INTERNATIONAL BIOHERBICIDE GROUP

IBG NEWS

June 2011

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CHAIRMAN'S COMMENTS

REMINDER:

IBG Meeting Saturday September 10, 2011
Marriott Hotel, Kona, Big Island, Hawaii

Registration $30 USD (cash)

Payable to Karen Bailey at the meeting. Recipts will be provided there.
Still room for a few participants and presentations.
Let me know if want a confirmed space.

Karen Bailey (Karen.Bailey@agr.gc.ca)

IBG WEBSITE

As you might have seen, the IBG Website (http://ibg.ba.cnr.it) has been updated and renewed. Due to the scarcity of funds, I have prepared it by myself, and of course it hasn't a professional style. I hope you will appreciate it.

It contains, as pdf files, almost all the previous issues of the IBG newsletter, and most of the books of abstracts of previous IBG Workshops.

I have arranged also sections for hosting pictures of previous meetings, or of biocontrol agents. They are still empty, but with your help we can have nice pages.

In order to have a better visibility of previous bulletins and proceedings, I have also placed most of the documents in a free-hosting website, i.e.: issuu.com, that allows a better view of the PDF files. From that site, you can read on line, download, print and save the PDF files. You can also find some other related documents. Maybe a good way to let other people getting into the group.

(by Maurizio Vurro - maurizio.vurro@ispa.cnr.it)

PEOPLE & PLACES

National symposium held at Bangalore, India

The Society for Biocontrol Advancement, on the occasion of its Silver Jubilee, organised the "National Symposium on Harnessing Biodiversity for Biological Control of Crop Pests" at Bangalore, India, during 25-26 May 2011. There were 18 invited lectures spread across seven sessions in addition to several platform presentations and posters. The themes were: Biodiversity, conservation and utilisation of entomophages; Semiochemicals and insect behaviour; Stress tolerance, genetic improvement and molecular characterization of

biocontrol agents; Microbial biodiversity, entomopathogenic nematodes and their application in pest and disease management, including endosymbionts associated with bioagents; Classical biological control of alien invasive pests; Application of bioinformatics in biological control/ GPS for biodiversity/ cataloguing/ documentation; and Policy issues in quarantine and exchange of biocontrol agents, including the implications of Biodiversity Act on biological control. I presented the sole invited talk on weeds ("Classical biological control of weeds in India: is it time to step on the gas?").

(by Dr P. Sreerama Kumar, National Bureau of Agriculturally Important Insects, Bangalore, India - psreeramakumar@yahoo.co.in)

BIOHERBICIDE RESEARCH

News from Agriculture and Agri-Food Canada, Saskatoon

Phoma macrostoma received conditional registration from the Pest Management Regulatory Agency in Canada to use this bioherbicide for control of several broadleaved weeds in turfgrass.

Two new publications on *Phoma macorstoma* were accepted by the journal Biological Control : (Please cite this article in press as):

1) Bailey, K.L., et al. The effects of *Phoma macrostoma* on nontarget plant and target weed species. Biological Control (2011), doi:10.1016/j.biocontrol.2011.06.001

2) Bailey, K.L., Pitt, W.M., Leggett, F., Sheedy, C., Derby, J., Determining the infection process of *Phoma macrostoma* that leads to bioherbicidal activity on broadleaved weeds, Biological Control (2011), doi: 10.1016/j.biocontrol.2011.06.019

(by Karen Bailey, Karen.Bailey@agr.gc.ca)

Evaluation of *Chondrostereum purpureum* (Pers.) Pouzar to control re-sprouting of cut stumps of *Rhododendron ponticum* in the UK

Rhododendron ponticum was introduced into the British Isles from the Iberian Penninsula in the 18th century and planted widely in gardens of large houses and estates. During the last 50 years, however, the shrub has become a serious invader of natural habitats (Cronk & Fuller, 1995). Particularly affected are the western parts of the British Isles, e.g. areas of Wales (such as Snowdonia National Park) and Scotland as well as Western Ireland, where mild and wetter climates favour the spread of this invasive shrub. Management of *R. ponticum* is not only important from an invasive plants point of view. It is also of relevance for the control of the introduced invasive plant pathogens *Phytophthora kernoviae* and *P. ramorum*, (the latter of which is known as the causal agent of 'Sudden Oak Death') since the shrub is susceptible to and harbours both of these species, without dying back itself. It thus acts as a continuous source of spore inoculum of these detrimental organisms and aids their spread.

