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New developments, strategies and overviews: synthesis of session 4

S.V. FOWLER and J.K. WAAGE

International Institute of Biological Control Silwood Park, Ascot SL5 7TA, UK

Introduction

It is not surprising that a conference session with a title as broad as this one included papers and posters on a wide range of topics within the subject area of weed biocontrol. The range of new developments reveals both a subject area that is growing and one that has to adapt to meet new challenges. Although wide ranging, the presentations did fall into a number of subject areas, including: (i) information transfer and education in biological control; (ii) international collaboration and linkages between countries and organizations; (iii) new or potential developments in the use of pathogens for biocontrol, particularly in crop systems; (iv) environmental concerns in biocontrol and risk assessment; (v) biological control of alien plants in 'natural' habitats; and (vi) research into improving current methods in biological control of weeds, particularly methods for surveying and prioritizing weeds and agents and methods for multiplying and releasing insects and pathogens as weed biocontrol agents.

In an attempt to provide a synthesis for this stimulating session, we return to one international event and its repercussions that we think will have an enormous effect on weed biocontrol, namely the Earth Summit held in Rio de Janeiro in 1992. From this meeting grew Agenda 21, a blueprint for sustainable development and the environment for the next century, and the Convention on Biological Diversity (Glowka *et al.* 1994). Together, these important documents produced by governments and for governments make the following points: (i) priority should be given to biological control as a component of future pest management; (ii) countries are obliged to control alien invasive species that threaten their indigenous biodiversity; (iii) safety and environmental impact are key issues in the introduction of new species; and (iv) countries and companies must be fair and equitable in sharing the benefits from the sustainable use of biodiversity.

The international message is clear - biological control has a crucial role to play not only in agriculture but particularly in environmental conservation. Its practitioners need to convince the public at large that biological control is appropriate, safe and fair. This paper looks at the relevance of biological weed control to both agriculture and the conservation of biodiversity, highlighting what we regard as key issues, particularly those raised in the presentations and subsequent discussions during this session.

Agricultural pest management

The United Nations Conference on Environment and Development (UNCED) in its Agenda 21, recognized integrated pest management (IPM) as the preferred strategy to achieve sustainable agricultural production. IPM typically involves a reduction in the reliance on chemical pesticides, including herbicides. However, weed problems and herbicide-use are likely to increase, particularly in developing countries, as rising labour costs and emigration from farming to urban communities raises the cost of manual and mechanical weed control.

An example of this trend is found in rice, one of the worlds most important and intensively-grown food crops. In wealthier rice-growing countries in Asia, such as Malaysia, reduced availability of labour, and hence increased costs, are resulting in a change from the traditional, manually-transplanted rice, to the less labour-intensive method of broadcasting seed directly into the rice fields. A significant consequence of this change of practice is that weed problems increase, as the weed controlling effects of flooding are lost to the production system. Furthermore, the nature of transplanted rice is that the plants grow in discreet units, sometimes even in regular rows, so manual weeding is relatively easy. Easily-removed weeds have an important role as animal feed, but all this is changing with a move to broadcast seeding, and with it will come a growing demand for selective herbicides.

In this manner, a range of new markets are opening up for herbicides. Further, as concern spreads about the

misuse of insecticides and fungicides, agrochemical companies are seeing herbicides, with their relative human and environmental safety (with some notable exceptions), as a good area for investment. Genetic engineering which has permitted the recent introduction of herbicide-resistant crops indicates the extent to which the industry is prepared to invest to secure weed control markets.

This growth in herbicide-use raises concerns as well. Some herbicides can have serious environmental effects - disturbingly, some appear in groundwater, herbicide resistance is appearing, and many people are concerned about the ecological implications of engineering herbicide-resistance genes into outcrossing crops. Overall, a dependence on repeated chemical inputs for weed control is not in step with the trend towards IPM. More self-renewing and safe, biological methods will attract increasing attention. The opportunities for biological control are tremendous. The exciting developments in the use of pathogens for weed control in crops reported in this session (e.g. Auld *et al.* this Volume; Müller-Schärer this Volume; Sands *et al.* this Volume; Smith and Holt this Volume) show that weed biocontrol has the potential to take these opportunities.

