Observations on the Susceptibility of *Chrysanthemoides monilifera* to Infection by *Sclerotinia sclerotiorum* and Implications for Control of this Weed

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Bitou bush (*Chrysanthemoides monilifera* subsp. *rotundata*), an invasive exotic weed from South Africa, was extensively planted for sand dune stabilisation from 1950's to the mid 1970's. It has established itself along much of the New South Wales coast and has been declared a noxious weed in many areas.

Natural infections of bitou bush by the fungus *Sclerotinia sclerotiorum* occur at several locations along the NSW coast. Disease in individual plants can be quite extensive but, at any one location, disease is limited in its occurrence and does not reach the levels observed in susceptible agricultural crops. Infection of neighbouring native flora has never been observed.

Inoculation of bitou bush in the glasshouse with mycelial suspensions of the pathogen or infected grain fragments produces rapid disease progression and death of plants. In the field, S*clerotinia* naturally produces ascospores from carpogenic germination of sclerotia and these are dispersed by wind and rain splash. Ascospores are assumed to be the source of infections observed in the field because diseased stems are remote from any sclerotia on the soil surface.

Preliminary attempts to infect detached leaves of bitou bush with droplets of ascospore suspensions, or by placing leaves directly above mature ascocarps at 15, 20 or 25°C, have failed to produce extensive lesions although ascospores are viable. Infection, where it occurs, is limited to necrotic flecking at the point of inoculation. Spray inoculation of plants with ascospores followed by 48 h of 100 % humidity have not produced visible lesions. As *Sclerotinia* ascospores require external nutrients for infection, it is possible that ascospores may need to colonise a food base such as flower petals or senescing leaf tissue to achieve the inoculum potential necessary for host penetration. Infection and lesion development have been achieved in flowers with ascospore suspensions.

If flowers are the only plant tissue susceptible to ascospore infection, this may explain the observed fragmented nature of disease incidence. Sclerotial numbers are very low compared to those produced in susceptible agricultural species. To achieve infection, ascospores must be produced when plants are flowering. Thus the temperature and rainfall constraints on production and discharge of ascospore, and the initial low numbers of sclerotia below bushes interact to keep disease incidence to a comparatively low level.

Colonised grain may be a more suitable inoculum for increasing disease incidence in bitoubush communities than producing and distributing sclerotia of the pathogen.

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The Importance of Insect 'Reserves' in the Biological Control of *Hakea sericea* in South Africa

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A mechanical control programme aimed at clearing rivers and water catchments of alien invasive plants countrywide in South Africa was launched in 1995. This programme has targeted a number of alien invasive plant species, including silky hakea (*Hakea sericea* Schrader), that are presently subjected to biological control. Two seed-attacking agents were introduced in 1970 to slow the spread of *H. sericea* and to reduce its aggressiveness. Both of these insects are now widely established and are contributing to the control of *H. sericea* but their effectiveness is restricted by their limited ability to disperse rapidly. Although mechanical methods are extremely effective for control of *H. sericea*, they can be detrimental for biocontrol and can cause local extinction of agents when *H. sericea* populations are removed entirely. Seed-feeding species are particularly at risk because seedlings that recolonize cleared areas do not produce fruits for several years and the insects are unable to recolonize the infestations of *H. sericea* during this period. One solution is to deliberately leave pockets of plants during mechanical clearing to act as 'reserves' (refugia) for the insects. These 'reserves' could serve as foci from which the insects will recolonize newly established *H. sericea* infestations on the cleared areas. Alternatively, other insect species, including non seed-feeders that disperse rapidly and have good host seeking abilities, will need to be introduced for biological control of *H. sericea*.

The Noxious and Nuisance Plant Management Information System (PMIS) and the Aquatic Plant Information System (APIS)

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PMIS (version 4.0) and APIS (version 1.0) were developed by researchers at the U.S. Army Engineers Waterways Experiment Station and provide identification information and management techniques for many plant species considered noxious and nuisance in the U.S. PMIS contains information on over 60 plant species from the terrestrial, aquatic, and wetland habitats, while APIS concentrates mainly on species from the aquatic and wetland habitats. Information contained in these systems includes plant biology, ecology, and identification strategies as well as information on the application and use of the foremost management techniques (i.e., chemical, biological, and mechanical). Both systems

use a variety of media types to allow for efficient access to the included information. These include hyper-linked text, photographs, maps, illustrations, and expert system programming. The CD-ROM is a Windows™ based product and performs under Windows™ 3.1 and Windows™ 95 only. Another feature of PMIS is that an additional information system has been incorporated into the information manager and can be run directly from PMIS. This system, entitled the 'State Noxious Plant and Pesticide Laws Information System (SNPPLIS)' allows access to noxious weed and pesticide laws as well as noxious weed lists for 25 states.

