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Some basic aspects of biological weed control¹

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Biological Control is defined as the action of parasites, predators and pathogens (viruses, fungi, and bacteria etc.) in maintaining another organism's density at a lower average level than would occur in their absence (Debach, 1964). The practice of biological control has been used effectively against both weeds and insects in the U.S. and other parts of the world.

Some examples of successful biological control of weeds include the control of prickly pear cactus, *Opuntia* sp., by the moth *Cactoblastis cactorum*, the control of skeleton weed *Chondrilla juncea* in Australia, by the rust, *Puccinia chondrillina*, the control of St. John's-wort, *Hypericum preforatum*, in California by the defoliating beetle *Chrysolina quadrigemina*, and the successful reduction of musk thistle densities in Montana by the action of the seed-head weevil, *Rhinocyllus conicus*.

Chemical and cultural weed management methods have played a vital role in controlling weeds in crop and rangeland in the past. But, because of the marginal economic aspects of much of our rangeland, the increased cost of petroleum derived chemicals, the development of resistance of some weeds to herbicides, the inaccessability of many rangeland areas to herbicide application, and the restrictions on herbicide use along waterways and some Park and Forest Service land, additional control methods that are more practical and economically feasible in rangeland, such as the use of biological control agents, will find greater utility in the management of weeds in these areas in the future. Furthermore, in a newly developing technology, plant pathogens hold great promise for controlling weeds of cropland in the future because of their quick kill potential, and relative ease of culturing and broadcasting into the field.

In contrast to conventional chemical and cultural weed management practices, which have traditionally been used to solve immediate weed problems, the practice of using biological control agents has generally not been used for short term control purposes but rather a more long term management of the weeds is the goal. Developing a successful biological control program for a given weed generally takes a number of years and is dependent on the biology of the weed, the success in finding effective and safe natural enemies that have the ability to adapt to a new release area, the number of economically important and/or native plants in potential conflict with the introduced natural enemies

¹ Introductory remarks made during the banquet speech.

(which may restrict the number of agents sanctioned for release and increase the number of host range and host-specificity tests required for each control agent), environmental, political, and other factors.

The protocol for developing a biological control program generally includes: 1) determining the suitability of a weed for biological control (i.e., does it have few economically important or native plant relatives, or perhaps conventional control measures in some areas are not economically feasible or physically impossible); 2) conducting a survey for natural enemies in the place of origin of the weed as well as for native or “naturalized” control agents that might already be present in the introduced area; 3) ecological studies of the weed and natural enemies, preferably in the area of origin of the weed, to determine the potential of the natural enemies in regulating the weed; 4) screening studies to determine the host range and specificity of natural enemies and ascertain their safety; 5) approval by the working group on Biological Control of Weeds, our USDA governing committee that determines the safety of the release agents and sanctions their release; 6) collection/colonization, release, establishment, and redistribution of the natural enemies; and 7) evaluation of the natural enemies effectiveness on the weed (Schroeder, 1984).

There are many advantages in utilizing biological control agents for weed management, particularly for rangeland. Among them are: 1) the application of the practice to economically marginal land where the use of herbicides or cultural management may be too expensive or impossible, such as up steep mountain draws, or along waterways and Park/Forest Service lands with restrictions on the use of chemicals; 2) permanency – once these control agents are established they become a permanent fixture in the environment and year after year they reappear to have an impact on the weed and thus savings accrue year after year; 3) environmental safety – there are no toxic residues associated with these agents or their associated feeding; 4) specificity – the sanctioned biological control agents only attack the weed in which they are purposely released against or, at most, a few close relatives, otherwise they are not given the okay for release; 5) cost-effectiveness – because biological control agents, once they are established and having an impact on the weed, tend to increase on their own, disperse, and find new weed infestations, savings in control costs accrue year after year, which makes biological control a very cost-effective weed management approach, particularly in rangeland; and 6) the potential for integration of biological control with chemical and cultural weed management strategies – there have been numerous weed management programs that have successfully utilized all feasible control methods in a complementary fashion to successfully manage weed problems (i.e., Integrated Weed Management). If the chemical and/or cultural weed control measures are properly timed so that they have a minimal impact on the natural enemies and still control the weeds, then the control strategies will be complementary in their impact on the weed and the rancher will get a “double punch” for his money, so to speak.