Conservation of biodiversity

Alien weeds pose some of the most serious threats to biological diversity. Many weed species are amenable to biological control, but this is not widely appreciated in the environmental commmunity. A recent study for the Worldwide Fund for Nature listed over 120 invasive plant species causing problems in natural ecosystems around the world (Cronk and Fuller 1995). Of these species, 46 are already targets of biological control programmes in one or more countries, usually in connection with problems they have caused to agriculture. Against this background, we see some of the key issues that will affect the potential for biological control of alien invasive weeds threatening biodiversity as: (i) the sponsors and interest groups are different from those that have traditionally supported and used weed biocontrol; (ii) the problems of invasive alien weeds are on a truly global scale, and will benefit from international collaboration; (iii) there are a huge number of species of invasive alien plants, and increased transport and trade is likely to make this situation even worse in the future, despite any hoped-for improvements in quarantine measures and other controls on the movement of alien species; and (iv) there is a major issue in this same environmental community concerning the ownership of biodiversity, which will include species that we wish to use for biological control.

Different sponsors and interest groups

The relevance of biological control for the suppression of alien invasive weeds that threaten biodiversity is clear to us, but now we practictioners need to work with a different set of potential sponsors and interest groups from those that have traditionally supported weed biocontrol. Instead of Departments of Agriculture, who have a reasonable familiarity with this method, our counterparts will be Departments of Conservation, National Parks Services and local non-governmental organizations (NGOs) on a national level, and inter-governmental organizations and international NGOs on a regional or global scale. There is a clear need for enhancing awareness and understanding of biological weed control in this new constituency. Education and better information transfer will be key components in this increased awareness, and several papers and posters in this session presented interesting developments in information transfer (Grodowitz this Volume; Spencer this Volume) and education (McFadyen this Volume) indicating that weed biocontrol workers are taking on this challenge with enthusiasm and innovation.

Our impression is that there are three concerns that environmental groups typically raise. The first is the most common, namely the safety and potential environmental impact of introduced biocontrol agents. If the extent of the host-range testing and other research necessary for weed biocontrol is appreciated, then a second concern is often about the high costs of the programmes. If the long history of weed biocontrol is known, then a final concern is often over the rather low rate of success. Weed biocontrol workers will need to address all these issues.

With respect to safety, the recent ratification by the members of FAO of a new Code of Conduct on the Import and Release of Biological Control Agents, developed with the help of weed biological control experts from many organizations, is significant (FAO 1995). The Code is not a blueprint, only an informal guide to issues and possible actions, but it does begin to create a means by which non-professionals can have the confidence which we have long had that weed biocontrol agents can be safe, if proper testing

procedures are followed. The risk to non-target organisms is clearly of paramount importance in weed biocontrol, and in this session there was an example of a possible side-effect of biocontrol of saltcedar in the United States of America causing a programme to be stalled at least temporarily by the concerns of an environmental group: in this case a native bird is reported to use the alien shrub as a nesting site, so there are concerns that the successful biocontrol of the weed could harm populations of this bird (DeLoach *et al.* this Volume). In another presentation, the use of risk assessment methods for evaluating the threat to non-target organisms was proposed by Wan and Harris (this Volume). Finally, the importance of careful interpretation of host-specificity trials was emphasized in the case of biological control of alien *Solanum* spp. weeds in South Africa using agents that, in laboratory tests, do cause some damage to eggplant (*Solanum melongena* L.) (Olckers this Volume).

The global scale of the problem

The indigenous biodiversity in many continental areas and on almost all islands is under threat from invasive alien plant species. The scale of the task is daunting, but many countries have shared weed problems. There is a need for improved global links and better information flow between biocontrol workers, potential sponsors and other interest groups. Several presentations dealt directly with this issue and, together with the encouraging number of presentations by collaborating authors from a range of organizations and countries (e.g. Deloach *et al.* this Volume), it seems clear that weed biocontrol programmes are benefiting from improved cooperation.