Surveys have been conducted previously in the centre of origin of *R. ponticum* (Sierra do Mochique, Algarve, Portugal) and fungal pathogens associated with the shrub *R. ponticum* have been identified as potential biocontrol agents. However, a classical approach for biological control of *R. ponticum* cannot be considered as a management strategy for the shrub in the UK due to the horticultural importance of the genus *Rhododendron* based on which the associated risks must be considered as too high.

In April 2010, within the remit of an overall disease management programme concerning the two *Phytophthora* species the UK, the government department DEFRA decided to fund a project investigating the efficacy of specified chemical, biological and physical treatments to cut stumps of *R. ponticum.* The aim is to find improved treatments effective against re-sprouting and for killing stump and root material thereby reducing *Phytophthora* spore levels. As part of this project CABI E-UK, in collaboration with Forest Research UK, is currently evaluating the potential of an UK-native strain of the wood-rotting basidiomycete fungus, *Chondrostereum purpureum*, to prevent re-sprouting of *R. ponticum.* Assessments of the fungus as a mycoherbicide against woody invasives have been or are currently being undertaken in a number of countries including Canada, The Netherlands, Finland and New Zealand (Becker *et al*., 2005; Bourdôt *et al*., 2006; deJong, 2000; Vartiamaeki *et al*., 2009) and commercial products have come onto the market. To date no studies in that respect have been conducted with *R. ponticum* as the target weed, although *C. purpureum* is known to be associated with the genus *Rhododendron,* as well as *R. ponticum* in the UK (Farr *et al*, 1996; Strouts & Winter, 2000).

Work in the UK commenced in spring 2010 with an assessment of eight distinct *C. purpureum* strains isolated from different host species in the UK for the planned field trials. Laboratory studies were undertaken to establish the ability of individual strains to produce mycelial growth on cut branches of *R. ponticum* and to compare the growth rate to that recorded on cut branches of their original hosts. Each fungal strain was also evaluated for its enzymatic activity of laccases and manganese peroxidase which have been previously correlated with the ability to inhibit re-sprouting in other target species (Vartiamäki *et al*., 2008). Based on the results a strain of *C. purpureum* ex *Prunus* sp. was chosen as the most promising for the field trials and a methodology for mass production of the selected strain in liquid culture was devised. Since the pathogen was to be trialled not only as a sole agent but also in combination with the herbicide glyphosate, *in vitro* experiments were conducted to assess the impact of glyphosate on the viability and mycelial growth rate of *C. purpureum* and to establish the best application method.

In 2010, field experiments involving treatments with *C. purpureum, C. purpureum* plus glyphosate as well as treatments with different herbicides were established at a site in Cornwall invaded by *Phytophthora* infected *R. ponticum.* Applications were made during mid-summer, the season considered to be the most favourable for infection with *C. purpureum,* and early winter, the time considered to ensure highest efficacy of the trialled herbicides. Preliminary evaluations during follow-up visits to the site in 2011 have not detected any *C. purpureum* fruiting bodies on stumps treated with either the fungus or the fungus/glyphosate combination and limited re-growth was recorded from stumps treated with *C. purpureum* alone. Final assessments of the efficacy of the different treatments applied in reducing re-growth of cut-stumps of *R. ponticum* together with an assessment of the impact on levels of *Phytophthora* spore inoculum at the site will be undertaken during mid-summer and early winter 2012.

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(by Marion Seier, Sonal Varia and Sarah Thomas, CABI E-UK, Egham, UK, m.seier@cabi.org)

Mowing in the rain:
Long-term research leads to simple control technique for Californian thistle

Californian thistle (*Cirsium arvense*) is the most destructive pastoral weed in New Zealand. Introduced by early European colonists, it spread quickly and it is now found throughout the country.

