Article ID: AEN-2021-02-03-008

Recent Advances in Weed Management

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Weeds are one of the most important biological constraints in agricultural production systems. They negatively affect crop growth and yield by competing with crops for nutrient, sunlight, space, and water. Therefore, management of weeds in all agro-ecosystems is imperative to sustain our crop productivity and to ensure the food security to the burgeoning population.

Moreover, agriculture has promoted new methods, which also directly or indirectly affect weed control. These methods are demand a new approach for weed control. For example, organic agriculture does not permit the use of chemical herbicides, therefore cultural and biological control are the only possible means left to cope with weeds.

Allelopathy/Allelochemicals

Allelopathy is a biological phenomenon by which an organism produces one or more biochemicals that influence the growth, survival, and reproduction of other organisms. These biochemicals are known as allelochemicals and can have beneficial (positive allelopathy) or detrimental (negative allelopathy) effects on the target organisms.

Allelochemicals are a subset of secondary metabolites, which are not required for metabolism (i.e. growth, development and reproduction) of the allelopathic organism. The term allelopathy or Teletoxy was introduced by Molisch (1937). Parthenium daughter plants exhibiting teletoxy to its parent plants is known as autotoxy. The word allelopathy is derived from Greek –

allelo, meaning each other and patho, an expression of sufferance of disease.

The effect of allelochemicals on the growth of plants may occur through various mechanisms like reduced mitotic activity, suppress hormone activity, reduced rate of nutrient uptake, inhibit photosynthesis, respiration, and inhibit protein formation, reduction in permeability of cell membrane and enzyme action. The use of allelopathically active crops against weeds can be utilized in different ways: surface mulch, incorporation into soil, crop rotation, cover crops, intercropping, water extracts as natural herbicides and incorporating an allelopathic character into a desired crop variety.

Efficient Use of Herbicides/ Herbigation

Increased interest in organic agriculture calls for alternative solutions for weed management. As a result, number of directions has evolved of which a more efficient use of herbicide is a first track. This strategy can be implemented through the use of micro herbicides, different herbicide combinations, improvements in the application technology like types of nozzles, spray volume, diameter and use of factor adjusted dosages, use of surfactants or adjuvants and go for herbigation.

Compatible herbicide combinations control the weeds in a single pass. Besides that, it also reduces the occurrence of herbicide resistant biotypes in weeds by using single herbicide. In ready mix formulations, the different herbicides are mixed in desired concentration to avoid any phytotoxicity to crop. Through the use of micro herbicides, we can reduce the dose of chemicals applied on per ha to micro levels. Adding surfactants and adjuvants facilitates to improve spreading, wetting, dispersing and other surface modifying properties which enhance the action of active ingredient. Herbigation is the effective method of applying herbicides through irrigation systems. Success of good herbigation programmes depends upon good management, uniform water applications and knowledge of the movement of herbicides in the soil.

Residue Management of Herbicides

When applied at recommended rates most herbicides breakdown within a few days or weeks after application and impose no restrictions on cropping options the next year. Some herbicides however do not degrade quickly and can persist in the soil for weeks, months or years following application. The use of residual herbicides can be beneficial as the residues prevent growth of sensitive weed species throughout the season. These residues however can restrict the crops that can be grown in rotation. Understanding the factors that influence carryover and breakdown are key to assessing risk and the appropriate follow crop. If herbicide carryover is suspected, knowing the appropriate sampling procedures and soil tests to obtain will assist in determining and minimizing herbicide carryover.

Herbicide Resistance in Weeds and Crops

Herbicide resistance causes changes in the composition of the population because of resistant biotypes. Originally at very low frequencies in the weed population, resistant biotypes build up when the herbicide to which those individuals are resistant is used repeatedly.

Bioherbicides

A bioherbicide is a biologically based control agent for weeds. Bioherbicides are made up of microorganisms (e.g. bacteria, viruses, fungi) and certain insects (e.g. parasitic wasps, painted lady butterfly) that can target very specific weeds. The microbes possess invasive genes that can attack the defense genes of the weeds, thereby killing it. Bioherbicides may be compounds derived from microbes such as fungi, bacteria or protozoa; or phytotoxic plant residues, extracts or single compounds derived from other plant species. A bioherbicide based on a fungus is called a mycoherbicide. In the industry, bioherbicides and other biopesticides are often referred to as "naturals".

Mycoherbicides

A mycoherbicide is an herbicide based on a fungus. As a biological agent, these mycoherbicides. Work by producing toxic compounds that dissolve the cell walls of targeted plants". Unlike traditional herbicides, mycoherbicides can reproduce themselves and linger in the soil for many years to destroy replanted crops.