One group of weeds where the potential to share benefits is being realized is the aquatic water weeds. Work on water hyacinth and water fern in the USA and Australia has provided considerable benefits to Asia, Africa and Central America in biological control of these same weeds (Julien *et al.* this Volume; Wright this Volume). International cooperation is of great value, but often operates slowly due to politics. The delay in introducing water hyacinth agents into Lake Victoria is a testimony to this. Where scientists have a will to see change, they can have enormous impact, and meetings at this conference on water hyacinth and similar global weed problems should have a major effect. Avoiding duplication of effort, and making use of the research and experience gained in one part of the world in subsequent programmes elsewhere, is one clear way to reduce the overall cost of weed biocontrol which was one of the concerns about biological control frequently voiced by informed environmental groups. The cost of programmes, especially when combined with cuts in government budgets, as in Hawaii (Smith and Gardner this Volume), can be a major constraint to implementing biological control.

The large number of alien invasive plant species

There are a daunting number of alien plant species apparently invading natural and semi-natural habitats worldwide. As mentioned earlier, Cronk and Fuller (1995) identified over 120 plant species invading such habitats. However, estimates of the scale of the problem vary enormously. For example, in the USA (continent and islands such as the Hawaiian chain) the Exotic Plant Pest Committees have identified about 320 species of alien, invasive plants that they perceive as problems or potential problems (F. Campbell personal communication). Because of the large number of species of alien plants, and the inevitable limit on resources for weed biocontrol programmes, it is essential that potential targets for weed biocontrol are prioritized effectively. Attention is being applied to this issue and in this session, for example, Palmer and Miller (this Volume) provided an interesting example of a scoring system for prioritizing weed targets in Queensland, Australia. In general, for weeds affecting indigenous biodiversity, the most important factors that need to be considered in order to prioritize alien invasive weeds are the seriousness of the impact, or likely future impact, on indigenous biodiversity and the likelihood of biological control being at least partially successful.

For each perceived weed problem, ecological field research will need to establish the real impact of the invasive alien weed on indigenous biodiversity. Not all alien weeds will be of equal importance. On La Réunion island, Sigala and Lavergne (this Volume) highlight the environmental impact of just two alien weed species, *Rubus alceifolius* L. and *Ligustrum robustum* Blume, out of a total of more than 1000 alien plant species introduced by humans since the 17th century. The sheer number of alien plant species and the range of countries and habitats that they reportedly invade means that prioritizing targets for weed biocontrol is a considerable challenge. We feel that some simple guidance and protocols on how to assess, in a short time-scale, the threat to indigenous biodiversity posed by an invasive plant species would

be extremely useful. In this way, reserve managers or other people concerned about alien plant species, that do not have specific training in plant population ecology, could make more informed decisions about the multitude of alien plant species that they face on a day-to-day basis.

The likely success of weed biocontrol should also influence the prioritizing of weeds as targets. The relatively rare cases where weed biocontrol has been spectacularly and completely successful are widely quoted, but partial suppression of a weed is the more common outcome of weed biocontrol programmes. Partial suppression of a weed by biological agents may provide a central component in integrated weed management strategies. Integrating biological weed control with other weed management methods is the subject of another session and synthesis in this Volume, so all we want to do here is to point out that such integration is one way to increase the actual and perceived success rate of biological control of invasive weeds.

Selecting appropriate agents has been a perennial topic of discussion in weed biocontrol. Ecological studies of agents in their native range are clearly important, and can provide the data needed for prioritizing from a large list of potential agents, e.g. 21 insect species on *Senna obtusifolia* (L.) Irwin and Barnaby in Brazil (Sujii *et al.* this Volume). Traditionally, insect agents have been considered first in classical weed biocontrol programmes, to the sometimes obvious frustration of plant pathologists. With the benefit of hindsight, Sheppard and Lewis (this Volume) make the point that pathogens perhaps should have been considered first for use against the annual weed, *Heliotropium europaeum* L., in Australia, and then suggest that this conclusion might be relevant to summer annual-weeds in general. A major constraint in the use of plant pathogens for weed biocontrol is the relative lack of knowledge of this group of natural enemies of plants compared, for example, to plant-feeding insects. Field surveys will always be an important part of weed biocontrol programmes, but for pathogens there may some other approaches. For example, Mortensen (this Volume) suggests the novel idea of looking for potential weed biocontrol agents by screening seeds from the large number of companies involved in seed producing and cleaning.

