POTENTIAL FOR BIOHERBICIDES IN DEVELOPING COUNTRIES

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Summary. Three bioherbicides based on indigenous plant pathogenic fungi are registered commercial products and several bioherbicide research projects are in progress. There is, however, scope for further investigation into bioherbicides for developing country agriculture.

In developing countries, the possibility of mass producing plant pathogens of weeds in low-tech systems at local level is a feasible alternative to high-tech fermentation systems used in the industrialised world. Mass production at the locations and at the time of use would also overcome the need for long shelf-life which is required for commercial products. The tropical regions of the Asia/Pacific area with high humidity and relatively predictable rainfall may be particularly suitable for bioherbicide development and use.

INTRODUCTION

Bioherbicides are biological herbicides in which the active ingredient is a microorganism. The bioherbicide technique uses inundative doses of plant pathogens to create artificial and localised epidemics each season. (See (1) for recent reviews of the subject).

Up to this stage, bioherbicides have utilised indigenous or naturally occurring pathogens, although the use of exotic microorganisms is feasible, but requires adequate host range testing.

COMMERCIAL PRODUCTS

Three commercial bioherbicides Collego®, Devine® and Biomal® are registered products in North America. They utilise naturally occurring fungi and are thus also referred to as mycoherbicides.

Commercial products such as these are conveniently produced en masse by submerged culture fermentation then, separation, drying and storage, but this requires high capital expenditure.

In addition fermentation time competes with other potential uses for fermenters. For example, production of high value products such as antibiotics or hormones. Moreover not all microorganisms will reproduce in submerged culture. Oxygen mass transfer is a major problem for aerobic processes as its solubility in water is only about 6 ppm (2). While the use of solid substrate techniques may overcome these problems, these methods are generally regarded as too labour intensive and therefore too expensive in the industrialised world.

The bioherbicides which have so far been produced commercially have limited host ranges. This is operationally useful and ecologically desirable but it restricts the market size for the products and therefore may be a disincentive for commercial investment in bioherbicides.

Ideally commercial products should have long shelf-life. Application sites may be considerable distances from place of manufacture and making a product at a time suitable to the manufacturer is desirable rather than in response to an urgent need by potential users of the product.

Therefore commercial producers aim for a minimum shelf-life of a year. However the bioherbicide, Devine®, has a shelf-life of only six weeks in refrigerated storage, but it is feasible to distribute and market the product because of the limited target area: Milkweed vine (*Morrenia odorata*) infested areas in citrus groves in Florida.

Mycoherbicides generally have a requirement for dew or high humidity for satisfactory results. Collego® and Devine® are both used in irrigated rice and citrus orchards agriculture and this is part of the reason for their success. Biomal® is used in situations where rainfall events are likely and can be confidently predicted in the mid-west wheat growing region of Canada.

A moisture requirement has hampered the development of several potential mycoherbicides in dryland agriculture in temperate regions. Thus a great deal of research effort has recently been placed on the development of formulations to overcome this dew requirement. However complex formulations may add considerably to the cost of products.

DEVELOPING COUNTRIES

The use of bioherbicides has been relatively neglected in developing countries. The outstanding exception to this is the product, Lu-bao No. 2, based on the fungus *Colletotrichum gloeosporioides*, to control dodder, *Cuscuta* sp., in the People's Republic of China which was first used in 1963 as "Lu-bao No. 1". However, recent interest has focussed on potential mycoherbicides in a number of developing countries. For example: *Rottboellia cochinchinensis* in Thailand (research supported by the International Institute of Biological Control, U.K., this is also a major weed in Central America); *Striga* sp. control with *Fusarium* spp. in Ghana (research supported by University of Hohenheim, Germany).

Apart from the environmentally desirable aspects of using naturally occurring microorganisms over synthetic chemicals, the substitution of these products for imported herbicides would lead to valuable savings in foreign exchange.

Some of the factors which limit bioherbicide production and use in developed countries may not apply in developing countries:

<u>Mass production</u>. There is a tradition of food production by fermentation techniques in many developing countries, particularly in south-east Asia. Many of these fermentation systems use solid substrates and thus overcome the problem of oxygen limitation in submerged culture fermentation. Moreover they do not require the same capital investment as fermenters and the media used in such systems may be derived from waste products of food production or straw, for instance.

<u>Shelf life</u>. Because of the rapid multiplication rates of microorganisms in combination with the potential to produce them in local solid-state fermentation systems, the need for long shelf life diminishes. Products could be made in relatively small quantities locally to satisfy local needs.

<u>Moisture requirements</u>. Many developing countries, particularly in the Asia/Pacific area, are located in tropical regions where humidity is high and rainfall relatively predictable. Moreover many crops in developing countries are irrigated. Thus the moisture limitations imposed on mycoherbicides in dryland temperate agriculture often will not apply in developing countries.

Availability of suitable microorganisms. Plant pathogens associated with weeds have been poorly collected even in countries with large numbers of publicly supported research personnel and extensive laboratory facilities. Clearly the first steps to be taken would be the nomination of the most important weed species, then the deliberate searching for pathogens, their isolation, identification, virulence testing and host-specificity testing.

The steps to follow are then, defining optimal conditions for infection and disease development, mass production and field testing.

THE FUTURE

Successful bioherbicide projects require collaboration between plant pathologists, weed scientists and fermentation specialists in the public sector. This is true for developing countries, just as it has been in developed agricultures.

Cooperative projects between scientists with experience in bioherbicide development and interested plant protection research groups in developing countries should accelerate the adoption of bioherbicides as alternatives to conventional herbicides and manual weed control.

An International Bioherbicide Group (I.B.G.) has been established to foster communication and cooperative projects on bioherbicides and assist transfer of technology that will assure availability of bioherbicides.

This cooperation also has potential benefits for developed agricultures, including the introduction of alternative fermentation techniques for mass production of biocontrol agents and alternatives to the commercial model of bioherbicide production.

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