGRADE WEED FLORA

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Melliferousness of fifty herbaceous weeds most common along street-sides and in waste places throughout Belgrade was investigated, in order to establish significance and contribution of these plant species as a potential source of nectar for bee pasture. Melliferous potential analyses included measurements of total nectar amount per flower in 24 hours, estimation of flower number per plant and plants per square unit and determination of Index of nectar production for each plant. Nectar volume was established by the microcapillary method, based upon measuring height of the nectar column in the microcapillary glass tube and converted into ml.

The nectar secretion during 24 hours was the most intensive in *Prunella vulgaris* (9.5 ml), *Consolida regalis* (8.48 ml) and *Linaria vulgaris* (5.09 ml). The lowest nectar amount per flower was measured in *Melilotus officinalis* (0.62 ml), *Lamium purpureum* (0.71 ml) and *Astragalus onobrychis* (0.90 ml). The most numerous plants per square unit belonged to following species: *Salvia nemorosa* (128 plant/m²), *Astragalus onobrychis* (96 pl./m²), *Vicia villosa* (72 pl./m²), *Lamium purpureum* (70 pl./m²) and *Ballota nigra* (56 pl./m²). At the time of nectar collecting, the greatest number of open flowers per plant was found in *Leonurus cardiaca* (2600 flower/m²) and *Echium vulgare* (2070 flower/m²).

Comparing the melliferous potential of fifty investigated plant species, taking into consideration all mentioned parameters, the most important weeds, producing nectar as food resource for bees in Belgrade urban environment, were found to be: *Salvia nemorosa*, *Echium vulgare*, *Vicia villosa*, *Astragalus onobrychis*, *Ballota nigra*, *Medicago sativa*, *Prunella vulgaris* and *Trifolium pratense*.

S15MT20CP00
CROP-WEED COMPLEX OF PEARL MILLET IN MALI: WEED SEED BANK IN THE GRANARY?

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Pearl millet (*Pennisetum glaucum* [L.] R. Br.) is virtually the sole cereal crop grown under drought-prone conditions in the Sahel region of Africa. Pearl millet fields in this zone usually are infested greatly with weedy seed-shattering forms of pearl millet. Although the weedy form was reported to be generated by introgression between populations of crop and wild pearl millet, it exists independently of wild populations in most agricultural zones in Mali. The maintenance mechanism of weedy millet populations was investigated by field observation, interviews and progeny tests. Despite intense weed control by hoeing, a large number of shattering individuals still remained at harvest time. Because they are outbreeders, crop and weed forms can hybridize with one another. The proportion of shattering plants in the progeny of non-shattering seedheads was 8-17%, which could explain a large portion of the weedy millet population in the field. The shattering habit was proved to be controlled by single dominant gene. This suggests that a large fraction of the weedy millet population is produced recurrently year by year through fertilization of crop inflorescences by weed pollen. Their seed bank mainly lies in the granaries of farmers for this reason. Prevention of hybridization by picking shattering seedheads is not an acceptable way for farmers to manage weedy pearl millet because shattering seedheads mature earlier than the normal crop and serve as supplementary food until harvest time of the crop.

S15MT20CP00
PHOTOSYNTHETIC EFFICIENCY OF CALAMAGROSTIS EPIGEIOS AT FLY ASH DEPOSITS OF THE "NIKOLA TESLA - A" THERMAL POWER PLANT IN SERBIA

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The thermal electric plant "Nikola Tesla - A" burns lignite and disposes of high amounts of fly and bottom ash. The disposal area covers 400 ha, which is divided into lagoons. Revegetation of such sites is limited by soil that lacks essential nutrients, has high boron levels, and has unfavourable moisture, physical and thermal characteristics. This paper analyzes photosynthetic efficiency measurements (Fv/Fm) of *Calamagrostis epigeios* (L.) Roth. using the method of induced chlorophyll fluorescence kinetics of photosystem II. Measurements were made of plants growing at lagoons L1 (4 years old), L2 (12 years old), and a natural site. *C. epigeios* was less abundant at L1 than at L2. At L2 it formed a dense vegetation cover, flowered and produced fruit. Although mean values of Fv/Fm were similar at both lagoons (0.582 ± 0.129 at L1 and 0.581 ± 0.115 at L2), they had a wider range (0.268-0.771) at L1 than at L2 (0.356-0.779). At the control site, where *C. epigeios* grows in natural soil, the Fv/Fm was highest, with a mean value of 0.668 ± 0.071 (0.364-0.784). The lower vitality at L1 probably reflects the slow and gradual colonization of this site, whereas at L2 intraspecific competition (abundance of 100 %) may be affecting vitality. However, maximum values at all sites were close to the optimum photosynthetic efficiency range (0.750-0.850) for plants overall (Bjorkman and Demmig 1987). Such vitality (similar values at all sites) in the face of limited nutrients and water, as well as tolerance of toxic concentrations of boron, explained the ability of *C. epigeios* to successfully revegetate fly ash deposits by natural plant succession within a few years.

S15MT20CP00
IMPACT OF WEEDS ON BREADMAKING QUALITY OF WHEAT

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Field experiments were conducted at the University of Reading (UK) over two growing seasons to investigate the effects of cleavers (*Galium aparine* L.) and other weeds on wheat breadmaking quality. Winter wheat (*Triticum aestivum* L. cv. 'Hereward') was sown with or without cleavers infestation. In some plots, where cleavers was controlled with Starane-2, cleavers control positively affected the SDS sedimentation volume and protein quality of the wheat in the first season, but these effects were not confirmed in the second season due to an infestation of non-sown weeds (especially *Papaver rhoeas* L.). To explore the effects of the general weed infestation on breadmaking quality in more detail, regressions of the wheat quality characteristics against total ground cover of weeds were performed. There was a significant negative response of grain yield and grain protein content in the first season, when total ground cover of weeds was low. In the second season when there was a very high infestation of weeds, yield, 1000-grain weight, specific weight and SDS-sedimentation volume were negatively affected by weeds. The experiment, which had been conducted with different levels of nitrogen fertilizer, also showed an effect of weeds on grain protein content (at low nitrogen fertilizer levels). Hagberg falling number was unaffected by the weeds in both cropping years. Overall, the main effect of the weeds clearly was on grain yield, and the effects on breadmaking quality only became significant at much higher infestation levels than would be tolerated by farmers.