There ought to be other ways to improve the success rate of weed biocontrol. Several presentations suggested new methods for multiplying, releasing and monitoring the impact of biological control of weeds (Briese *et al.* this Volume; Forno *et al.* this Volume; Memmott *et al.* this Volume; Norambuena and Piper this Volume). We believe that these innovative ideas for improvements in practical methods and attempts to provide a more ecological/scientific basis to some of the processes in biocontrol programmes are all evidence of optimism and commitment to the future of weed biocontrol.

Even with greater awareness of invasive alien weeds, and more efforts to control them and limit their impact on indigenous biodiversity, the number of alien invasive plants is likely to increase in the future because of increased international transport and trade. For this reason, quarantine measures and other checks on the movements of alien species are likely to get more strict. This will be a welcome development, but as weed control practitioners we must ensure that rules governing the movement of alien species do not inadvertently restrict the importation of beneficial biological control agents. Whilst rules for importing beneficial species may become stricter, we can also expect countries to apply much tighter controls on the export of their own biodiversity. Potential biocontrol agents are part of this biodiversity, and the matter of ownership and use of agents is the issue we discuss next.

The ownership of biodiversity

The Convention on Biodiversity is clear that there must be fair and equitable sharing of the benefits from the sustainable use of biodiversity. Collecting biocontrol agents from one country for the benefit of another may well not be regarded as fair and equitable use of biodiversity. The country that owns the biodiversity could consider that it is gaining little from the arrangement and that the benefits from the use of its biodiversity are not being shared. Countries are becoming increasingly sensitive about the export and use of their biodiversity and several, such as China, India, Brazil and Venezuela, now have strict controls over the export of any species. Permission to conduct surveys and the need for permits to export potential biocontrol agents are likely to become necessary in the majority of countries. Where there may be commercial benefits from the use of biodiversity, then there will be a need for carefully negotiated agreements between the users and providers of the resources, although this is a complex area. However the Convention on Biodiversity also states that "each contracting party

shall endeavour to create conditions to facilitate access to genetic resources for environmentally sound uses by other contracting parties and not to impose restrictions that run counter to the objectives of this convention" (Glowka *et al.* 1994; CAB International 1994). Classical biological control is just such an environmentally-sound use of biodiversity, and hence it can be reasonably argued that relatively free access to potential biocontrol agents should continue to exist (CAB International 1994; Halbert 1994). We propose that the mutual benefit of biological control should be emphasized and publicised, to help to ensure that rules on exporting potential biocontrol agents do not become too restrictive. For example, using data extracted from the BIOCAT database we can demonstrate that 98 countries have been the source of biocontrol agents while 121 countries have made one or more introductions and that countries in the developing world have been the source of 57% of biocontrol introductions and the recipients of 52% of introductions.

There are other more direct ways that biological control programmes can benefit the country that provides the potential biocontrol agents, for example, through cooperation with local scientists for field surveys and ecological studies of potential agents in their native ranges. Visits by, and liaison with, overseas biological control scientists can offer valuable opportunities for training and development of staff in the source countries. Longer-term investment in facilities such as the overseas stations of IIBC and other organizations such as CSIRO and USDA, clearly can bring even greater benefits for capacity-building in the source country. National taxonomic collections should also benefit from the deposition of voucher specimens from the collections made during surveys for potential biocontrol agents. Although many of these benefits already accrue from biocontrol programmes, in many cases the governments of the countries concerned will be unaware of them. It is clearly in all our interests to increase the awareness of these benefits.

To conclude, we think that this is an exciting time to be a weed biocontrol practitioner. There are great opportunities and challenges to be addressed, particularly with some of the rapid changes in agriculture and with the increasing awareness of the threat that invasive weeds pose to indigenous biodiversity. There are also some risks, including for example that legislation controlling the movements of organisms and the use of indigenous biodiversity may become highly restrictive. As practitioners of weed biocontrol we need to publicise and increase awareness of our activities, and we must ensure that we can influence decision making by national governments and international organizations that will affect the future of biological control.

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