BIOCONTROL OF WEEDS
NEW APPROACHES IN THE CRC FOR TROPICAL PEST MANAGEMENT

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Summary Biological control of weeds is an important part of the activity of the Cooperative Research Centre for Tropical Pest Management (CTPM). Education in weed biocontrol has greatly increased; an important new short course on Biocontrol of Tropical Weeds is being run by the CTPM each year, and the Centre contributes to new courses in the Department of Entomology at the University of Queensland. New research areas include the use of molecular techniques to determine genetic identity and diversity in parthenium, lantana, fireweed and siam weed, and evaluation of the effects of biocontrol agents on lantana, parthenium and water hyacinth.

CTPM researchers are investigating host selection processes in insects, and how host testing methods can be improved for better prediction of field results.

INTRODUCTION

Although the CRC for Tropical Pest Management (CTPM) has been seen as mainly involved in the management of insect pests rather than weeds, in fact biocontrol of weeds was an important part of the Centre from its inception in 1991, through the contributions of the CSIRO Biocontrol Unit at Longpocket and the Queensland Department of Natural Resources (previously Lands) Alan Fletcher Research Station (AFRS). This significant input from biocontrol of weeds has continued, and we hope to expand it in CTPM-2, the proposal for which is now under consideration.

Since 1991, CTPM staff have been involved in biocontrol of parthenium (*Parthenium hysterophorus* L.) (Adkins *et al.* 1996), water hyacinth (*Eichhornia crassipes* (Mart.)), lantana (*Lantana camara* L.), and sida (*Sida acuta* Burman and *S. rhombifolia* L.). Work on parthenium will continue into CTPM-2, with prickly acacia (*Acacia nilotica indica* (Bentham)) and perhaps madeira vine (*Anredera cordifolia* (Ten.)) added. However, as my topic is 'New Approaches', I will not discuss these projects further, but will look at the new initiatives resulting from efforts within the CTPM.

EDUCATION

Universities Prior to 1991, education in weed biocontrol was limited to occasional lectures given by AFRS and CSIRO staff to students in the Entomology and Agriculture Departments of the University of Queensland and, for a few years, Griffith University. Beginning in 1994, a third-year course on Biological Control has been developed within the Department of Entomology, and includes a major component on the biocontrol of weeds. Lectures on Biocontrol by CTPM staff are included in the course on Weed Science in the Agriculture Department. Four PhD students in Entomology and Agriculture, one on a CTPM scholarship and the rest on university grants, are currently involved in weed biocontrol projects, evaluating aspects of effectiveness or host selection.

The most important initiative in education, however, is the 2-week intensive course on Biocontrol of Tropical Weeds, run by the CTPM each year since 1993. There was an obvious need for such a course and the possibility had been discussed, but the practical difficulties of running a course involving CSIRO, the State Government and the University had prevented it from getting off the ground. Once the CTPM brought the participants together, the difficulties could be overcome, and the course was the first of the CTPM's short courses to be operational.

The course is designed for entomologists or weed scientists in countries where biocontrol of weeds is a comparatively new venture, and who need training in both practical and theoretical aspects of the subject. Participants are taught by staff of the AFRS and CSIRO biocontrol units, with input from other CTPM staff and from outside lecturers as required. In particular, Dr. B. Auld from the NSW Department of Agriculture in Orange teaches a section on mycoherbicides. Participants receive hands-on training, using the quarantine insectaries and seeing biocontrol in action, both successful and unsuccessful, in the field trips. This has been the secret of the success of the course; in Brisbane, we have two different groups actively involved in weed biocontrol, both operating insect quarantines with new agents being imported and host-tested every year. In addition, with the USDA Melaleuca unit now based in Brisbane, participants can see the exploratory stage of a biocontrol program as well. In the two half-day and one full-day field trips, participants see the results of biocontrol programs against water weeds (pistia, water hyacinth and salvinia), lantana, Noogoora burr, cacti, groundsel bush, annual ragweed and sida.

Nowhere else in the world offers such a concentration of active biocontrol in the one locality. World-wide, there is no other intensive training course on weed biocontrol, and our course is recognised as uniquely valuable. In the four courses run so far, we have had 53 participants from 20 countries, financed by seven international donor organizations, with the Australian Centre for International Agricultural Research (ACIAR) our largest sponsor. There is a long list of applicants for future courses, and the continued support from donor agencies is evidence of the value of the course (McFadyen 1996).