I should mention that in every situation good range management should be practiced and competing grass and forage vegetation encouraged otherwise the biological control agents will probably have very little impact on the weeds particularly in ultimately reducing plant densities. Competing vegetation is one of the rancher’s greatest resources in solving the spread of a weed and enhancing the effectiveness of biological control agents and one should take great advantage of this and not overgraze the rangeland.

I've discussed some advantages of biological control – now I will elaborate on some disadvantages. Because of the underlying risks, however remote, that an introduced biological control agent may attack economically important plants or other desirable flora, biological agents are necessarily subjected to an exhaustive series of tests to guarantee their safety, otherwise they are not even considered for release. The long biological control protocol mentioned above is an example of the steps one goes through to guarantee this safety. Thus, getting from the point of finding the agents to eventually releasing them in the field on some target weed may take several years. Even after the control agents have established in the field it may take 5 to 10 years, or longer, to adapt to the weed or environmental conditions and have a substantial impact on the weed. Thus, biological control is a relatively slow, complex process in contrast to conventional weed management approaches. However, in some situation such as with the biological control of prickly pear cactus in Australia and St. John's-wort in California, the effective controlling agents were able to build up their populations very quickly and have a dramatic impact within a few years in reducing weed population levels. Another disadvantage of biological control is host-specificity. In rangeland and more commonly in cropland the rancher or farmer may be faced with a complex of different weeds that necessitate control. Since the biological control agents sanctioned for release are generally only adapted to a single species of weed host or at most a few close relatives, they would not be helpful in attacking other species of weeds they can not utilize. And lastly, another disadvantage is the potential risk of these introduced agents attacking economically important plants or other desirable flora. I should mention that one of the basic premises of biological control is that the control agents, even in the most highly evolved association between a weed and natural enemy, never completely eliminate their host. Thus, it becomes even less remotely possible that a given control agent could eliminate a plant it was not adapted to. For the record, there has been no case in which a "sanctioned" control agent has been released and has caused the decline of any non-target plant species to date.

I will finish my introductory remarks on biological weed control by discussing the applicability of biological control to rangeland versus cultivated land. Biological control is most suited for rangeland situations for a number of reasons. Rangeland is a more stable agroecosystem – it tends to be less disrupted by pesticides, herbicides, and cultivational practices, and thus the weed host tends to be more readily available for attack by the natural enemies in addition to providing conditions for natural enemy build-up and perpetuation. Furthermore, the economics of much of our marginal rangeland favors non-conventional control, and slower acting weed management strategies are tolerable. In contrast, biological control agents face a tougher situation in cropland. Any insecticides applied to control insects in the cropland could be potentially lethal to insect biocontrol agents. Also, any herbicide and cultivational measures practiced could potentially kill the weed host and thus the natural enemies. In short, it is an unstable agroecosystem. Because of the generally higher cash value per unit area of agricultural products produced from cropland, the economics still favors conventional weed control. More importantly, the farmer is often faced with having to control his weed problems in a hurry or risk losing his crop – something that herbicides and/or cultivational practices can generally prevent.

Insect biological control agents, because of their relatively slower kill potential, will probably continue to have limited utility in the management of weeds in cropland. How-

ever, some plant pathogens such as fungi do have great potential for selective weed control in cropping systems (Charudattan and Walker, 1982). Because fungal plant pathogens are relatively easy to propagate and apply in the field and because of their quick kill potential, they will find increased utility for selective weed management of cropland in the future.

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