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Opinion

# Weed Control: Current and Prospective Approaches


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### Abstract

Weeds impose considerable yield losses to agricultural crops and cause problems in water canals, railroads, etc. Despite of long history of the human effort to manage weeds, the subject is still very challenging. This article reviews the current approaches applied in weed management and deals with new opinions concerned with weeds and their management.

**Keywords:** Bioherbicide; Biologicals; Biomolecule; Herbicide; Weed

## Opinion

Weeds are defined as plants unwantedly grown in an area considered for a particular purpose. From an agricultural viewpoint, weeds impose deleterious effects on crop health and yield through several ways including competition for sun light, water and nutrients, action as survival shelters of plant pests and pathogens during unfavorable environmental conditions, action as alternate hosts of heteroecious rust fungi, action as shelters and/ primary foci for pests and disease vectors, the increase of water loss via the increased evapotranspiration area, and the predisposition of crops to pest infestation and pathogen infection. Additionally, some weeds are invasive and can conquer an area in a short time. Some of weeds grow in water canals and can prevent normal water flow and changes in natural flora of waters [1]. The yield loss caused by weeds are very considerable in direct-seeded rice (15-66%), maize (18-65%), soybean (50-76%), and groundnut (45-71%) [2], significantly varying depending on the crop, weed management strategies, weed composition, infestation period, and abiotic factors such as climate and soil edaphic factors [3].

To manage weeds, cultural, physical, chemical, and biological approaches are applied individually or as parts of an integrated weed management program.

Cultural approaches- These methods include summer or off-season tillage, field preparation, use of clean (free from weed seeds) and sufficient crop seed, right sowing, crop rotation, intercropping, mulching, soil solarization, stale seedbed, blind tillage, and crop management practices. Cultural methods are cheap, non-pollutant, technically simple, not crop damaging, ecofriendly, and lead to effective weed control. However, perennial and problematic weeds are not effectively controlled. Indeed, cultural approaches are not fast effective.

Physical approaches- These simple but maybe labor-consuming methods include hand weeding, hoeing, tillage, digging, chilling, sickling, mowing, burning, flooding, mulching, etc. These approaches range from ecofriendly methods such as mulching, to environmentally destructive methods such as burning. Hand-driven, to power rotary and tractor-drawn rotary weeders are now available.

Chemical approaches- The chemicals applied to control weeds are known as herbicides or weedicides. Considering herbicidal Mode Of Action (MOA), Herbicide Resistance Activity Committee (HRAC) has most recently classified herbicides to four major HRAC groups [4]:

### Herbicides that affect light activation of Reactive Oxygen Species (ROS)

A. Inhibiton of photosynthesis at photosystem II (PS II) exemplified with D1 Serine 264 binders and other non-histidine 215 binders (Amides, Phenylcarbamates, Triazines, Triazinones, Uracils, and Ureas), as well as D1 Histidine 215 binders (Nitriles);

B. Inhibition of protoporphyrinogen oxidase (N-Phenyl-imides, Diphenyl ethers, N-Phenyl-triazolinones, and N-Phenyl-oxadiazolones);

C. PS I electron diversion (Pyridiniums);

D. Inhibition of glutamine synthetases (Phosphinic acids)

E. Inhibition of homogentisate solanesyltransferase

F. Inhibition of hydroxyphenyl pyruvate dioxygenase (Triketones, and Pyrazoles)

G. Inhibition of phytoene desaturase (Phenyl-ethers, N-phenyl heterocycles, and Diphenyl heterocycles)

H. Inhibition of deoxy-D-xylulose phosphate synthase (Isoxazolidinones)

I. Inhibition of lycopene cyclase

### Herbicides that affect cellular metabolism

A. Inhibition of acetolactate synthase (Imidazolinone, Pyrimidinyl benzoates, Sulfonanilides, Sulfonylureas, Triazolinones, Triazolopyrimidine types 1 and 2);

B. Inhibition of acetyl CoA carboxylase (Aryloxphenoxy-propionates, and Cyclohexanediones);

C. Inhibition of very long-chain fatty acid (VLCFA) synthesis (Alpha-chloroacetamides, Alpha-oxyacetamides, Alpha-thioacetamides, Azolyl-carboxamides, Isoxazolines, Oxiranes, and Thiocarbamates);