S15MT20CP00**ENVIRONMENTAL AND MANAGEMENT EFFECTS ON THE COMPOSITION OF WEED COMMUNITIES FROM THE ROLLING AND INLAND PAMPA, ARGENTINA.**

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Soil and climate are the main regional factors determining the structure of plant communities. But in agroecosystems, these factors interact with the environmental modifications derived from management practices (e.g. tillage and pesticides) resulting in novel ecological conditions that mold crop-weed plant assemblages. In order to evaluate the environmental and management effects on weed community, its floristic composition was studied collecting data of species presence and management histories of cropped fields from two subunits of the Pampas (Inland and Rolling Pampa). We calculated two indexes that reflect the level of pesticide and tillage use in each field. Results from multivariate analyses (principal components and cluster analysis) indicate that weed communities of each region were different. Analysis of similarity (ANOSIM) of these data showed a significant regional effect on weed assemblages, but no significant dissimilarity between farms and crops within each region ($P < 0.001$). Among the management aspects evaluated, only the pesticide toxicity to insects and the years of continuous cropping were significantly associated with weed composition, with no evident tillage effect. When effects on weed species richness were evaluated, the effect of pesticides and the years of continuous cropping were also evident, with increasing richness as environmental impact decrease. However, there was no correlation between species richness and tillage impact. Our results may indicate both a strong regional effect on controlling final composition community and pesticide use and continuous cropping as two important on-farm factors affecting weed composition.

S15MT20CP00**Investigations on the population variability of *Cirsium ARVENSE***

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Cirsium arvense (L.) Scop. (Canada thistle) is an aggressive perennial weed broadly distributed on arable and ruderal lands. Different populations show enormous variation in numerous morphological properties as well as herbicide tolerance. To determine its taxonomy precisely, we examined relevant morpho-anatomical characteristics of 19 populations of this species. The following morphological traits were monitored: stalk length, number of heads, leaf length, maximal and minimal leaf breadth, number of lobes per leaf and terminal spine length. To define the basic anatomical differences between leaves the following was analyzed: leaf thickness, height of epidermal cells of leaf upper surface, thickness of palisade and spongy tissues and height of epidermal cells of lower leaf surface. Anatomical parameters were measured using permanent microscope preparations of leaf cross sections using the standard paraffin method for light microscopy. Significant statistical differences occurred among populations for the measured parameters. The following four groups were distinguished: 1) smooth and lobed leaves, 2) smooth and non-lobed leaves, 3) hairy and lobed leaves, and 4) hairy and non-lobed leaves. These belonged to the varieties *C. arvense arvense* and *C. arvense vestitum* Wimm. & Grab. The parameters most affecting the distinction between populations were leaf length and breadth, number of heads and leaf thickness.

S15MT25P00**SULFOSULFURON A NEW HERBICIDE FOR WEED CONTROL IN WARM SEASON TURFGRASSES**

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Sulfosulfuron is a sulfonylurea herbicide being investigated for control of weeds in warm season turfgrasses like bermudagrass [*Cynodon dactylon* (L.) Pers.]. It is very difficult to control annual bluegrass (*Poa annua* L.) especially when bermudagrass is overseeded with perennial ryegrass (*Lolium perenne* L.) during the fall season. The objective of the studies was to evaluate the effect of sulfosulfuron in selectively controlling annual bluegrass in an overseeded stand of perennial ryegrass at the California State University, Pomona during the fall season. Tolerance of perennial ryegrass, Kentucky bluegrass (*Poa pratensis* L.) and tall fescue (*Festuca arundinacea* Schreb.) to sulfosulfuron was also evaluated. Activity of sulfosulfuron in controlling quackgrass (*Elytrigia repens* (L.) Nevski) was also studied in the greenhouse at the University of Massachusetts, Amherst. Sulfosulfuron was applied at 67 and 140 g ai/ha with 0.50% v/v of a non-ionic surfactant, 10 days, 7 days and 3 days prior to overseeding. All the treatments were compared to rimsulfuron applied at 34 g ai/ha 7 days prior to overseeding. All the sulfosulfuron treatments controlled 88-99% of the annual bluegrass 3 weeks after treatment (WAT) but the high rates applied 7 days prior to overseeding injured 11-24% of the perennial ryegrass 3 WAT. Rimsulfuron controlled 100% of the *Poa annua* but injured 50-62% of the ryegrass 5 WAT. There was no visual injury on the ryegrass 7 WAT from lower rates of sulfosulfuron. Kentucky bluegrass was more tolerant to sulfosulfuron (20 g ai/ha) (5-11% injury 3 WAT) compared to tall fescue (10 g ai/ha) (58% injury 3 WAT). Sulfosulfuron (20 g ai/ha) controlled 88-93% of the quackgrass population 3-6 WAT.

S15MT25P00**BIO-EFFICACY OF GLYPHOSATE + 2, 4 – D FOR WEED CONTROL IN NON-CROP AREAS**

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Weeds in non-agricultural land pose menace as in agricultural land. An experiment was conducted at the University Inceptisol farm, India with three different concentration combinations of Glyphosate & 2,4-D at 9 different doses along with sole application of this herbicide besides control. Observations on density, dry weights and re-growth of weed flora were recorded in addition to phytotoxicity and beneficial micro flora studies.

Results revealed that Glyphosate and 2,4-D when applied in different combinations and Glyphosate when applied alone showed phytotoxicity on most of the weed species within 7-10 days and 10-15 days after application respectively. 2,4-D did not show any phytotoxicity on any of the grassy weeds when applied alone. Amongst the three different combinations the herbicide mixture B where 9 % Glyphosate was mixed with 18 % 2,4-D recorded lower weed dry weight irrespective of the doses in comparison to herbicide mixture A (13.5% Glyphosate+13.5% 2,4-D) or C (18% Glyphosate + 9 % 2,4-D). The herbicide mixture B when applied @ 4.5% showed full control of all types of weed flora within 7 DAS. The herbicide mixture of other two combinations A & C, irrespective of their doses also recorded better effective weed control than even their local tank mixture doses (Glyphosate 7.5 ml + 2,4-D 5 g/litre of water) or application of Glyphosate 41 % SL alone. The study on population of beneficial micro-flora N-fixing and P-solubilising bacteria in soil indicated no such harmful effects of these chemical mixtures in this Inceptisol.

S15MT25P00**DRIP APPLICATION OF METHYL BROMIDE ALTERNATIVES FOR THE CONTROL OF WEEDS IN COASTAL FLOWER CROPS**C. L. Elmore¹, C. A. Wilen², J. A. Roncoroni³, K.L. Robb⁴

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In California, flower production is predominantly along the state's coastal region. Productivity of these regions is threatened by the pending loss of methyl bromide in the U.S. Some methyl bromide alternatives being proposed for other crops may not be suitable for ornamental production because of differences in cropping systems, economics, and regulatory restrictions. We conducted trials to evaluate chemical alternatives to methyl bromide in combination with chloropicrin for weed control in *Ranunculus asiaticus*. Treatments injected preplant through the drip lines in 2001 were Metam (359 kg/ha under HD tarp), iodomethane/chloropicrin (393kg/ha (50:50)), chloropicrin (224kg/ha, 337kg/ha), sodium azide (67kg/ha, 112kg/ha), 1,3-D+chloropicrin (449kg/ha), and untreated (water+tarped). In 2002 the treatments were the same except sodium azide was applied only at 112kg/ha and 1,3-D+chloropicrin was applied at 168 and 337kg/ha. Sachets containing seeds of *Malva parviflora*, *Poa annua*, *Portulaca oleracea*, *Brassica kaber*, or *Cyperus esculentus* tubers were buried at three depths. In 2001, all treatments had significantly fewer weeds than the untreated control with no difference in crop vigor. Buried seeds in sachets showed a similar response but the sodium azide treatments were significantly less effective in reducing germination of *P. annua* and *P. oleracea*. A similar trend occurred in 2002 for *P. annua* and *C. esculentus*. In 2002 the ranunculus stand was higher in the untreated plots than the treated ones and time required for handweeding the plots treated with Metam, chloropicrin (168 kg/ha), sodium azide, and 1,3-dichloropicrin (168 kg/ha) was significantly less than in the untreated control