Synthetic herbicides and other control methods are not effective in eliminating this weed, which, according to preliminary results of a national survey of pastoral farmers in 2009, covers on average about 8% of New Zealand's grazed pasture land at its seasonal summer peak.

Since 1991, a team of scientists from the Crown Research Institutes AgResearch and Landcare Research, Bio-Protection Research Centre, industry organisations and community groups have been working collaboratively for find effective control methods. One of the outcomes of this long-term research is the recent discovery of a simple technique that farmers can use to control the thistle: mowing in the rain.

Project leader Dr Graeme Bourdôt says the finding emerged from a national survey of diseases found on Californian thistle, funded by Meat and Wool NZ (now Beef + Lamb NZ). The team collected samples from hundreds of farms throughout New Zealand and found several pathogens of particular interest.

One of these, the vascular wilt fungus *Verticillium dahliae*, a pathogen that causes diseases in many crops, was common on the thistle in this survey. The fungus produces spores inside the thistle that are released by mowing, dispersed by splashing rain and then gain entry into other thistle plants through wounds.

This finding sparked the researchers' interest, because there is anecdotal evidence that mowing pasture in the rain helps to reduce the thistle's abundance. Although no quantitative evidence existed to show that mowing in the rain really worked, the team hypothesised that the spread of the fungus by splashing rain and wet mower blades could be the explanation for this phenomenon.

To investigate this intriguing possibility, Beef + Lamb NZ funded an experiment on twelve farms throughout New Zealand over two years. The experiment showed that mowing in the rain produced a 30% reduction in the ground cover of thistle in the spring compared to mowing in dry conditions.

The team also sampled for the wilt fungus, but found no correlation between its abundance and the mowing effect. It may be that more samples were needed to show the effect, or it is possible that a combination of pathogens contributes to the effect, or even that it is caused by a different pathogen altogether.

For now, the biological basis of the mowing in the rain effect remains unproven. However, the research does show conclusively that mowing in the rain works to reduce Californian thistle abundance. As Dr Bourdôt says, “It is a simple technique that farmers can use right now at little cost.” The idea has been captured in a 4-minute video filmed in the Waikato region of New Zealand.

The team’s next step is to apply the fungus to some plots and not to others, and then mow the paddocks in the rain and in the dry. If the fungus is found to be the causal agent behind the mowing in the rain effect, it could potentially be formulated and marketed as a biological herbicide that farmers would apply when they mow paddocks in the rain to increase the effect.

(By Graeme Bourdôt, graeme.bourdot@agresearch.co.nz)

Video may be viewed at:

http://www.agresearch.co.nz/our-science/biocontrol-biosecurity/weed-control/Pages/californian-thistle.aspx

PUBLICATIONS

A special issue (SI) of Pest Technology, which is due online in July, 2011, will feature specifically on microbial bioherbicides. This SI “Bioherbicides then and now - Innovations in microbial herbicide research” is a compilation of research conducted all over the world that not only highlights exciting progress, but also identifies new research directions and perspectives in bioherbicides. Dr. TeBeest says in his foreword, the initial success of early bioherbicides sets certain expectations that these developments may be readily repeated using similar approaches. But if anything, the last 30 years has taught us that plant-pathogen interactions are more complex, diverse, and sophisticated than we initially suspected. This realization has spawned whole new areas of research, allowed greater insight into the factors that govern a successful bioherbicide development, and these have, in turn, made significant contributions to science. This SI is intended to give the reader an appreciation for the recent past and inspire new approaches leading to successful bioherbicide development.

The issue begins with a look at phytotoxins produced by pathogens and the potential these have as novel modes of actions for bioherbicides. This is followed by a review of the interactions of synthetic- and bio-herbicides that explores synergism for increased efficacy and efficiency in weed control. A detailed study of one such interaction is also presented in a later paper. The view is widened with a topic on intertrophic interactions in which components of an ecosystem may work together to achieve the desired outcome. Regulatory aspects are also considered, showing how measurement of added and natural inoculum density can identify safe isolation distance from susceptible organisms. The possibility of genetic modification of agents or plants to modify the bioherbicide

performance is also discussed. A detailed look at the biology of a biocontrol agent and its associated toxin shows its complexity and diversity of action, and allows for possible application in areas not initially considered.