Community education Successful biocontrol depends upon the continued introduction of new agents, insects or pathogens, into Australia, and there is growing community disquiet regarding this. We feel this distrust is unjustified, but we ignore it at our cost. Even though the present system for granting import and release permits has no community involvement other than through Government departments, this may not continue and we must be prepared to function under public scrutiny. Furthermore, many in the scientific community itself, particularly the conservation community, are increasingly reluctant to support the release of new biocontrol agents in Australia. There are many reasons for this; primarily a desire to avoid all possible risks, apparently without understanding that uncontrolled exotic plants can destroy whole ecosystems, or that the damage caused by introductions of general predators, such as snails into Pacific islands or cane toads into Australia, has no relevance to the use of highly host-specific plant-feeding agents for weed biocontrol (cf. Cronk and Fuller 1995).

The CTPM biocontrol program has therefore taken initiatives to improve community awareness and understanding of the process of weed biocontrol. The first is Sonya Broughton's Beetle Watch project for primary schools. This project was financed by the CTPM and Landcare, and involved primary schools throughout eastern Queensland. The schools were supplied with an informative booklet for each pupil plus a teacher's kit, and instructions in collecting and identifying lantana beetles from lantana in their area. The beetles were then sent back to the CTPM for identification, and the schools informed of results through a follow-up survey. The primary aim of the project was to obtain information on current beetle distribution, but the secondary aim was to inform students about biocontrol, how it operated, and why it did not always succeed. The Beetle Watch project was judged successful but we now need to find ways to continue this initiative.

The second initiative was the production of a leaflet on biocontrol of weeds for the general public. This leaflet is designed to answer common questions about weed biocontrol and to allay some of the usual fears – "Will it be another cane toad?" The leaflet is distributed through extension outlets and at field days, Science shows and other displays. We will produce similar leaflets explaining biocontrol of the common weeds of the north and describing the insects which people may find on these weeds in their local area, using parthenium and lantana as the first examples. Similar leaflets describing biocontrol of particular weeds have been produced by CSIRO and other organizations, but not for the common weeds found in Queensland.

The third initiative is a CAL (computer assisted learning) package designed to explain the procedures followed in biocontrol programs, and the issues and risks to be considered before approval to import or release new agents is granted. This package, written by Dr. G. White, and partly based on material from the CTPM Biocontrol course, is intended primarily for the scientists (often from unrelated disciplines) who review applications to import or release new agents. It is also an excellent teaching tool for universities and other tertiary institutions, and would be invaluable for conservation and community groups wanting to increase their understanding of the topic. If funding is available, the package should shortly be made available on CD for general distribution.

MOLECULAR BIOLOGY

Last year's Brighton Crop Protection Conference had a whole session on Molecular Ecology of Weeds, with five papers dealing with genetic diversity in weeds (Anon. 1995). We are also using DNA and isozyme studies to determine the genetic make-up of certain weeds, and to compare them with other strains of the same species. This technique has been used to determine the country of origin of fireweed (*Senecio madagascariensis* Poiret) (McFadyen and Sparks 1996) and of the recently discovered outbreak of siam weed (*Chromolaena odorata* (L.)) in north Queensland. When the siam weed outbreak was discovered, the immediate presumption was that the infestation originated from seed accidentally imported from Indonesia or the Philippines, both of which have large infestations of this weed. However, there was also the possibility that seed might have come in as a contaminant in pasture seed from Brazil (Waterhouse 1994, Waterhouse unpublished report, QDPI Mareeba October 1994). The DNA studies clearly demonstrated that two separate strains were present in the Tully River area, one of which is only known from southern Brazil (L. Scott unpublished report 1996). The infestation must therefore have originated from seed imported from Brazil rather than from the south-east Asian infestations of this weed. This has important quarantine implications – the direct use of pasture seed imported from overseas is no longer permitted.

The genetic diversity of weeds may also be of critical importance to biocontrol programs, as is demonstrated by the fireweed studies (McFadyen and Sparks 1996). Lantana is one of biocontrol's great failures, and this has often been attributed to the great diversity of cultivars present in Australia and elsewhere (Swarbrick *et al.* 1995). ACIAR are supporting a project whereby DNA patterns will be used to characterize the various strains of lantana present in the South Pacific countries. The results will be used to determine from which varieties in the Americas new biocontrol agents, but pathogens in particular, can best be collected for control of the same varieties in this part of the world. If successful, the study will be extended to include Australian varieties.

The genetic diversity of prickly acacia in Queensland is also being explored through an analysis of the flavonoids present. The weed in Queensland is believed to be *A. nilotica indica* originating from the Indian subcontinent, but it is known that many separate introductions were made, and some of these may have originated from Africa rather than India (Bolton and James 1985). It is possible that more than one subspecies is present and hybridization may also be involved. Again, the knowledge gained will influence the choice of countries and plants to be searched for biocontrol agents in the future.