D. Inhibition of fatty acid thioesterase (Benzyl ethers);

E. Inhibition of cellulose synthesis (Alkylazines and Nitriles);

F. Inhibition of serine threonine protein phosphatase

G. Inhibition of enolpyruvyl shikimate phosphate synthase

H. Inhibition of dihydroorotate dehydrogenase

I. Inhibition of dihydroorotate synthase

### Herbicides that affect cell division and growth

A. Inhibition of microtubule assembly (Dinitroanilines, Phosphoroamidates, and Pyridines);

B. Inhibition of microtubule organization (Carbamates);

C. Mimicry of auxin (Benzoates, Phenoxy-carboxylates, Pyridine-carboxylates, Pyridyloxy-carboxylates, and Quinoline-carboxylates);

D. Inhibition of auxin transport (Aryl-carboxylates)

E. Uncoupling (Dinitrophenols)

## Herbicides that Affect Via Unknown Mode of Action

Herbicides are fast, however, their use needs cost, labor, and chemical treatment tools. Additionally, most herbicides are ecologically regarded as chemical pollutants and affect useful organisms (for instance, earthworms and fish). Some herbicides are associated with the endemic occurrence of cancers and abnormalities in humans and animals [5-10]. Another problem with the widespread use of herbicides is the herbicide-resistance development in weeds. Although some herbicides predispose treated plants (including crops) to some diseases [11], however, there are also some herbicides that directly affect the growth and development of some plant pathogens [12]. Some herbicides can modify crop physiology in a way toward increased resistance to some diseases. From this point of view, herbicides can be selected in a manner that the control of current weeds is accompanied with the suppression of the pathogens of the next crop. The importance of herbicides in such a scenario has been reviewed [13]. Therefore, the conscious selection of appropriate herbicides and their label-based use in a MOA-based rotation is strongly recommended. The diversity of herbicides in their mode of action provides an opportunity for such a strategy.

Biological approaches- These methods take advantage of living organisms (for example, livestock, birds, and even weed insect pests) and/ microorganisms (such as fungi and bacteria) that can control weeds. There are commercialized biological herbicides shortly regarded as bioherbicides. Bioherbicides consist of microorganisms such as pathogens and other microbes or phytotoxins derived from microbes, insects or even plant extracts that serve as natural means of weed control [14]. Among bioherbicides, mycoherbicides are a sub-group of bioherbicides that their active ingredients are plant pathogenic fungi that specifically affect targeted weed plant(s) or the formulated propagule is so short-living that cannot pass over weed to the next crop. The biological nature of these approaches leads to the variability in their outcome due to the factors discussed in the concept of a disease triangle.

## Future Prospects

With physical approaches, the development of conscious unmanned aviation vehicles as well as robotic vehicles equipped to laser guns may help to targeted eradication of weeds without any damage to crops and animals. Such vehicles can scout whole the land and eradicate weeds without any environmental pollution or soil erosion. They can also be programmed to recognize the first foci of pathogenic infections and pest attacks and treat the foci with effective chemicals. The pointed targeting of a weed will leave a chemical free mulch that can lead to increasing improved soil biology over time. With chemical herbicides, the development of nanotechnology can lead to nano-based herbicidal products which are more penetrative and more effective than their conventional counterparts. The application rate of nano-based products is significantly less than their conventional counterparts and this can lead to reduced environmental pollution [15,16].

With bioherbicides, microbial herbicides seem to be more interesting. The production of microbial herbicidal biomolecules seems more practical and amenable to biotechnological production. With microbial herbicides, it may be more practical to use soilborne fungal pathogens of weed plants due to the necessity of sub-surface drop irrigation in global warmth era. While increased temperatures may restrict the efficacy of biological control agents on weed foliage, the continuous supply of water provides a humid environmental conditions under cooler temperatures favorable for its growth, development, and biological activity. Also, the genetic transformation of biological control agents can help increasing the effectiveness of BCAs applied in weed control [17,18].

Some microbial metabolites, in particular phytotoxic metabolites may serve as herbicidal biomolecules. These toxins are not as sensitive as bioherbicidal microorganisms to unfavorable environmental conditions. Furthermore, toxins may be more stabilized via chemical engineering and improved formulations [19]. Moreover, toxin bioactivity can be enhanced by addition of synergistic chemicals [20]. The application of biomolecules is safer from the view point of bio-immunity as well as illegal misuses. Biological control agents can be easily isolated and illegally fermented and misused. As toxins usually act in very low concentrations (physiological rates), therefore, their application rates are so low that the probability of their involvement in environmental pollution and consequent biohazards would be practically ignorable. Current studies with purified fungal metabolites have shown the potential of fungi as the resources of new generation of herbicides [21,22]. Some herbicidal biomolecules may also represent new modes of herbicidal actions for the production of new synthetic herbicides.

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