The issue concludes with new developments in the control of major problem grassy weeds which showed some of the challenges in their scale-up and commercialization, but also identified opportunities for products with a wider host range. Collaborations with industry led to new perspectives that may need to be included in future product development. Improvements in application methods, either with sprays or with mowing implements showed potential for better agent deposition and activity. These, combined with several specific research papers on formulation and application technologies, show that we still require better knowledge of plant target sites and basic biology of potential agents.

(by Gary Peng & Tom Wolf, Saskatoon Research Centre, Agriculture and Agri-Food Canada, Gary.Peng@AGR.GC.CA)

Bioherbicides then and now - Innovations in microbial herbicide research

Gary Peng and Thomas M. Wolf
Guest Editors

Authors, titles and abstracts:

Antonio Evidente, Anna Andolfi, Alessio Cimmino (Italy) Fungal Phytotoxins for Control of *Cirsium arvense* and *Sonchus arvensis*

ABSTRACT
Invited Review: Perennial weeds, including *Cirsium arvense* and *Sonchus arvensis*, are a common problem in crop fields, especially in agricultural systems with reduced herbicide usage. Herbicides recommended for control of these perennials generally are restricted to only a few active ingredients that tend to have low selectivity, especially on dicot crops. Microbial phytotoxins or their synthetic analogues may be candidates for new weed-control options. Many plant pathogens, especially necrotrophic or hemibiotrophic fungi, produce a range of phytotoxins responsible for disease damage and may be a source of such useful metabolites. Several pathogens, including *Stagonospora cirsii* and *Ascochyta sonchi*, were found commonly on *C. arvense* and *S. arvensis*, and these fungi also produce phytotoxic metabolites. *Phyllosticta cirsii* and *Phomopsis cirsii*, belonging to two well-known toxin-producing genera, have also been proposed for biocontrol of *C. arvense*. Phytotoxins isolated from these fungal pathogens are metabolites belonging to several classes of natural compounds including enol pyruvic acid derivatives, cytochalasins, nonenolides, oxazatricycloalkenones, pentasubstituted bicyclooctatrienyl ester of acetic acid, pentasubstituted hexahydrobenzodioxine carboxylic acid methyl ester, and β-nitropropionic acid. Some of these metabolites may be used as biomarkers, for studies on mode of action and development of structure-activity relationships.

Gary Peng, Thomas M. Wolf (Canada) Synergy between Synthetic and Microbial Herbicides for Weed Control

ABSTRACT
Invited-Review: Synthetic herbicides have been investigated as tools to synergize mycoherbicides (fungal bioherbicides) for improved efficacy or management of hard-to-control weed problems. Herbicides may weaken weeds and impair their defence systems, thus making weeds more vulnerable to mycoherbicide infection. Despite many positive

results, the practical value of synergy remains elusive. This review will discuss several fundamental aspects of synergy relating to development of this technology based on author's own experiences in biocontrol of green foxtail and scentless chamomile. These include application timing, dose effect, weed growth stage, and spray retention efficiency. Issues relating to the practicality, non-target risks, and cost of weed control are stumbling blocks to the adoption of synergistic technologies, and some tactics are proposed to address these challenges.

A. J. Caesar (USA) The Importance of Intertrophic Interactions in Biological Weed Control

ABSTRACT
Invited Mini-Review: The earliest research leading to successful weed biocontrol included observations and some analysis that the strict "gate-keeping" by peer reviewers, editors and publishers does not often allow today. Within these pioneering studies was a valid picture of the biology of weed biocontrol that is applicable today. Two major studies pointed to successful weed biocontrol of perennials as an outcome of intertrophic interactions. Later work indicated that there was a consistent association of certain fungal species with insect damage. In recent years, ecological studies have provided evidence of the effect of the soil microbiota in combination with root herbivory on plant community structure and on invasiveness. This accretion of evidence and the authors own findings have led to the conclusion that in selecting agents for biocontrol of exotic perennial invasive plants, the capacity of the agent to synergistically interact with other agents should be included in the criteria. If the hypothesis that insect/pathogen interactions underlie successful biocontrol of herbaceous perennial invasive plant species, then efforts to restore native plants would be affected by the biotic legacy of the interactions. Findings from a post-biocontrol native plant restoration have provided such evidence. The existence of insect/pathogen interactions provides a unique position for plant pathogens as being an important factor prior to, during and after biocontrol.

