Current Journal of Applied Science and Technology

31(2): 1-4, 2018; Article no.CJAST.45888
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Biotechnology Applications in Weed Management

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2018/45888

Received 07 November 2018
Accepted 28 November 2018
Published 08 December 2018

Review Article

ABSTRACT

Biotechnology provided new dimensions to herbicide technology. Transgene technology has generated herbicide-resistant crops (HRCs) that have profound impact on the herbicide market. This same technology has the significant potential to make crops better competitors with weeds through improving competitive traits or making the crop more allelopathic. Living biocontrol agents can sometimes be applied to weeds, much like a herbicide. In the bioherbicide approach, microbial plant pathogens are applied to target weeds. Fungi, bacteria and viruses offer great promise as bioherbicides. Formulations of *Phytophthora palmivora* (De Vine) as a selective mycoherbicide for the control of milkweed (*Morrenia odorata*) in citrus, and *Colletotrichum gloeosporioides* (Collego) for the control of Northern joint vetch in rice and soybean, are now widely used in developed countries. Extensive research has demonstrated that several allelochemicals possess good herbicidal activity. Thus, A crop that is genetically engineered to be resistant to yet another selective herbicide must fulfil a weed management need that is unmet, such as those niches that were filled by bromoxynil-resistant crops.

Keywords: Weed Management; herbicide technology; HRCs; bromoxynil.

1. INTRODUCTION

Genetic improvement of plants has challenged agronomists throughout the long history of agriculture. Extensive research in the last few decades has resulted in dramatic increases in agricultural crop production [1]. In a broad sense, biotechnology is commonly defined as "the

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Note: Special issue with selected papers presented in National Conference on Biotechnological Initiatives for Crop Improvement (BICI 2018), December 08-09, 2018, Organized by Bihar Agricultural University, Sabour, Bhagalpur - 813210 (Bihar), India. Conference organizing committee and Guest Editorial Board completed peer-review of this manuscript.

application of biological organisms (microorganisms, plants, animals), systems, or processes to provide desirable goods and services" [2]. A particular subset of biotechnology is a genetic modification (GM), which we have also been doing for centuries with artificial selection of bacteria, plant and animals, including trans-species hybrids. A recent general review of the potential applications of molecular biology in weed management was commissioned by the Weeds CRC and published by Paltridge [3]. One of the areas of plant agriculture in which biotechnology is expected to have immediate practical applications is undoubtedly the field of weed management [4], Jaworski, 1987). Opportunities for the application of biotechnology:- (1) the development and use of bioherbicides, i.e., the use of plant pathogenic organisms such as fungi, bacteria, and viruses as biological control agents; (2) the discovery and use of naturally occurring herbicides; (3) the genetic improvement of crop tolerance to herbicides; and (4) the use of genetically engineered microorganisms for other areas of weed management such as the decontamination of herbicide spills or the protection of selected crops against herbicide injury. The principles and mechanisms involved in the potential application of biotechnology in these areas of weed management and herbicide technology as well as specific examples are described in the following sections of this review.

2. EMPERICAL REVIEW

Biocontrol measures are ideal for weeds that escape chemical control, for organic farming, and for weeds that are in areas in which herbicides cannot be used because of environmental sensitivity. Another major concern is evolved herbicide resistance, which now has developed in more than 450 weed biotypes. The concept of deliberately using organisms to control a pest constitutes the fundamental basis of all biological pest control systems. In the classical approach, a biocontrol agent is simply introduced or released into a weed population to establish itself and control the weed population, requiring no further manipulation (Templeton et al. 1979). The bioherbicide approach employs the massive, usually annual, release of a biocontrol agent into specific weed-infested fields to infect and kill susceptible weeds [5]. The utilization of biological weed control agents in weed management offers many advantages including (1) a high degree of specificity for the target weed; (2) no effects on nontarget and beneficial plants or man; (3) absence of weed resistance development; (4) absence of residue buildup in the environment; and (5) potential impact from biotechnological research and development [6,5]. Some drawbacks associated with the production and use of bioherbicides include:-

1. Bioherbicides have to be registered with the Environmental Protection Agency (E.P.A.) and the registration process may be lengthy, 2. Suppression or killing of weeds by bioherbicides may be a slow process., 3. Stability of bioherbicides under field conditions is highly dependent on environmental conditions. 4. Production of a bioherbicide for the large-scale application may be an expensive process. 5. Numerous fungi need to be discovered and developed as bioherbicides.