EVALUATION

Biocontrol has always suffered from insufficient evaluation of results. Too often the attitude has been that if the weed is still a problem, then biocontrol is unsuccessful and resources should be spent on more biocontrol efforts, rather than on evaluating the previous program. Unfortunately, this has meant that reasons for failure are poorly understood and also that many partial successes do not get the credit they deserve. The CTPM has tried to remedy this by putting at least some effort into evaluation of the impact of agents, both in the field and in the laboratory. With a CTPM scholarship, S. Broughton is studying the impact of lantana beetles on common weedy varieties of lantana in south-east Queensland, where the beetles are widespread and abundant and appear to be causing severe damage each year, yet lantana remains a serious weed. In another important study, S. Winterton has been studying the differential impact of the two water hyacinth weevils (*Neochetina eichhorniae* Warner and *N. bruchi* Hustache) on water hyacinth in eutrophic water. The results clearly show that although both beetles are equally effective in clean waters, *N. bruchi* is much more effective in the polluted waters so common in many tropical countries (Winterton and Heard in press). The reasons for variable establishment and impact of biological control agents has also been investigated. The leaf beetle *Calligrapha pantherina* is a damaging agent of *Sida acuta* in the tropics. CTPM work showed that the reason for the failure of this insect to establish on *S. rhombifolia* in cooler areas is climatic and not due to the different plant species present (Heard and Gardner 1994).

Another study at the University of Queensland is investigating the effect of the stem-galling moth *Epiblema strenuana* (Walker) on the growth and seed production of parthenium weed. *E. strenuana* was introduced as a biocontrol agent in the early 1980s and is now widespread and apparently damaging to parthenium weed in the field, but its effectiveness in reducing growth and seed production has never been evaluated (McFadyen 1992). Preliminary results show that early attack on young plants is devastating, but later attack is ineffective. These effects are greatly increased if there is also competition from buffel grass (*Cenchrus ciliaris* L.) (McFadyen, Adkins and Priest unpublished data 1996). In a new Queensland government initiative, field evaluation of other biocontrol agents on parthenium has now commenced (Dhileepan *et al.* 1996).

HOST SPECIFICITY TESTING

Host specificity testing and the accurate prediction of field host range of new biocontrol agents, both insects and pathogens, is the key to the continued safe introduction of new agents. Testing methods and protocols have developed over the years and, to date, no weed biocontrol agents have caused significant damage to non-target plants after release. The damage has been in the other direction – the need to minimize the risks has led to the rejection of potentially useful agents. The lantana mealybug *Phenacoccus parvus* Morrison, for example, was rejected as an agent because of attack on a wide variety of plants in greenhouse conditions, yet in the field it is confined to lantana (Marohasy 1994). On the other hand, tests showed that the parthenium beetle *Zygogramma bicolorata* Pall. will only feed on sunflower if starving, and never if given a choice. Yet this may still result in damage to sunflower in the field when very large beetle populations have developed and consumed all the parthenium (Jayanth *et al.* 1993)

Current CTPM research is investigating the processes involved in this feeding, and how laboratory tests can be better designed to predict field behaviour. Investigations of host-finding behaviour on both the previously mentioned insects is continuing, using direct observation behavioural techniques as well as more usual methods involving measurements of development rates on different host plants. Other research on the water hyacinth moth *Acigona infusella* is investigating the role host plant odours play in host selection, and how, in small cages, this can produce anomalous test results.

CTPM research on the oviposition behaviour of flower feeding biological control agents of *Mimosa pigra* has been used to design more meaningful and interpretable host-range tests to ensure the safety of these insects (Heard and Forno 1996). Oviposition and feeding behaviour were studied in relation to host development (Heard 1995a), insect damage (Heard 1995b) and flower gender (Heard in preparation). Other uses of this research is for the design, conduct and interpretation of sampling plans to evaluate the establishment and impact of insects in the field. Flower feeding insects are potentially important agents but are difficult to rear and test. This research provides a generic approach for the evaluation of this group of insects for biological control of weeds.

DISCUSSION

Biocontrol remains the best option for sustainable, economic, and long-term control of many of our introduced weeds. Unfortunately, economic pressures and 'rationalization' of government services means that biocontrol practitioners are forced to concentrate on the immediate issues and problems. Answering the more basic questions is pushed to the back of the queue. Both in CTPM-1 and CTPM-2, we are trying to take a wider view of the issues involved. Our research into these generic issues and problems should benefit all biocontrol programs.

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