Trade name	Pathogen	Target weed
Devine	*Phyophthora palmivora*	*Morreria odorata* (Strangler vine) in citrus
Collego	*Colletotrichum gleosporoides f.sp. aeschynomene*	*Aeschynomene virginica* (northen joint vetch) in rice and soyabean
Biopolaris	*Biopolaris sorghicola*	*Sorghum halepense* (Johnson grass)
Biolophos	*Streptomyces hygroscopius*	General vegetation(non-specific)
LUBAO 11	*Colletotrichum gleosporoides* f.sp. *Cuscuttae*	Cuscutta sp. (Dodder)
01	*Alternaria cassiae*	*Cassia abtusifolia*
ABG 5003	*Cercospora rodmanii*	*Eichhornea crassipes* (water hyancinth)

Weeds as Bio Fluids

Liquid fuels made from biomass for energy purposes. This has a high energy density. This is helpful to reduce dependency on nano fluids. Adding product value to the invasive weeds may prove to be an effective way for weed management. So many weeds have the potentiality of being used as bio fluid. Thermal conduction nature of these weed based bio fluids are comparable with presently used nano fluids.

Thermal weed control

Several options for controlling weeds using heat have been developed. These include: fire, directed flaming, hot water, steam, microwave, infrared, ultraviolet radiation, electrocution and freezing. Heating results in the coagulation of proteins and bursting of protoplasm due to expansion, which kills the tissue. Weeds can also be killed by exposure to very low temperature, e.g. by exposing aquatic weeds to low air temperature by removing water from a pond or lake or by freezing terrestrial weeds using dry ice or liquid nitrogen.

Thermal weed control options offer several advantages. They generally do not disturb buried seeds, leave dead biomass on the soil surface, which offers protection against erosion and moisture loss, and may kill some insect pests and pathogens and most importantly, do not pollute the environment with synthetic herbicides.

Remote sensing in Weed Management

Art and science of obtaining useful information about an object without being in physical contact with it without physically contact between the object and sensor. Remote sensing uses the electromagnetic spectrum to image the land, ocean and atmosphere. Remote sensing applications for distinguishing between agricultural crop types and internal crop characteristics have been extensively researched during the past decade.

Robotics in Weed Management

Autonomous robotic weed control systems hold promise toward the automation of one of agriculture's few remaining unmechanized and drudging tasks, hand weed control. Robotic technology may also provide a means of reducing agriculture's current dependency on herbicides, improving its sustainability and reducing its environmental impact. Agricultural robots have great potential to deliver weed control technologies that are much more adaptable even down to the plant scale. They potentially could direct chemical or cultivation tools to directly target weed plants.

Agricultural robots can have these characteristics because they bring recent advances in artificial intelligence (AI) to bear on the control of weeds in crop fields.

Laser Technology in Weed Management

A laser beam directed towards weeds can be an efficient weed control method as an alternative to herbicides. Lasers deliver high-density energy to selected plant material, raising the temperature of the water in the plant cells and thereby stop or delay the growth. A commercial use of lasers for weed control, however, require a systematic investigation of relationship between energy density and the biological effect on different weed species, growth stages, etc.

RNA Interference Technology in Weed Management

It's a way to destroy specific RNA messages so that a particular protein is not made. It is an elegant way of targeting particular genes and turning those genes off. It involves the topical application of a mixture of glyphosate and double stranded RNA to interfere with the expression of herbicide resistance genes in weeds.

Nanotechnology in Weed Management

Nanotechnologies are the design, characterization, production and application of structures, devices and systems by controlling shape and size at nanometer scale. Molecular characterization of underground plant parts for a new target domain and developing a receptor-based herbicide molecule having specific binding property with nano-herbicide molecules like carbon nanotubes capable of killing the viable and dormant underground propagates of weed seeds. In addition, nano-encapsulation allows for the gradual release of herbicide, which can provide improved levels of crop safety over other formulations. Nanomaterials have found unprecedented utility in various fields of science including medicine, manufacturing and material construction, chemical formulation, delivery of molecules into cells, sensors, and others. It has opened unchartered territories of scientific investigations in agriculture. Being 100 nm or less in size, nanoparticles have large surface area: volume ratio enabling applications that were formerly untenable.

Conclusion

Even though, there are so many advances had undertaken in the field of weed management, the importance of these methods lies in its usability in farmer's field. The advances in weed management includes efficient use of herbicides, laser technology, site specific management, herbicide interaction, herbicide bioassays, RNA Interference Technology, use of bioherbicide, use of mycoherbicide, use of herbicide resistant crops, robotics, drones, remote sensing, nano technology, used as heat transfer biofluids, adjuvants and allelopathy. Out of these methods, the most adaptable method is efficient use of herbicides. This can be easily practiced by the farmers in the field when compared to other methods. Biological methods and non-chemical weed management are useful for maintaining good soil health and also environmental quality. Other approaches are need based or demand driven in nature.

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