S17MT08P01**ABSORPTION, TRANSLOCATION, AND METABOLISM OF 14c-GLYPHOSATE AND LEAF SURFACE AND WAX ANALYSIS**P A Monquero¹, P J CHRISTOFFOLETI¹, M D OSUNA², R De PRADO² AMIAN², A J MATAS² And A HEREDIA²

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Laboratory and growth chamber studies were conducted to characterize ¹⁴C-glyphosate absorption and ttranslocation in *Commilina benghalensis* L. (benghal dayflower), *Ipomoea grandifolia* (morninglorry), *Amaranthus hybridus* (smooth pigweed) and glyphosate resistant (R) and susceptible (S) *Glycine max* (L) Merryl (soybean). Glyphosate metabolism, leaf surface characteristics, and was decomposition in the weeds were also studied. After a seventy-two-hours treatment with glyphosate at 720 g a.e./ha (HAT), benghal dayflower absorbed 66% of the applied glyphosate, whereas morningglorry absorbed 80% and smooth pigweed and R and S soybeans more than 90%. Translocation of glyphostae was greater for benghal dayflower, soybeans, and smooth pigweed than for morningglorry. Analysis of extracts from benghal dayflower indicated that the glyphosate metabolism increased from 20 to 40.8% over time. Cuticular membrane composition ou young leaves of smooth pigweed and morningglorry included alcohols, acids, and esters. In contrast, cuticular membrane of young leaves of benghal dayflower included hydrocarbons, hydroxy-diketones, and abcohols. Leaf surfaces of these weeds were visually different. The adaxial surface of benghal dayflower was covered with trichomes and all stomata were covered by epicuticular was. No wax crystals were observed on the leaf sufarce of morningglorry, whereas in smooth pigweed granular wax was present and stomata were evaluated relative to the surrounding leaf surface. The results suggest that differences in glyphosate susceptibility may be associated to differences in glyphosate absorption and metabolism for benghal dayflower, and differences in glyphosate translocation for morningglorry.

S17MT08P02**DIFFERENTIAL SEED PRODUCTION OF GLYPHOSATE-RESISTANT AND SUSCEPTIBLE INDIVIDUALS IN A *LOLIUM RIGIDUM* POPULATION IN COMPETITION WITH WHEAT**B P Pedersen¹, P Neve¹, C Andreasen² and S B Powles¹

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The reproductive success of glyphosate resistant (R) and susceptible (S) individuals from a single *L. rigidum* population in pure culture and in competition with wheat was studied. An additive design was chosen with 5 *L. rigidum* plants and 0, 2, 4, 6, 10 or 30 wheat plants per pot. Initial seed weight was recorded for each plant and used as a covariate in the statistical analysis. Initial seed weight was significantly greater for the R phenotype. Gene flow and cross-pollination between treatments was prevented by surrounding individual treatments with pollen proof enclosures prior to flowering. Inflorescences were harvested and total seed weight and number of seeds was measured for each individual *L. rigidum* plant. Wheat yield was measured as the mean weight of inflorescences per pot. Overall, S plants produced smaller seeds but the total number of seeds was greater. R plants produced larger seeds and had a greater total seed weight per plant, but individual R seeds produced relatively less progeny than S seeds. This apparent cost of resistance showed a tendency to be density dependent as the difference in seed production of R and S plants decreased with wheat yield. The results of this study showed that the S phenotype was able to produce more seeds than the R phenotype without competition and at low crop densities. However, at higher densities the R phenotype had a competitive advantage possibly because of its greater initial seed weight

S17MT08P03**GLYPHOSATE AND PARAQUAT RESISTANCE IN WEEDS OF THE WESTERN CAPE**

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During the past three years poor control of some weeds by glyphosate and paraquat was reported in the Western Cape. The objective of this study was to identify if induced resistance to these herbicides was the cause of the problem. Seed from the suspected resistant populations was collected in vineyards and orchards and germinated in petri dishes or in pots. The resultant seedlings were transplanted into pots and subsequently subjected to dose response trials. Glyphosate resistance in *Lolium rigidum* was found to be widespread and was identified in the Boland and the Breede River Valley. Some of these populations could withstand more than 7.2 kg a.e. glyphosate ha⁻¹. Paraquat resistance in ryegrass was also widespread in these areas and some populations could withstand 4.0 kg paraquat ha⁻¹. Glyphosate resistance in *Coryza bonariensis* was confined to a few sites in the Breede River Valley where some plants could withstand 3.6 kg a.e. glyphosate ha⁻¹. Paraquat-resistance in this weed was far more widespread and plants from the same area could survive more than 4.0 kg paraquat ha⁻¹. Populations of *L. rigidum* and *C. bonariensis* that are resistant to both glyphosate and paraquat have also been identified. Glyphosate-resistance was recently discovered in a population of *Plantago lanceolata* from the Breede River Valley where dosage rates in excess of 3.6 kg a.e. glyphosate ha⁻¹ were needed to control more than half of the population.

S17MT08P04
EVOLUTION OF GLYPHOSATE RESISTANCE IN NEW SOUTH WALES, AUSTRALIA

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Annual ryegrass (*Lolium rigidum*) is one of the most serious weeds in the southern cropping region of southern Australia. Much of the annual ryegrass present in this area has already evolved resistance to one or more herbicides. In many cases, glyphosate is one of a dwindling number of herbicides effective in controlling this weed species. Therefore, the evolution of glyphosate resistance in a significant number of annual ryegrass populations across Australia is a cause for serious concern. New South Wales has the majority of cases of glyphosate resistance so far identified. It is important to know whether these populations represent evolution of one or more resistance mechanisms, in order to minimise further resistance and design appropriate controls for existing resistant populations. Dose-response experiments were conducted on six glyphosate-resistant populations from three areas of New South Wales, Darlington Point, Orange and the Liverpool Plains. These populations were from four to seven-fold resistant to glyphosate. F₁ populations were created from a cross of a resistant (R) parent with a known susceptible (S) parent. Progeny of these crosses were examined using a tiller cloning technique. Inheritance of glyphosate resistance in five populations was semi-dominant, with one population showing complete dominance. The dose response data and differences in inheritance suggest there may be more than one mechanism of resistance present within these six populations. Reduced translocation of glyphosate from leaves to meristematic regions has been identified as one mechanism of resistance in these populations and other potential resistance mechanisms are being explored.