Copies of both CD's can be obtained free-of-charge on a first come, first serve basis by requesting them (in writing, e-mail, or fax) from: Michael J. Grodowitz U.S. Army Engineers Waterways Experiment Station CEWES-ER-A 3909 Halls Ferry Road Vicksburg, MS 39180, fax: (601) 634-2398 e-mail: grodowm@mail.wes.army.mil

Development of a Bioherbicide for Wild Oats in Australia

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In Australia *Avena fatua* is a principal weed in a range of cereal crops including wheat, barley and oats. The fungus *Drechslera avenacea* causes leaf lesions and damping-off of seedlings and its use as a bioherbicide is under investigation. Experiments were conducted to determine the feasability and merit of foliar application of low rates of herbicides and a conidial suspension to control the weed. A range of herbicides were applied to wild oats and wheat at rates lower than those recommended for the control of wild oats. The selective post-emergent herbicide Achieve™ (Tralkoxydim; Cropcare Australasia Pty ltd) reduced weed growth at 10% of the recommended rate and was included in susbsequent experiments. In a second series of experiments, V8 agar plates were amended with herbicides at 0, 10 and 20% of the manufacturer's recommended rate for control of wild oats. Plugs of *D. avenacea* were placed in the centre of these plates and the radial growth of colonies was measured for 9 days. All herbicides slowed fungal growth. However, colonies growing on Achieve™-amended media were able to grow steadily and produced viable and infectious spores. Finally, the effect of a combination of the herbicide Achieve™ and *D. avenacea* was tested for its effect on *A. fatua* and wheat. The above-ground dry weight of wild oats was reduced by 85% compared to an uninoculated control, ten days after a conidial suspension (1.5 x 10^5) and Achieve™ at 10% of recommended application rate were applied. Wheat was unaffected. The effects of a number of inoculum amendments, including amino acids and iron chelators, were also examined.

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IWM - The Key to Sustainable Management of Pasture Weeds

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Broadleaf weeds in pasture, such as *Carduus nutans* L., *Onopordum* spp. (Asteraceae) and *Echium plantagineum* L. (Boraginaceae) are a major problem for graziers in southern Australia. Many previous attempts to combat these weeds with a single technique, such as herbicide application have only been successful over the short term. Longer term control requires that a number of these techniques be combined. Such an approach is being evaluated in an Integrated Weed Management (IWM) program, currently under way in high rainfall grazing areas in south-eastern Australia. It combines biological control with different grazing and herbicide techniques. The management tools under investigation are biological control, various combinations of light and heavy sheep grazings and deferments, competitive species, spray grazing (sub-lethal herbicide rate and heavy grazing), and a one-off herbicide application. The IWM of *C. nutans* is pioneering work in that it is one of the few IWM projects in the world that has a major emphasis on the biological control agents. During the field trials, we are monitoring the impact of grazing and herbicide treatments on the weed and biocontrol agents, as well as on pasture composition. The density, growth and reproductive parameters of the weeds, and the impact and abundance of the different development stages of the biocontrol agents are being recorded. The three main pasture components under the different treatments are also being monitored using BOTANAL. The aim of the study is to enable the development of a management package that will result in sustainable management of these weeds, and can readily be adopted by landholders.

Extension Service and Biological Control of Weeds - A Successful Match

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Cooperative Extension Service specialists and county-based agricultural extension agents can play an important role in conducting biological control programs and educating the public about these programs. Extension specialists and agents can provide valuable contacts with landowners and stakeholders to encourage local support and understanding of the biological control programs. In Texas, Extension entomologists and county extension agents of the Texas Agricultural Extension Service have assisted in the release, evaluation and redistribution of biological control agents for musk thistle (*Carduus nutans*), alligator weed (*Alternanthera philoxeroides*) and most recently saltcedar (*Tamarix ramosissima*). These programs have been in partnership with USDA-ARS, -APHIS, -NRCS, Texas Parks and Wildlife, Texas Department of Agriculture, and the Texas Nature Conservancy. The professional expertise of 14 District Extension entomologists and 29 county based IPM agents located throughout Texas multiply the limited resources often available to these and other biological control programs.

Biological Control of Weeds in European Crops: Recent Achievements and Future Work

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The potential of biological weed control as an integral part of a well designed weed management strategy has been studied in the framework of a concerted European Research Programme (COST-816), with the aim of reducing pesticide input and increasing biodiversity in agro-ecosystems. During a five year period (1994-1999) some 25 institutions from 14 countries have concentrated their efforts on five target weed complexes. Major emphasis has been given to the use of indigenous fungal pathogens. Some major scientific achievements are: (i) the combination of the fungal pathogen *Ascochyta caulina* with a phytotoxin isolated from the fungus, and with sulfonylurea herbicides to con-

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trol *Chenopodium album* in maize and sugar beet; (ii) the elaboration and preliminary field application of a system management approach using the weed-pathogen system *Senecio vulgaris-Puccinia lagenophorae* as a model; (iii) successful combination of underseeded green cover with the application of spores of *Stagonospora convolvuli* to control bindweed species in maize fields; (iv) the development of formulation and delivery techniques for *Alternaria* sp. and *Trematophoma lignicola*, and a preliminary field survey of native insect species to control *Amaranthus* spp. in the target crops; and (v) isolation of highly pathogenic strains of different *Fusarium* spp. that attack all the economically important *Orobanche* spp. We think that two major routes may be followed in future work: (i) a technological approach with a focus on a single disease cycle of the control agent to be developed as a product that can be marketed (traditional approach); and (ii) an ecologically based approach based on a better understanding of the weed-natural antagonist-environment interaction to be managed in order to maximise spread and impact of an indigenous antagonist on the weed (to be developed).