3. MATERIALS AND METHODS

Use and biocontrol of Weeds with Plant Pathogens concerns of health, safety, and sustainability, there is a growing interest in reducing chemical weed control measures in both agricultural and natural systems. This has led to an increased interest in the use of biological agents to control weeds. Insects, pathogens, grazing animals, and allelopathic crops can all be used for biological control of weeds Biological control of weeds has several advantages over chemical or cultural methods Biological control methods for weeds usually cause less contamination of soil, water, and food with unwanted synthetic compounds, and they do not contribute to soil erosion, as does tillage, the main nonchemical method of weed management [7].

Table 1. Past and present commercial microbial biocontrol agents used for weed management

Microbe	Target weed	Trade name
Fusarium spp.	*Abutilon theophrasti*	Velgo
Phytophthora palmivora	*Morrenia odorata*	DeVine
Colletotrichum gloeosporioides f. sp. Aeschynomene	*Aeschynomene virginica*	Collego; LockDown
Phoma macrostoma	Turf weeds	Phoma
Alternaria sp.	*Cuscuta* spp	Smolder

The use of indigenous plant pathogens with limited host specificity in an inundative approach has been the primary emphasis of research and development of microbial herbicides or "bioherbicides.

4. RESULTS AND DISCUSSION

4.1 Control of Weeds with Allelopathy

Current Status of the Use of Allelopathy for Weed Management. Plants can interfere with each other through competition for resources or through allelopathy. Although more expansive definitions of allelopathy are used for our purposes, allelopathy can be narrowly defined as chemical warfare between different plant species. Both crops and weeds produce phytotoxins that could be allelochemicals that provide an advantage in plant–plant competition. There are several ways that allelopathy could be used in weed management. allelopathic cover or smother crops, allelopathic companion crops, allelopathicmulch or incorporation of phytotoxic crop residues, production of allelopathic crop cultivars with weed-suppressing potential, and use of allelochemicals as sources of natural herbicides.

Cover crops can cause the accumulation of one or more allelochemicals in the rhizosphere recent example is the use of Sorghum sudanenseas a cover crop to inhibit weed establishment, followed by no-tillage planting of large-seeded crops such as soybeans that are relatively insensitive to the allelochemicals. Many others have considered the allelopathic suppression of weeds by various cover crops: buckwheat, sorghum, wheat, and rye.

4.2 Biotechnology to Improve Allelopathy

The available literature on allelopathy is extensive, but its practical use in modern agriculture has been basically limited to the use of cover crops as weed suppressants. Little research has concentrated on the development of allelopathy as an important trait in major agricultural crops, even though it clearly exists in the germplasm of cucumbers, barley, rice, wheat, rye , and sorghum . However, as long as allelopathy is considered a value-added trait of little economic value and yield remains the major selection criterion of most breeding programs, allelopathy is unlikely to be developed in cultivars produced by traditional methods. A major reason is that in most cases allelopathy will act as a quantitative trait that is difficult to select for in conventional breeding programs but might be possible using newer techniques such as genomic selection. Using breeding methods, imparting this trait to crops that have no allelopathic potential would be impossible. Therefore, the fate of allelopathy, as a practical tool for more environment-friendly agriculture, appears to lie in the hands of biotechnology. In the few cases where phytotoxic allelochemicals have been identified, there is limited knowledge about their biosynthetic pathways. There are three exceptions: sorgoleone, the benzoxazinones of maize, and momilactone B in rice. The severe plant genome projects of other crop species will eventually be helpful in providing some of the basic biochemical and genetic information to dissect the biochemical pathways of allelochemicals. A traditional approach to identification and isolation of genes encoding enzymes for allelochemical production is to purify the enzymes and work back to the genes.