S17MT08P06
MODELLING THE RISK OF GLYPHOSATE RESISTANCE IN ROUNDUP READY® COTTON

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Herbicide resistant weeds threaten the continued success of herbicide technology to contribute to world crop production. The introduction of glyphosate tolerant cotton into Australian farming systems will have an effect on conventional weed management practices, the weed species present and the risks of glyphosate resistance evolving. It is therefore important that the effects of these management practices, particularly a potential reduction in IWM practices, be examined for their influence on weed population dynamics and resistance selection. The aim of this project is to develop a framework to assess the potential for glyphosate resistance to develop in Roundup Ready® cotton systems. This involves the investigation of the population dynamics of *Echinochloa colona* and *Urochloa panicoides* as model weeds and the interactions between these dynamics and a range of management practices. Field experiments have been established examining the population dynamics of the two model weed species. The treatments consist of an IWM approach with and without the Roundup Ready® technology, a half IWM approach with the technology, and utilizing the Roundup Ready® technology only. Studies are also underway to measure the effect of planting densities on growth and reproduction of *Echinochloa* and *Urochloa* in terms of biomass and seed production. Results from these experiments will be used to develop a model that will predict the likelihood of glyphosate resistance evolution over a range of management strategies for a range of weed species. This will facilitate the development of sustainable weed management practices in Roundup Ready® cotton.

S17MT08P05
PRELIMINARY RESULTS ON GENETIC BASIS OF GLYPHOSATE RESISTANCE IN *Conyza canadensis* (L.) CRONQ. BIOTYPES

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Glyphosate has been extensively employed throughout the world for the last 30 years for the control of annual and perennial weeds in a wide range of different situations. However one of the constraints of many herbicides is the potential for the weeds to evolve resistance, the capability to withstand normally effective herbicide dose. The first-reported case of glyphosate resistant weed refers to *Lolium* populations and to date glyphosate resistance has been observed in four weed species, *Conyza canadensis* (L.) Cronq., *Eleusine indica* (L.) Gaertn., *Lolium multiflorum* Lam. and *Lolium rigidum*. Currently, information on the relationships between response to glyphosate and genetic diversity of *Conyza canadensis* (L.) Cronq. is not available, nevertheless the many molecular methods developed. Among them, differential display (DDRT-PCR) is a powerful tool for analysing altered gene expression. The technique allows simultaneous display of all expression differences, side-by-side comparison of different samples, detection of up- and down-regulated gene and isolation of rare transcripts. Given these premises, three resistant (R) and two sensible (S) biotypes of *Conyza canadensis* from different Northern America's locations were analyzed to detect differential gene expression of glyphosate resistance. Accessions were previously screened for their susceptibility to glyphosate by Rapid Resistance Test (RRT) and pot experiments with glyphosate doses ranging from 0.18 to 5.76 kg/ha. Total RNA from plants was extracted after and before glyphosate treatment, reverse transcribed and possible variations in ESPS expression were evaluated. Results showed a variation in electrophoretic patterns between resistant and susceptible accessions of *Conyza canadensis* (L.) Cronq.

S17MT08P07
WEEDS RESISTANT TO FOLIAR APPLIED HERBICIDES IN TAIWAN

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Taiwan has a total farmlands of 0.9 million ha. In the past three decades, herbicides are commonly used for field crops, orchards and environmental vegetation management. Foliar herbicides are applied in far more total areas than that of the soil applied chemicals. In the middle 90s, total annual herbicide applied area was around 2.8 million hectares and foliar herbicides accounted form 2 million hectare. So far, all confirmed cases on weed resistance in Taiwan are related with paraquat, glyphosate, or ACCase inhibitors mainly fluzafop-p-butyl. Resistant *Conyza sumatrensis* (Retz.) Walker and *Eleusine indica* (L.) Gaertn occur primarily in orchards where these herbicides have been used persistently 2-4 times a year. Recent studies suggest glyphosate-resistant *C. sumatrensis* are more widespread than that of paraquat-resistant type in central and south Taiwan. Resistant *E. indica* occurs in some separated grape, guava and bitternut producing areas. We have found populations that resistant to glyphosate, fluzafop-p-butyl or multiple resistant to both herbicides in neighboring fields of the same area. The fluzafop-p-butyl resistant type is also cross-resistant to other ACCase inhibitors, the R/S value with fluzafop-p-butyl is highest followed by that of haloxyfop-methyl, cycloxydim, sethoxydim and quizalofop-ethyl in decreasing order. Enzyme level studies show that the glyphosate resistant *E. indica* is similar in mutation site of the target enzyme EPSPS as reported with resistant goosegrass from Malaysia.

S17MT08P08**THE SUSTAINABLE FUTURE OF GLYPHOSATE AND ROUNDUP READY CROPPING SYSTEMS.****J. Koscelny¹, R. Sammons, D. Heering, G. Elmore and N. DiNicola**¹Monsanto Company, 800 N. Lindbergh Blvd. St. Louis, MO 63167, Jeffrey.koscelny@monsanto.com

Over 280 cases of weed resistance to herbicides have been confirmed globally to-date¹. Of these, over seventy percent involve herbicides in four mode-of-action categories (ACCase, acetolactate synthase, bipyridiliums and photosystem II representing 50% of commercial compounds). By contrast, glyphosate formulations have been used worldwide for almost 30 years and Monsanto has confirmed resistance in biotypes of four weed species and is investigating two additional resistance claims. Only one of these resistant species has been observed where Roundup Ready® crops are grown. Resistance levels to glyphosate have been low in magnitude suggesting that a high dose strategy can delay or prevent resistance development. Long-term research trials have demonstrated that Roundup Ready crops can be effectively grown in rotation with each other. The key to success in these research trials has been to implement stewardship practices to maximize weed control. Using the correct glyphosate rate at the appropriate application timing in combination with other tools or practices can accomplish this effectively and economically. A four-step stewardship program is being effectively used to encourage the proper use and long-term effectiveness of glyphosate. The steps include 1) develop appropriate weed control recommendations, 2) continued research to refine and update recommendations, 3) educate growers and retailers on the importance of good weed management practices and 4) respond to repeated weed control inquiries through a performance evaluation program.

S17MT20CP01**THE UNPALATABLE GRASS SYNDROME IN AUSTRALIA – AN AGRICULTURAL AND ENVIRONMENTAL DISASTER.****David A. McLaren^{1,7}, David Officer^{2,7}, Val Stajsic³, Wayne Vogler^{4,7}, Craig Walton⁵ and Ben Lawson⁶**¹Primary Industries Research Victoria (PIRVic), Department of Primary Industries, Frankston Centre, PO Box 48, Frankston 3199, david.mclaren@dpi.vic.gov.au.²NSW Agriculture, PMB 2, Grafton NSW 2480, david.officer@agric.nsw.gov.au³National Herbarium of Victoria, Royal Botanic Gardens, Birdwood Avenue, South Yarra 3141, val.stajsic@rbi.vic.gov.au⁴QLD Department of Natural Resources and Mines, Charters Towers QLD 4820, wayne.vogler@dnr.qld.gov.au⁵QLD Department of Natural Resources and Mines, Brisbane QLD, craig.walton@nrm.qld.gov.au⁶School of Natural and Rural Systems Management, The University of Queensland, Brisbane, QLD 4072, b.lawson@mailbox.uq.edu.au⁷CRC for Australian Weed Management

Unpalatable grasses are one of the most significant issues affecting grazing industries in Australia. The current and potential distributions of exotic stipoid grasses and weedy *Sporobolus* species are documented. The known ecology and impacts on agriculture and the indigenous vegetation are presented. The exotic stipoid grasses and weedy *Sporobolus* grasses share a number of common traits. They are difficult to identify, they are competitive invaders, they are mostly unpalatable and they are difficult to control. This paper presents an overview of projects underway to address some of these issues. *Nassella trichotoma* and *N. neesiana* are declared Weeds of National Significance in Australia. This paper recommends that weedy *Sporobolus* species should also be declared as Weeds of National Significance to Australia.

