

However, control was reduced to only 30% by September 1995 once the larvae stopped feeding and pupated to adults in early summer. The greatest leafy spurge stem-density reduction was 99% by the insect plus fall-applied herbicide treatment, which occurred after the first application in 1992. The spring-applied herbicide plus insect treatment reduced leafy spurge populations less than the insects alone. The *A. nigriscutis* population in the non-herbicide treatments increased from seven beetles/m² in 1992 to 130 beetles/m² in 1994. The *A. nigriscutis* population declined to less than one beetle/m² when herbicides were spring-applied, but increased to 30 beetles/m² when herbicides were fall-applied. Beetle populations declined in 1995 compared to 1994 regardless of treatment as leafy spurge stem-density decreased. Fall-applied herbicide treatments combined with *A. nigriscutis* provided better long-term leafy spurge control than either control method used alone.

An emerging research protocol for biological weed control in crops: the case of common groundsel, *Senecio vulgaris*

HEINZ MÜLLER-SCHÄRER and JOS FRANTZEN

Institute of Plant Biology, University of Fribourg, 3 rue Albert-Gockel, CH-1700 Fribourg, Switzerland

A 'system management' approach to biological weed control in crops is being proposed and compared with other methods of biological weed control. This approach is based on the management of a weed pathosystem in order to maximize the natural spread and disease severity of a native or naturalized pathogen. In situations where it is necessary to control single weed species in crops, this approach may well be appropriate, provided: (i) that no immediate and complete control is required; (ii) that the production of large amounts of the agent is limiting (e.g. when using biotrophic fungi); or (iii) where the importation of an exotic agent is not possible. This strategy provides fundamental knowledge on the underlying mechanisms of crop production systems and fits well into the view of modern agro-ecology, in which complete eradication of weeds is not desirable. The fundamental research required for a successful application of the 'system management' approach was illustrated with the biological control project of *Senecio vulgaris* using the naturalized rust fungus *Puccinia lagenophorae*. A five-step procedure, together with selected results was presented. Emphasis is given to the infection window, the study of the genetic structure of the plant and pathogen population, and the management of the infection conditions: a) to maximize the spread of the disease and the impact on the plants; and b) to minimize the development of resistant plant populations. Joint application of herbicides at low doses, additional necrotropic pathogens, and the application of biochemicals interfering with the weed's defence are envisaged, as well as their integration into general pest control practices. In this regard, biological weed control agents have to be seen as stress factors, not as weed killers, and biological weed control as an integral part of a well designed pest-management strategy, not as a cure by itself.

Eutrophication and the biological control of water hyacinth

SHAUN L. WINTERTON and TIM A. HEARD

*Cooperative Research Centre for Tropical Pest Management, CSIRO Division of Entomology, PMB No.3,
Indooroopilly, Qld 4068, Australia*

Water hyacinth (*Eichhornia crassipes*) is a major weed of waterways in many parts of the world, creating management problems by affecting water quality, obstructing navigation and displacing native species. Two of the main biological control agents employed against this weed are *Neochetina eichhornae* and *N. bruchi* (Coleoptera: Curculionidae). In eutrophic waters where nutrient levels are increased, water hyacinth plants are typically of high quality with rapid growth-rates. Previous studies and field observations have revealed that although weevil

populations often increase in response to better plant quality, their overall impact on the plant population may be negated by profuse plant growth. The net result in many of these situations is that adequate biological control is not achieved. We are investigating the interactions between aquatic nutrient-loads, plant-tissue nutrient-storage and insect- and plant-population dynamics. Experiments carried out in large 'hydroponic' systems measure water and plant nutrient concentrations, plant growth and insect damage at nutrient levels representative of eutrophic and oligotrophic waters. Results indicate that *N. eichhorniae* has little impact on water hyacinth at high levels of N and P, while *N. bruchi* displays a reasonable level of control. At low nutrient levels both weevil species cause high levels of damage to the weed population. Further experimentation and field validation are required to confirm these results. This project should provide important information on integrating biological control with other water hyacinth control methods into an overall water-catchment management-strategy for eutrophic waters.

Combined non- or low-virulent pathogens and special formulated carriers as broad-spectrum bioherbicides

SHAW-MING YANG and NORMAN W. SCHAAD

USDA-ARS Foreign Disease-Weed Science Research Unit, Fort Detrick, Frederick, MD 21702, USA

The use of broad-spectrum bioherbicides to control weeds is proposed here. The advantages of using broad-spectrum bioherbicides include: (i) appeal to industry regarding product market-size; (ii) limited environmental pollution; (iii) safety; and (iv) ease of application by homeowners and farmers. One disadvantage is that non-specific organisms may be difficult to register for commercial use. However, such difficulty may be moot for saprophytic or low-virulent organisms that require special carriers for infection. With the use of specific carriers, organisms can be applied to target weeds with very little or no possibility of infecting nearby plants; only plants which come into contact with the organism will be damaged. Drift from oil-based sprays is extremely limited, and the small amount of spray that reaches desirable plants would cause insignificant damage. The technique is especially suited for orchards and vineyards. Results of greenhouse studies are described for the effects of saprophytic or low-virulent pathogens applied in special carriers to a broad-range of plants.