Graeme W. Bourdôt, David J. Saville (New Zealand), Meindert D. de Jong (The Netherlands) Evaluating the Environmental Safety of Broad-host-range Bioherbicides

ABSTRACT
Invited Mini-Review: Broad-host-range pathogens, indigenous in their areas of intended use as bioherbicides and endemic in populations of the weeds of interest, are more appealing commercially than host-specific pathogens because of their wider market potential. However, these pathogens may spread in space and/or in time following their application, thereby potentially increasing the risk of disease to non-target host plants. The ratio of the density of inoculum added to the non-target host plant's environment by the bioherbicide to that occurring naturally, can be used to assess the 'relative risk' of the bioherbicide and determine its acceptability and/or best management practice. Empirical and modelling methodologies have been used for quantifying the additional and natural background inoculum levels of an indigenous plant pathogen being considered for development as a bioherbicide, enabling the ratio of 'added to natural' inoculum density to be determined. We first review how this ratio has been used to define a minimum isolation distance, or safety zone, between areas of application and locations of non-target host plants, using the example of *Sclerotinia sclerotiorum* applied to *Cirsium arvense* in permanent pasture in New Zealand. Secondly, we consider how the ratio has been applied for the same purpose but at a much larger geographic scale using as examples *Chondrostereum purpureum* deployed for weed control in forests in the Netherlands and on Vancouver Island. Lastly we review how the ratio has been used to determine the duration of a withholding period using, again, the *S. sclerotiorum* - *C. arvense* system.

Determining an acceptable value for the ratio requires knowledge of the relationship between the disease that a bioherbicide pathogen causes in non-target host plant populations, and the pathogen's inoculum density.

Gavin J. Ash (Australia) Biological Control of Weeds with Mycoherbicides in the Age of Genomics

ABSTRACT
Invited Mini-Review: Mycoherbicides offer an innovative approach to the management of weeds in disturbed environments using formulated fungal phytopathogens. The efficacy of these mycoherbicides could be improved in the future through the application of genomics (the study of genes and their interactions) to both the target and the biological control agent. In this review, an update is given on approaches to genetic enhancements of mycoherbicides and how a knowledge of, and recent advances in, genomics could be used to improve this process. Specific examples are given of novel approaches that could be used. Genetic modification of mycoherbicidal agents has been shown to be possible, but caution is warranted in terms of public perception and the acceptance of these approaches in the wider community.

John Lydon, Hyesuk Kong, Charles Murphy (USA), Wenming Zhang (Canada) The Biology and Biological Activity of *Pseudomonas syringae* pv. *tagetis*

ABSTRACT
Invited Review: *Pseudomonas syringae* pv. *tagetis* (Pst) is a disease of plants in the family Asteraceae. A distinctive characteristic of this bacterial pathogen is the symptom of apical chlorosis in infected plants, caused by the phytotoxin tagetitoxin. Strains of Pst have been isolated from several plant species from a number of countries. One strain isolated from *Cirsium arvense* (Canada thistle) has been evaluated as a biological control agent for this invasive weed and other weeds in the family Asteraceae. Genetic analysis of the strains in this pathovar indicate that it is highly clonal. There is another strain of *P. syringae* (CT99) that was also isolated from Canada thistle and causes apical chlorosis that may produce tagetitoxin as well. However, multilocus sequence typing analysis indicates that it is not a Pst strain. The major impact of Pst on infected plants is stunting and the reduction in sexual reproductive structures, symptoms attributed to tagetitoxin. While initially considered for the control of Canada thistle, the utility of this pathogen as a biological control agent may be limited to controlling annual weeds. Alternatively, tagetitoxin may be of value as a natural herbicide because of its impact on chloroplasts.