S17MT20CP02**URBAN-INDUCED MACRO-CLIMATIC CHANGES ALTER WEED ESTABLISHMENT, SPECIES DIVERSITY AND SECONDARY SUCCESSION.****LH Ziska¹**Alternative Crop and Systems Laboratory, United States Department of Agriculture, Agricultural Research Service, Building 1, Room 323, 10300 Baltimore Avenue, Beltsville, Maryland 20705, USA. lziska@asrr.arsusda.gov

Although future increases in atmospheric carbon dioxide (CO₂) are projected to alter the growth and biology of weedy species, increasing data from different urban environments suggests an existing CO₂/temperature difference between urban and rural settings that could potentially be affecting the growth and establishment of weedy species. To determine the impact of such urban-rural macro-climatic differences, a transect of weather stations and homogenous, fallow field plots was established between the downtown area of Baltimore, Maryland and an organic (rural) farm approximately 45 km distant. Along the transect, average daytime CO₂ concentration increased by 20% and maximum (daytime) and minimum (nighttime) daily temperatures increased by 1.6 and 3.3°C, respectively in an urban relative to a rural location. These urban-induced environmental changes are consistent with most global change scenarios. For the first year, plots at all sites were dominated by a single weedy species, lambsquarter (*Chenopodia album*), and vegetative productivity, determined as final above-ground biomass, was positively affected by warming and enhanced CO₂, increasing 60 and 115% for the suburban and urban sites, respectively, relative to the rural site. For the second year, overall productivity was reduced, but still greater for the urban location. However, the number of species (both weeds and woody perennials) was increased for the urban site. While information on long-term changes in species diversity and productivity is needed, these are the first *in-situ* data indicating how projected changes in CO₂ and temperature could alter weed establishment, weed populations and the rate of secondary succession in fallow agricultural soil.

S17MT20CP03**ECOLOGY AND BIOLOGY OF INVASIVE WEED *AGERATUM HOUSTONIANUM* IN SHIVALIK RANGES OF NORTHWESTERN INDIAN HIMALAYAS****R K Kohli^{1,2}, K S Dogra¹, Daizy R Batish², and H P Singh²**¹Panjab University, Centre for Environment and Vocational Studies, Chandigarh 160 014, India, E-mail: rkkohli45@yahoo.com; ²Panjab University, Department of Botany, Chandigarh 160 014, India, E-mail: daizybatish@yahoo.com;

India is one of the mega centers of origin of cultivated plants and perhaps the richest repository of plant diversity. The northwestern Indian Himalayas are the ideal place for the diverse flora because of wide climatic regions. However, during the last 2 decades the exotic plants have invaded this area very fast due to increased anthropogenic activities, climatic changes and interplant interactions at the cost of the native flora. *Ageratum houstonianum* (Blue mink / Floss flower / Horny goat weed) - a native of Tropical America, has encroached upon the vast areas very fast and resulted in depleting the native vegetation. It is a vigorous colonizer, particularly of agricultural fields, orchards and weak pastures. It is an annual weed with a tendency to be perennial. It attains a height up to 1m with branches, which may further increase it to 1m. The stem is yellowish green and hairy. The white colored inflorescence is capitulum, which is terminal or axillary and hairy in nature. The leaves and stem of the plant bears a horny hair like structures called trichomes. Plant is known to possess a number of ecological and biological strategies like strong regenerative and reproductive potential, with large number of small and light air-borne seeds, lack of natural predators, and very wide ecological amplitude that favor its invasive potential. It has the capacity to form its monocultural stands, wherever invades by overpowering other vegetation. The present contribution attempts to discuss the role of ecology and biology of a *Ageratum houstonianum* in successful colonization / invasion in the Shivalik ranges of northwestern Indian Himalayas.

S17MT20CP04
INVESTIGATING THE DISTRIBUTION AND ABUNDANCE OF
OPUNTIA STRICTA, AN INVASIVE ALIEN WEED IN KRUGER
NATIONAL PARK, SOUTH AFRICA.

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Opuntia stricta (Haw.) Haw. is an invasive alien weed that has invaded an area of more than 35 000 hectares in the Skukuza region of Kruger National Park (KNP). The distribution of *O. stricta* and features of the environment were mapped to unravel the dynamics of its invasion. This represented an attempt to determine those factors that affect the distribution and density of the plant. A principal component analysis of *O. stricta* density revealed that none of the monitored environmental factors influenced the distribution or abundance of *O. stricta* in KNP. Furthermore, no natural barriers were indicated that might limit the extent of invasion within KNP. The study, therefore, shows a high probability that *O. stricta* eventually will invade the entire KNP unless appropriate intervention occurs.

S17MT20CP05
GRAPPLING WITH HARPAGO - THREATENED AND
THREATENING!

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Harpagophytum procumbens (Burch.) DC. ex Meissn., Pedaliaceae, is native to South Africa, Botswana and Namibia. A CLIMATE analysis indicates grapple plant could thrive across large areas of central Australia and southwestern North America. Extracts of harpago root tubers contain harpagoside which is reputed by some to be effective in the treatment of arthritis and lower back pain. There is such a demand for products made from harpago, the plant is being overharvested in its native range. At the April 2000 conference of the Convention on the International Trade in Endangered Species (CITES) the motion to declare grapple plant as an Appendix II species was temporarily withdrawn. Internet sales of seeds and plants have been documented. The threat from grapple plant relates to its fruit which is a large woody capsule covered with stout hooks. The fruits are adapted to attach to the feet of animals. Harpago has certain characteristics that indicate it could become a weed if introduced outside its native range, particularly that in its native habitat it often grows in disturbed sites such as roadsides and overgrazed land. The plant can also establish a considerable seed bank. Harpago is unpalatable to livestock and its rough stems can cause gastrointestinal disorders in horses and other animals. It is very well adapted to arid conditions, producing a primary root tuber that can reach two metres in depth and remain dormant during drought. It responds very quickly to rain, sending up shoots that are quick to flower and set fruit.