4.3 Development of Crop Herbicide Selectivity-A Novel Aproach

Herbicides generally function by disrupting unique and essential processes in plants e.g. photosynthesis, mitosis, pigment biosynthesis or essential amino acid biosynthesis. Both crops and weeds share these processes. Consequently, at present, selectivity is mostly based on differential herbicide uptake between weeds and crops, controlled timing and site of application or rapid detoxification of the herbicide by the crop plants. Reliance on these natural selective processes limits the effective use of potent herbicides; hence mechanisms to impart better herbicide selectivity in crops need to be investigated. Two approaches can be pursued to achieve this goal. The first is the design of specific chemicals with broad selectivity for crops. This approach, however, is expensive and the products thereof may be uneconomical for use by growers, not to mention that it is also a way to increase the already growing chemical load to the environment. According to Gressel [8], it has become increasingly difficult to discover new herbicides and even harder to come up with one that has a novel mode of action. In the 1940s only about 500 compounds needed to be screened to select a potential herbicide [8]. In addition" chemical handles" have to be designed to aid the rapid delivery of new chemicals into the target weed plant systems (Owen and DeBoer, 1995). The second and

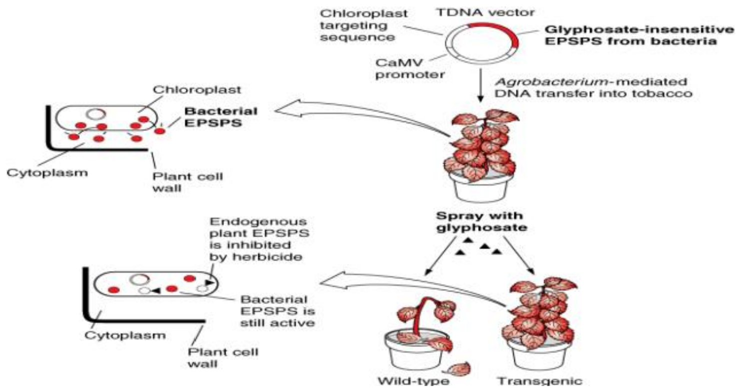

Fig. 1. Mechanism to develop glyphosate tolerant crop

more popular approach to crop herbicide selectivity is the development of crop cultivars with tolerance to the already existing effective broad spectrum herbicides so as to expand the crop options in which they can be used. Two methods can be used to develop crops with resistance to herbicides. Conventional plant breeding utilising lines that are known to be tolerant to specific herbicides is one approach that could confer resistance to susceptible crops from closely related species. However, this approach has limitations in that natural herbicide resistant plants are found more among weed species than in crops. Also, conventional plant breeding takes a long time to produce a single useful line. A faster approach is the use of biotechnology techniques such as in vitro cell culture, mutagenesis and selection in physiologically inhibitory concentrations of herbicides (also referred to as brute force selection) or genetic transformation of already existing crop cultivars with genes than confer resistance to herbicides.

5. CONCLUSION

As biotechnology progresses in all areas of science, and the cost of these large-scale technologies reduces, the influence to weed research will increase. These technologies allow new integrated approaches to investigate the advancement and spread of resistant weeds with the ultimate goal of providing better management strategies for weeds. weed resistances to many selective herbicides and the prohibitive expense and difficulty associated with the development of new herbicides, a need has arisen to seek alternatives to address these challenges. Further efforts to create more herbicide-tolerant crops are needed to ensure more economical crop production and safeguard environmental quality by reducing the demand for and the number of selective weed killing chemicals required for economical chemical crop protection.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Barton KA, Brill WJ. Science. 1983;219: 671-676.
2. Anonymous. High Technology Industries: Profiles and Outlooks-Biotechnology. U. S. Department of Commerce, Washington, D.C; 1984.
3. Paltridge NG. Plant protection quarterly. 2000;15:50-56.
4. Hardy RWF. *In* Pesticide Resistance: Strategies and Tactics for Management. (E.H. Glass, Chairman). National Academy Press, Washington, D.C. 1986;130-141.
5. Templeton GE. Weed Sci. 1986;34(Suppl. I):35-37.
6. Khachatourians GG. Trends Biorechnol. 1986;4:120-124.
7. Duke SO, Scheffler BE, Boyette CD, Lydon J, Oliva A. Herbicides, biotechnology. In Kirk-Othmer Encyclopedia of Chemical Technology, Wiley-Interscience, New York. 2005;13:346-369.
8. Gressel J. Molecular biology of weed control. Taylor andFrancis, London; 2002.