Jianping Zhang, Shuang Yang, Yongjun Zhou, Liuqing Yu (China) Development of Bioherbicides for Control of Barnyard Grass in China

ABSTRACT
Invited Mini-Review: Research progress on bioherbicides against barnyard grass in rice fields was reviewed with a focus on Chinese perspective. In China, barnyard grass is one of the most problematic weeds in paddy rice fields. Several fungal biocontrol agents have been studied extensively and the most promising candidates explored for commercial development, including strain selection and improvement, inoculum mass production, formulation, efficacy trials under various conditions, synergy with chemical herbicides, and safety to crops. Overall, mass production and formulation technologies have proved to be the major stumbling blocks that hinder bioherbicide development. Strategies are discussed to overcome the challenges and facilitate the development of selected fungal agents into commercial bioherbicide products.

Yunzhi Zhu, Sheng Qiang (China) *Curvularia eragrostidis*, a Promising Mycoherbicide Agent for Grass Weeds

ABSTRACT
Invited Mini-Review: A fungal pathogen isolated from diseased leaves of large crabgrass (*Digitaria sanguinalis*) at three different geographic locations in China was identified as *Curvularia eragrostidis*. A series of biological assessments have been carried out to determine the potential of the fungus as a bioherbicide agent. The fungus is able to germinate and grow in a very wide range of temperature (10-40ºC) or pH (2-11) conditions, although 28℃ and pH 6 were optimal. This implies a great versatility for infection of weeds under field conditions. Several phytotoxins have been identified from *C. eragrostidis* cultures. At least two of them, α,β-dehydrocurvularin and helminthosporin, are associated with the pathogenicity on crabgrass. The α,β-dehydrocurvularin impairs the PS-II reaction center and inhibits re-oxidation of the primary electron acceptor (*QA*) of photosynthesis. With slightly different modes of action, the helminthosporin affects the chloroplast function of large crabgrass leaves. Forty-one plant species belonging to 20 families were inoculated with *C. eragrostidis* to assess a potential host range. Many of these were important crop species commonly grown in China, including rice, corn, soybean, cotton, and peanut. The fungus caused no disease or any other negative impact on the crop species tested, while resulted in infection on several additional grass weeds including Chinese crabgrass and Chinese sprangletop. This reveals a potential broader spectrum of weed control. Formulation is urgently needed to make this bioherbicide agent perform consistently under field conditions.

Thomas M. Wolf and Gary Peng (Canada) Improving Spray Deposition on Vertical Structures: The Role of Nozzle Angle, Boom Height, Travel Speed, and Spray Quality

ABSTRACT
Original Research Paper: In order to be effective, bioherbicides need to be deposited on the most susceptible weed plant tissues. For bioherbicides that attack above-ground vegetation, vertically oriented vegetative structures such erect leaves, stems or petioles typically receive much lower dosages compared to horizontally-oriented targets. Experiments were conducted to study the effects of travel speed, nozzle configuration, boom height and spray quality on spray deposition on simulated vertically-oriented surfaces. Results showed that a combination of forward-angled nozzles, coarser sprays, lower boom height, and faster travel speed increased spray retention on these vertical targets by more than 100%. These results indicate that optimization of application parameters potentially contribute to better performance of those bioherbicides whose efficacy depends on sufficient spray deposition and infection on vertical surfaces of the target.

Karen L. Bailey (Canada), Stuart Falk (USA) Turning Research on Microbial Bioherbicides into Commercial Products — A *Phoma* Story

ABSTRACT
Original Research Paper: The literature cites many claims of potential new bioherbicides based on isolate screening and biological assessment. However, only 8.1% have achieved verifiable commercial success, 19.4% uncertain (i.e. registered but not commercialized), and 72.5% have been ineffective. To get more bioherbicides to the marketplace there must be a better partnership between business and science in order to strengthen the research supporting commercialization. This paper describes how a

bioherbicide innovation chain (research model) has been merged with the stage and gate process (business model) to develop *Phoma macrostoma* for broadleaved weed control. Prior to industry involvement, research concentrated on discovery and proof-of-concept by characterizing the fungus, evaluating fermentation requirements, demonstrating efficacy and environmental safety, learning the mode of action, and studying the economics and market potential. The inclusion of industry to assist with technology assessment and product development brought new perspectives and defined key decision points that would either let the project proceed or stop it completely. Key issues were: economically feasible fermentation process; consistent and high efficacy; long shelf life stability; safety to mammals and the environment. Presently, *P. macrostoma* is in the latter stages of pre-commercialization completing the pilot scale manufacturing process and waiting for the regulatory decisions in anticipation of a product launch.