S17MT20CP06
BIODIVERSITY AND WEED ESCAPES IN GLYPHOSATE-
TOLERANT SOYBEAN

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There are two main concerns about the effects of glyphosate resistant crops: (i) what weeds escape glyphosate and (ii) the loss of biodiversity. Some weeds escape this herbicide, and would become bigger problems in the future. Identifying these weeds and their mechanisms of escape allows to develop more effective management strategies. The objectives of this study were to compare changes in weed diversity and crop yields in GR soybean systems in a large production area of U.S. Treatments included: (i) one application of glyphosate after soybean planting when weeds were 10 cm height; (ii) two applications of glyphosate, when weeds were 10 cm and again at 15/20 cm; (iii) standard preemergence herbicide plus glyphosate applied when weeds were 10 cm height; (iv) standard preemergence plus standard post-emergence herbicides; and (v) the weedy check. One-pass glyphosate maintained higher biodiversity than two-pass and equivalent or higher than conventional systems. The two-pass glyphosate decreased diversity to levels comparable to standard weed management treatments. Thus, in terms of biodiversity, intensive use of GR technology may be no better and no worse than conventional weed management. When we plotted soybean yield in relation to the latitude, there was a significant correlation between the percent of maximum yield and latitude for the one-pass glyphosate and the Standard Preemergence plus Postemergence herbicide. The apparent "cut-off" point for a 10% yield loss occurred at 40° N latitude. This suggests that it is possible to maintain high diversity and yields with a one-pass glyphosate, but only at higher latitudes.

S17MT23P01
EVALUATION OF TANK MIX APPLICATION OF PRE-
EMERGENCE HERBICIDES FOR WEED CONTROL IN
FLORIDA CITRUS.

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Glyphosate is largely used to manage citrus weeds, however, its continuous use is reflecting shift in weed flora. Pre-emergence herbicides can lower dependence on repetitive use of glyphosate to lower the risk of herbicide failure. Field experiments were conducted using tank mix of diuron, simazine, oryzalin and norflurazon in a sandy soil. Plots of 3 by 46 m with 4 replicates were sprayed with glyphosate at 1.68 kg ae/ha before treating with mixtures with single or repeat applications. Herbicides were sprayed using a tractor mounted sprayer fitted with 80015 Teejet nozzles delivering 190 L/ha volume at 152 kPa pressure. Percent weed control and emergent weed species were recorded periodically.

Diuron plus norflurazon 3.6+2.7 kg ai/ha repeat application after 60 days provided more than 97% control of weeds and was better than their single application (95%) or oryzalin plus diuron 3.4+3.6 kg/ha. Tank mix of diuron plus simazine 3.6+3.6 kg/ha provided 90% or higher weed control for 90 days and was better than 2 applications of glyphosate or diuron and oryzalin alone. Repeat application of diuron plus simazine improved weed control, but it was lower than diuron plus norflurazon at 120 days. When averaged over durations, simazine plus norflurazon 3.6+2.7 kg/ha and their repeat application resulted in 90 to 92% control, respectively, but mortality was slightly lower than diuron plus norflurazon. All the pre-emergence herbicides applied after three weeks of glyphosate provided satisfactory control of weeds for more than 120 days and can effectively be substituted for repeat applications of glyphosate.

S17MT23P02
SUSTAINABLE WEED MANAGEMENT IN BRAZIL CITRUS ORCHARDS

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Brazil is the biggest citrus producing country in the world. Control of weeds is an important economic factor, well recognized by growers in Brazil citrus production. Optimum weed management is done by herbicides applied in strips combined with mechanical mowing of the vegetation prior to seed heads formation between the rows. Nitrogen –fixing leguminous crops have been used to increase organic matter and add nitrogen to the soil. The adequate use of residual herbicides by one annual application did not show any adverse effects in a long-term use. The post-emergence type herbicides predominate over the pre-emergence ones, and glyphosate is the one most used. Today it is recommended to be used safely only as a directed spray. Some growers are worry about the interference to the citrus orchards. The pre-emergence herbicide diuron has a good safety margin in citrus in a long term use. Some growers are using cover crops during the rainy season in the first years of the orchard or a permanent cover crop or native vegetation. It has been observed that the population and seedbank dynamic alters depending on the green manure source. Lateral rotary mower has been used to manage the weed near the plant. The use of glyphosate or diuron in the citrus row has continually altered the distribution of the weed seed bank in the soil profile. Studies of intercropping cover crops, tillage systems and allelopathy indicate that in citrus, managing the orchard floor is more important than weed control itself, used toward economically and environmentally sustainable weed management systems.

S17MT23P04
EFFECT OF GLYPHOSATE MIXTURES AGAINST WEEDS UNDER YOUNG RUBBER FOREST PLANTATION

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Rubber forest is a new concept of rubber cultivation in Malaysia and is becoming increasingly important in order to meet the high demand of rubber wood for the timber industry. During the early stages of establishment of rubber forest, weed infestation is a major problem. Currently, limited information is, however, available on effective weed control method in young rubber forest. The rubber forest plantation is generally located in remote areas and weed control technology which provides longer duration of control is preferred. Trials were conducted in a young rubber forest plantation to determine effective treatments and rates of herbicides against weeds using glyphosate and its mixtures since glyphosate is relatively inexpensive. Comparison of two glyphosate formulations at 1.08 kg ae/ha showed that glyphosate trimesium was as effective as glyphosate isopropylamine against mixed weeds comprising mainly *P. polystachion*. Glyphosate isopropylamine at 1.08 kg ae/ha in mixtures with metsulfuron methyl (0.03 kg ai/ha), fluroxypyr (0.3 kg ae/ha), dicamba (0.6 kg ae/ha) or premixed picloram + 2,4-D (0.097 kg ae/ha + 0.36 kg ae/ha) were effective against mixed weeds comprising grasses and woody broadleaves and were more effective than glyphosate isopropylamine alone. Glyphosate isopropylamine + metsulfuron methyl applied at four rounds per year provided more effective weed control than at two rounds per year in rubber forest of more than two years old and the herbicide treatments were more effective than slashing. Glyphosate mixtures are therefore promising for controlling mixed weeds comprising woody broadleaves and grasses in young rubber forest plantation.

S17MT23P03
HERBICIDE APPLICATION TECHNOLOGY FOR EFFECTIVE CITRUS ORCHARD FLOOR VEGETATION MANAGEMENT

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Herbicide application within Florida citrus orchards utilizes multiple boom technology to achieve optimum vegetation management in a single application. Multiple chemical applications in a single pass are necessary to minimize application costs through improved labor and equipment efficiencies. Application sites are divided into two areas, sub-canopy and row middles. Applications to the sub-canopy areas require booms that provide uniform herbicide applications to the soil surface while minimizing applications to lower fruit and/or limbs. Usual operational boom height is 30-40 cm above the soil/vegetation. Boom cover design incorporates a rounded leading edge of at least 15 cm prior to the spray nozzles, are recessed within the boom cover and followed by a fully flexible back cover which minimizes off target drift of applied materials. Application volumes are 190-280 L/ha at 135 to 207 kPa for preemergence herbicides and 90-190 L/ha for postemergence materials. Row middle applications utilizing low rates of glyphosate limit the growth and/or regrowth of sod forming and other vegetation species is commonly referred to as chemical mowing. Row middle applications of 40-60 L/ha are made with a fix boom at heights of 60-90 cm with a fully flexible back cover. Ground speed, determined by site conditions, ranges from 4.8-8 km/h. Application pressure is based on variable ground speed monitoring systems.