Integration of the Flea Beetle, *Aphthona nigriscutis*, and Herbicides for Control of Leafy Spurge, *Euphorbia esula*

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Aphthona nigriscutis has reduced the density of leafy spurge at many locations; however, there are locations where *A. nigriscutis* has not established or is found at densities too low to be effective. Therefore, it may be necessary to integrate biological and chemical control to reduce leafy spurge densities to non-economic levels. The objective of this experiment was to evaluate the integration of picloram plus 2,4-D and *A. nigriscutis* for leafy spurge control. *A. nigriscutis* were released into cages in June and oversprayed with picloram plus 2,4-D at 0.56 plus 1.1 kg/ha on four dates, August 15, September 1 or 15, or October 1. Previous data indicated that picloram plus 2,4-D applied in the spring was not compatible with *A. nigriscutis*. *A. nigriscutis* were sampled from soil cores and in the field to determine the effect of herbicides on the population. Regardless of herbicide application date, the number of *A. nigriscutis* collected from soil cores or in the field were similar compared to the untreated control. Leafy spurge root nutrient content was not affected by picloram plus 2,4-D applied in the fall. Soluble, insoluble carbohydrate and soluble protein concentrations were similar among herbicide application dates compared to the untreated control. The combined treatment of *A. nigriscutis* plus herbicides tended to have better leafy spurge control compared to *A. nigriscutis* or herbicides used alone. The reason for increased leafy spurge control in the combined treatment was not clearly understood. Radioisotope studies indicated there was no increase in herbicide absorption or translocation in plants with or without *A. nigriscutis* larvae. The increase in leafy spurge control was likely a result of preferential feeding by *A. nigriscutis* larvae on root buds combined with the number of root buds killed from the herbicides.

Biological Control of Weeds as an Alternative to Methyl Bromide

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The impending loss of methyl bromide for soil fumigation presents a significant challenge to vegetable producers, particularly in Florida and California. Weed control without this tool will require an integrated approach in which biological control can play a central role. Studies were conducted during the 1998-1999 vegetable production seasons to determine which weed species will increase in importance without methyl bromide for their control. Phytopathogenic fungi were sought as biological control agents for these weeds. *Phomopsis amaranthicola* has been under evaluation for control of pigweeds and amaranths (*Amaranthus* spp.). Environmental conditions necessary for optimal performance of this fungus were previously determined and field efficacy has been confirmed. Current studies focus on compatibility of this fungus with fungicides and insecticides that are used in vegetable production. Similar studies are underway with the fungus *Dactylaria higginsii* for control of nutsedges (*Cyperus* spp.) Systems for inoculum production of these fungi are underway, as well as for *Dichotomophthora portulacae*, a pathogen under development for control of *Portulacca* spp. These fungi will be incorporated into an integrated pest management program for tomatoes and peppers grown in Florida.

The Impact of Parthenium Weed in India and the Development of an Integrated Management Strategy Based on Australian Experiences

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Parthenium hysterophorus L. (Asteraceae) or Parthenium weed is a major weed of agricultural and urban situations throughout India, whereas in Australia it is currently a weed principally of agriculture. The weed was first noted in India near Poona in

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Maharashtra State in 1951 and it is now present throughout the Indian subcontinent. It is probably the dominant weed in Karnataka State where it infests about 5 million ha. The weed is an aggressive coloniser of fallows, wastelands, pastures and roadsides in India. It competes strongly with crops such as sunflowers, and in infested sorghum, *P. hysterophorus* suppresses yield and contaminates grain samples. As well as being toxic to livestock, *P. hysterophorus* taints both the meat and milk, making them unsafe for human consumption. However, it is in human welfare that parthenium weed has had the most dramatic impact in India. Regular contact with the plant induces an acute form of contact dermatitis, photo-phytodermatitis, asthma and even death. In 1995, a collaborative project was started between IIBC (now intergrated into CABI Bioscience) and four Indian research centres (Tamil Nadu Agricultural University; Kurukshetra University; Indian Council for Agricultural Research (PDBC-Bangalore & ICRWS-Jabalpur)). The project has involved several components: a socio-economic survey, undertaken to establish the impact of the weed in the Indian state of Tamil Nadu; evaluation of the exotic neotropical rust *Puccinia melampodii*, as a classical biocontrol agent; screening of native, adapted Indian pathogens for their mycoherbicide potential; and evaluation of suppressive plants. The results of these studies are presented and the possibilities of an integrated control strategy for Parthenium weed in India are discussed in comparison with the Australian biocontrol programme.