Russell K. Hynes, Susan M. Boyetchko (Canada) Improvements to the Pesta Formulation to Promote Survival and Dispersal of *Pseudomonas fluorescens* BRG100, Green Foxtail Bioherbicide

ABSTRACT
Original Research Paper: A modified pesta granule was developed for *Pseudomonas fluorescens* BRG100, a bioherbicidal bacterium for grass weeds, green foxtail (*Setaria viridis*) and wild oat (*Avena fatua*). This study reports: i) the effect of formulation water activity (a_w) on survival of *P. fluorescens* BRG100 and, ii) the effect of starch on disintegration and dispersal of a green fluorescent protein transformant of *P. fluorescens* BRG100 from pesta in laboratory sand columns. The long-term refrigerated storage stability of *P. fluorescens* BRG100 was examined in pesta granules dried to different a_w. Drying pesta to 0.3 a_w stabilized the population of *P. fluorescens* BRG100 for 16 months at 8.5 $\log_{10}$ cfu/g. When pesta was dried to 0.8 a_w, *P. fluorescens* BRG100 population decreased to 7.3 $\log_{10}$ cfu/g over six months. The impact of starch addition (corn, pea, rice and potato) to pesta and concentration (13% and 26%, wt/wt) on the disintegration rate of pesta granules was determined with laser diffractometry. The order of fast to slow disintegration following starch amendment was pea>potato>corn> rice. Increasing pea, potato and corn starch content from 13 to 26% promoted faster disintegration of pesta, conversely, increasing rice starch content decreased disintegration. Half-life disintegration profiles were determined with pea starch amended pesta (26% w/w) being most rapid, 0.8 minute, rice starch (26% w/w) amended pesta was slowest, 4 minutes and non-amended pesta, 2.5 minutes. *P. fluorescens* BRG100*gfp* was detected 2 hr earlier in the middle and bottom sections of the sand columns from corn starch amended (26%) pesta than from non-amended pesta. The ability to produce pesta granules with different disintegration and bioherbicide release characteristics provides the formulator with the potential to design pesta that insures the active ingredient is delivered to the pest when it is most susceptible.

Robert E. Hoagland, Clyde D. Boyette, Kevin C. Vaughn (USA) Interactions of Quinclorac with a Bioherbicidal Strain of *Myrothecium verrucaria*

ABSTRACT
Original Research Paper: The fungus, *Myrothecium verrucaria* (Alb. & Schwein.) (IMI Accession No. 3601690) (MV), is being developed as a bioherbicide for kudzu [*Pueraria lobata* (Willd.) Ohwi] and other invasive weeds. Spore and mycelial formulations of MV exhibit relatively rapid bioherbicidal activity when applied to the foliage of these weeds, and that application of MV with the herbicide glyphosate [*N*-(phosphonomethyl)glycine] can exhibit synergistic herbicidal interactions in certain instances. Several synthetic auxin-type herbicides are labeled for use to control kudzu. The auxin-type herbicide quinclorac

(3,7-dichloro-8-quinolinecarboxylic acid) is not labeled for kudzu control, but is effective on hemp sesbania [*Sesbania exaltata* (Raf.) Rybd. Ex. Hill]. In bioassays of hemp sesbania and sicklepod (*Senna obtusifolia* L.) seedlings and in greenhouse tests using kudzu plants, sub-lethal concentrations of both MV and quinclorac (high purity, technical grade) applied to plant tissues caused some additive and/or synergistic effects on the reduction of growth and chlorophyll accumulation. These important findings under controlled conditions provide the basis for further characterization of MV and quinclorac interactions on weeds under field conditions.