S17MT23P05
RESPONSE OF CYNANCHUM ACUTUM AND ARAUJIA SERICOFERA TO POST-EMERGENCE HERBICIDES

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Cynanchum acutum and *Araujia sericofera* are hard to kill perennial species spreading in several agriculture areas in Israel. Both plants are members of the ASCLEPIADACEAE family. *C. acutum* and *A. sericofera* are climbing plants that exhibit very high re-growth ability and became major weeds in citrus orchards. The increased infestation of these weeds coincides with the reduction in bromacil use in orchards. Initially, bromacil was applied at high rates (4.0 kg a.i/ha) but in recent years its use decline dramatically because of its high price. In order to control these troublesome weeds, several alternative chemical treatments were examined. Glyphosate applied alone or in combination with very low rates of oxyfluorfen, flumioxazin or carfentrazone, which are commonly used for the control of annual weeds, were tested during 2001 and 2002 in various locations, climates and soil types. Combinations of fluroxypyr (1% of the spray volume) with glyphosate (2%) or fluroxypyr with flumioxazin 0.02 - 0.05% improved the control of these species with no damage to the crop and provided excellent weed control for three months. Additional residual effect, especially on *A. sericofera* seedlings was detected when flumioxazin was applied to sandy soils. Combinations of glyphosate or fluroxypyr with carfentrazone (0.05%) provided reasonable control of both weeds. The longevity of these treatments was temperature-dependent, where high temperature during spring decreased herbicide efficacy.

S17MT23P06**PROSPECTS FOR THE BIOLOGICAL CONTROL OF BRIDAL CREEPER IN CITRUS ORCHARDS****R M Kwong^{1,2} and S Holland-Clift¹**

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The southern African vine, bridal creeper (*Asparagus asparagoides* (L.)) is recognised predominantly as an environmental weed, posing a major threat to biodiversity and conservation in Australia's temperate natural ecosystems. However, its status as a weed of horticulture has more recently gained recognition.

Bridal creeper is considered by citrus growers in the irrigation areas of southern Australia to be one of the most troublesome weeds affecting their orchards. The smothering effect of the bridal creeper foliage, combined with the displacement of citrus roots by the extensive, perennial root system contributes to reduced tree growth, fruit production and increased susceptibility to disease.

Citrus growers have been struggling to adequately control bridal creeper due to a reluctance to use herbicides because of fears of damage to the crop, the expense of manual removal and constant reinvasion of bridal creeper from unmanaged roadside and bushland vegetation. Hence, many growers have turned to biological control in an attempt to reduce the damage and spread of the weed.

This poster provides an overview of the strategy used to implement biological control of bridal creeper in citrus orchards. It evaluates preliminary results of agent establishment combined with findings from a grower survey to draw conclusions on the prospects for the effective integration of biological control into orchard management practices.

Keywords Bridal creeper, *Asparagus asparagoides*, citrus, biological control, surveys.

S20MT5P01**CHARACTERIZATION OF HERBICIDE AVAILABILITY IN SOILS****W C Koskinen¹ and M A Locke²**

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Herbicide availability is the result of integration of various processes in soil, and it controls herbicide transport, uptake, and degradation. Sorption-desorption is arguably the most important soil process that determines herbicide availability. It is suggested that only herbicide in solution, or readily desorbable from soil, is available for transport, degradation, or uptake. Herbicides sorbed to soil are not instantaneously available, but must first be desorbed from the soil, therefore availability is directly related to desorption characteristics. Various methods have been used to characterize availability. Batch methods have traditionally been used to generate sorption coefficients, i.e. K_d, K_{oc}, with lower sorption coefficients indicating lower affinity for soil, thus greater availability. Other commonly used techniques include determination of aqueous-extractable herbicide, which is considered "readily available pesticide", and various solvent extraction techniques, which determine different degrees of availability. These methods have limitations, e.g. a slurry does not represent field conditions and does not account for desorption hysteresis or changes in availability over time. Alternative methods for availability characterization have included isotopic exchange, which determines the non-readily available herbicides; use of supercritical fluids to determine desorption at typical field moisture contents; and determination of nonavailable herbicides by sequential solvent extraction; methods that also have limitations. Precaution must be taken in method selection. For instance, depending on the method of characterization of sorption-desorption, herbicide mobility classification can be changed. After 40 years of research, there is still no universally accepted method to characterize availability, and the search continues for innovative, practical, and realistic methods.

S20MT5P02**ATRAZINE, METOLACHLOR, AND PRIMISULFURON-METHYL MOBILITY IN FIELD LYSIMETERS OF THREE SOILS AS INFLUENCED BY SOIL AND HERBICIDE PROPERTIES AND WATER INPUT****Jerome B. Weber¹, Ralph L. Warren², Len R. Swain¹, and Leon E. Danielson³**

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Understanding herbicide mobility in soils is necessary to prevent ground water contamination. We studied the mass balance distribution of three ¹⁴C-labeled herbicides (atrazine, metolachlor, and primisulfuron-methyl) in three soils (Blanton, Norfolk, and Rains) 128 days after application to fallow soil column field lysimeters. Analyses were made of surface soil, subsoil, and leachate samples. Volatilization losses were calculated by difference. Our objectives were to examine, measure and correlate the leaching patterns of the chemicals and correlate their leaching characteristics with the physicochemical and biological properties of the herbicides and the physicochemical properties of the soils. Metolachlor was the most mobile herbicide followed by atrazine and primisulfuron-methyl where mobility was greatly affected by water input. Herbicide mobility (R_i) was related to ¹⁴C-parent in leachate, leachate volume, and ground water contamination potential (GWCP) index for each herbicide/soil combination. The herbicides were most mobile through Blanton, followed by Norfolk and Rains soils and mobility was inversely related to mean %OM content of the soil profiles and directly related to soil pH and soil leaching potential (SLP) indices of the soils. Physicochemical and biological properties of the herbicides and soils were related to many of the measured herbicide distribution parameters.

S20MT11P01**OVERVIEW OF THE U.S. NATIONAL EARLY DETECTION AND RAPID RESPONSE SYSTEM FOR INVASIVE PLANTS****Randy G. Westbrooks**

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Currently, the U.S. Geological Survey (USGS) is cooperating with the Federal Interagency Committee for the Management of Noxious and Exotic Weeds (FICMNEW) to develop and implement a National Early Warning and Rapid Response System for Invasive Plants in the United States. Ultimately, the system will be part of an All Taxa Early Detection and Rapid Response System under the National Invasive Species Management Plan. The overall purpose of developing such a system for invasive plants is to provide a coordinated framework of public and private partners to more effectively address new invasive plants through: 1) Early detection and reporting of suspected new plants to appropriate officials; 2) Identification and vouchering of submitted specimens by designated botanists; 3) Verification of suspected new state, regional, and national plant records; 4) Archival of new records in designated regional and plant databases; 5) Rapid assessment of confirmed new records; 6) Rapid response to new records that are determined to be invasive. Currently, USGS is working with a number of state and regional partner groups to develop and field test elements and processes that were identified in the Conceptual Design Plan. Once fully implemented across the nation, the proposed system will provide an important second line of defense against invasive plants that complements federal efforts to prevent unwanted introductions at the ports of entry. With both prevention and early warning systems in place, the nation will be better able to defend against future economic and environmental losses due to "plants out of place".

S20MT11P02**PLANT NATURALIZATION RATES AS A RISK ASSESSMENT TOOL****P.A. Williams**^{1,4}, **R.P. Duncan**², **R.P. Randall**^{3,4}¹Landcare Research, Private Bag 6, Nelson, New Zealand, Williams@Landcareresearch.co.nz.; ²Ecology and Entomology Group, Soil, Plant, and Ecological Sciences Division, P.O.Box 84, Lincoln University, New Zealand, Duncanr@Lincoln.ac.nz;³Department of Agriculture, Western Australia, Locked bag 4, Bently Delivery Centre, Western Australia 6983, Australia, RPRandall@agric.wa.gov.au⁴Cooperative Research Centre for Australian Weed Management

Weed risk assessment at the border or early in an invasion of a new area by a plant species must often be undertaken with minimal information, particularly when there is no history of weediness elsewhere. The historical behaviour of the taxonomic group to which the species belongs can indicate the potential impact of a species. Becoming naturalized involves escaping from cultivation and establishing self-sustaining populations in the wild. This is a critical step towards becoming invasive, before impact will be revealed in time for some species. We compared the probabilities of naturalization in the 24 452 seed plants (i.e. gymnosperms and angiosperms) introduced into Australia and 24 739 introduced to New Zealand. Some families are better able to naturalize and than others. Naturalization rate is also significantly clumped within genera for most large families. There is wide variation around the mean transition from naturalised to weedy although families with high naturalization rates also tend to be the most weedy. Differences in naturalization rates between Australia and New Zealand indicate the importance of climate matching in determining the outcome of introductions. Introductory effort, or propagule pressure, as determined from whether a species was widely planted as a crop, a contaminant of a crop, is also a significant factor in determining naturalization rates. Countries, or political-biogeographical regions that are establishing quarantine protocols should determine their existing introduced floras, respective naturalization rates, and transitions to weeds as a guide to the risk posed by proposed introductions of new plant species.

S20MT13P02**ECHINOCHLOA CRUSS-GALLI CONTROL BY ALLELOCHEMICALS****F A Macías**, **N Chinchilla**, **R M Varela**, **D Marín** and **D Castellano**

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Oryza sativa L. (rice) is one of the most important cultivars in the world. *Echinochloa cruss-galli* is the most common weed of rice, and the current weed suppression methods have shown lack of efficacy, mainly related to the developing of herbicide resistant *E. cruss-galli* spp. Herein we report the effect of new allelochemicals (natural plant toxins) isolated from rice and also from other crops, in addition to their synthetic analogs to the development of *E. cruss-galli*. These effects have been evaluated by suitable bioactivity assays in which high inhibition of *E. cruss-galli* germination and growth has been achieved. A structure-activity relationships (SAR) study for these compound effects is also presented.

S20MT13P01**BIOSYNTHESIS OF SORGOLEONE: RETROBIOSYNTHETIC NMR, ROOT HAIR SPECIFIC EST, AND BIOCHEMICAL ANALYSES****F E Davan**¹, **I A Kagan**¹, **A M Rimando**¹, **Z Pan**¹ and **S R Baerson**¹, and **N P D Nanayakkara**²¹USDA, ARS, NPURU, National Center for Natural Products Research, University of Mississippi, University, MS, 38677, USA. fdavan@ars.usda.gov. ²National Center for Natural Products Research, University of Mississippi, University, MS 38677, USA

Sorgoleone is the main allelopathic component produced by sorghum (*Sorghum bicolor*) root hairs. Its biosynthetic pathway, the key genes and their gene products involved in the biosynthesis are being investigated through chemical, biochemical and molecular approaches. Carbon-13 NMR analysis of sorgoleone, extracted from seedlings fed with various ¹³C-labeled substrates, indicated that the putative pathway arises from the convergence of the fatty acid and polyketide synthase pathways for the aliphatic tail and quinone ring, respectively. The tail, derived from an unusual C16:3 fatty acid precursor possessing a terminal vinyl bond is probably synthesized in the plastids, exported into the cytosol and converted into 5-pentadecatriene resorcinol by a polyketide synthase. This resorcinol intermediate, which was identified in root hair extracts, is subsequently methylated by a SAM-dependent O-methyltransferase and dihydroxylated by a P450 monooxygenase to yield the reduced form of sorgoleone. Sorgoleone converts to the more stable oxidized form in the presence of air. A root hair-specific expressed sequence tag (EST) analysis was performed on approximately 5,500 random sequences from a cDNA library. Highly expressed candidate sequences representing all of the putative target enzyme classes suggested by the retrobiosynthetic study were identified within the root hair EST data set. Functional analysis of some of these genes has thus far led to the characterization of a resorcinol specific O-methyltransferase catalyzing a key step in the biosynthetic pathway of sorgoleone.

S20MT14P01**TRENDS IN HERBICIDE DISCOVERY****M Drewes**, **K E Pallett**, **A Schulz** and **H Stuebler**Bayer CropScience GmbH, Industriepark Hoechst, Building H 872, D-65926 Frankfurt am Main, Germany
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During the 1980s and 1990s there has been a constant development of new herbicides. At each biannual BCPC-Weeds Conference throughout these two decades an average of ten new herbicides were presented.

Recently a significant decline has been observed. This reduction was caused by a combination of several factors:

- changing economical conditions with increasing costs of research and development for new herbicides
- decreasing growth rate of the global herbicide market
- lack of new herbicidal Mode of Actions
- consolidation of the agrochemical industry resulting in fewer companies participating in herbicide discovery.

To combat current trends major changes have been implemented within research. For the discovery of novel herbicides an innovative and integrated discovery platform has been set up within the industry. Target based ultra-High-Throughput-Biochemical-Screening (uHTBS) has been established for the discovery of new compounds acting on established or novel targets. To identify new herbicide targets functional genomic programs have been initiated. Ultra-High-Throughput-in-Vivo-Screening (uHTVS) evaluates the efficiency of new compounds on whole organisms. Virtual-Target-Based-Screening (VTBS) can be utilised as tool for rational design approaches, resulting in more successful chemical structures (hit enrichment). Chemical research efforts are today applying various state-of-the-art synthesis technologies to diversify chemistry and optimise a more agrophoric approach. Thus new innovative substances will be discovered. However, besides superior agronomic properties and cost efficiency new herbicides must also have optimal safety and environmental profiles, which are the preconditions for fast and successful registration within the development process.