Clyde D. Boyette, Charles T. Bryson, Robert E. Hoagland (USA) Biological Control of *Cucurbita pepo* var. *texana* (Texas Gourd) in Cotton (*Gossypium hirsutum*) with the Fungus *Fusarium solani* f. sp. *cucurbitae*

ABSTRACT
Original Research Paper: Experiments were conducted to evaluate various formulations and application methods of the fungus *Fusarium solani* f. sp. *cucurbitae* (FSC) for controlling Texas gourd (*Cucurbita pepo* var. *texana*) in cotton. In greenhouse tests, Texas gourd was controlled 93% and 96%, respectively, with pre-emergence applications of FSC-infested cornmeal/sand medium (CMS) and FSC-wheat flour/kaolin ('Pesta') granules. Post-emergence applications of CMS or 'Pesta' granular formulations were less effective overall. However, >90% control of Texas gourd was achieved with post-emergence applications of FSC spores formulated in an emulsion consisting of 25% unrefined corn oil and 0.2% Silwet L-77 surfactant. Dew was not required to achieve optimal levels of weed control with either the pre-emergence granular formulations or with post-emergence corn oil/surfactant applications. In field tests, pre-emergence applications of FSC-infested CMS and FSC-'Pesta' granules controlled 90-94% of the weeds. Post-emergence applications of FSC formulated in corn oil/surfactant were equally efficacious in controlling Texas gourd in cotton. No damage to cotton was observed.

James T. DeValerio, R. Charudattan, J. Jeffrey Mullahey, Pamela D. Roberts (USA) Application of a Bacterial Pathogen, *Ralstonia solanacearum*, with a Wet-blade Mower for Biological Control of Tropical Soda Apple, *Solanum viarum*

ABSTRACT
Research Note: Tropical soda apple (*Solanum viarum* Dunal; TSA) is an invasive noxious weed in Florida and several southeastern U.S. states. To develop a bioherbicide agent that could be integrated with mowing, a recommended management practice for TSA, we screened several isolates of bacterial pathogens of Solanaceous plants and established that a *Ralstonia solanacearum* (=*Pseudomonas solanacearum*) (RS) isolate (10 Q, Race 1), originally from tomato, was capable of killing TSA without affecting tomato. RS is a xylem-invading, wilt-causing pathogen that when applied to cut main stems of TSA prevented regrowth and killed TSA plants under greenhouse conditions. To determine the effectiveness of this model bacterial bioherbicide agent under field conditions, a novel application method using a wet-blade mower was tested. Whereas wet-blade systems are used to deliver chemical herbicides and plant growth regulators to target weeds while mowing, none has been tested to deliver a biocontrol agent. We used the Burch Wet Blade™ mower system (BWB) and conducted the study in a pasture with 18% TSA coverage. RS cells suspended in sterile tap water at 1.4 x 10^9 CFU units/ml were used as inoculum. Treatments included a BWB-applied control (culture medium without RS), RS applied at 23 L/ha with BWB, and RS applied at 23 L/ha with BWB plus RS over-sprayed at 560 L/ha with a backpack sprayer. Both RS treatments reduced TSA regrowth compared to the control (P = 0.0003). There was no difference between the wet-blade-

applied RS treatment and the wet-blade + over-sprayed RS treatment. The wet-blade mower was an effective, practical means of application of the bacterial wilt pathogen to control TSA and it may have broader applicability to other types of wilt-causing pathogens.

EDITOR'S CORNER

Dear All,

Thanks for the contribution received for the preparation of this issue of the bulletin.

In particular, please let me thank (in alphabetical order):

- Karen Bailey
- Graeme Bourdôt
- Sreerama Kumar
- Gary Peng
- Marion Seier

Although this time I didn't receive too many contributions, I decided to prepare and distribute a new issue of our bulletin, always hoping that the future issues will contain many more contributions and information.

Please remember that this bulletin is prepared on a voluntary basis and it contains only the information sent by the newsletter subscribers, under their responsibility. The newsletter is not an official journal and cannot be considered exhaustive. Please also remember that the mailing list can be used as a moderated list for distributing information related to weed biocontrol at any time during the year.

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Thanks

Regards

Maurizio