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Herbicide Resistant Crops- Its Prospects and Impacts

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SUMMARY

The creation of herbicide-resistant crops has led to significant adjustments in agronomic procedures, one of which is the adoption of efficient, straightforward, low-risk crop production systems that rely less on tillage and use less energy. Overall, the changes have had a positive environmental effect however, repeated and intensive use of herbicides with the same mechanisms of action and in the absence of herbicides with various modes of action being used concurrently, the application of mechanical, cultural, or combination mechanical and cultural activities can rapidly select for shifts to tolerant, difficult-to-control weeds and the development of herbicide-resistant weeds.

INTRODUCTION

In comparison to other biotic restrictions, weeds are the main crop production constraint that results in the biggest crop productivity losses of more than one-third. Herbicide-resistant weeds are one issue brought on by an over-reliance on herbicides for weed control in various cropping systems. A new frontier in herbicide technology has opened up with the development of herbicide-resistant crops as a result of recent advancements in diverse biotechnological approaches. So, herbicide-resistant crops (HRCs) are genetically modified plants that can withstand certain broad-spectrum, non-selective herbicides that destroy all the associated weeds without harming the particular cultivated crop. HRCs are also referred to as herbicide-tolerant crops. When used wisely, HRCs offer farmers significant promise in the simplification and increased flexibility of weed management. The benefits of herbicide resistant crops include greater agricultural production due to broad spectrum weed control, decreased crop damage, decreased herbicide carryover on succeeding crops, less influence on the environment due to usage of ecologically friendly herbicides, and decreased cost of cultivation. The commercialization of HR crops may result in the spread of the gene causing herbicide resistance to related wild and weedy relatives, which could result in the development of super weeds, weed shift species, and a reduction in biodiversity.

Significance of Herbicide-Resistant Crops

Herbicide resistant crops provide a huge efficient, economical and simplified weed management potential. These crops may be beneficial to the environment by enabling reduced or no-till systems and thus reducing erosion or allowing for later weed control when handled judiciously and thus may increase biodiversity in the field. It enables the farmer to more effectively apply low- or no-tillage cultural methods, promote conservation agriculture, remove the use of some herbicides that are particularly hazardous to the environment, and use less herbicides to control practically all weed species. It may be a weed control technology that can be used in conjunction with cultural, preventive, mechanical, and chemical weed control methods as one of the integrated weed management (IWM) strategy components. This helps to ensure the long-term benefits of a successful and environmentally responsible weed control programme.

Definition of HRCs

Herbicide resistant crops are genetically modified crops designed to withstand and survive specific broad-spectrum herbicides, that will kill the surroundings weeds without harming the cultivated crops. Herbicide resistance is the inherited ability of a population of plants to survive and reproduce following exposure to a dose of herbicide which is normally lethal to the wild type of that plant.

Impact of Herbicide-Resistant Crops

Herbicide resistant crops have both positive and negative impacts of which positive impact overshadow the negative ones.

Positive impacts:

Efficient weed control

Herbicide resistant crops technology provide a great potential for efficient weed management as it involves the use of non-selective herbicides like glyphosate and glufosinate that aid in broadening the spectrum of weed control. Glyphosate-resistant and glufosinate-resistant crops are the two mostly grown transgenic HRCs presently. The systemic activity of these herbicides not only efficiently control perennial weeds but also helps in destroying their perennial vegetative structures such as tubers, rhizomes and stolons. Simpler and more flexible weed control programmes can be designed, *viz.* post-emergence only (*e.g.*, glyphosate, glufosinate), tank-mixtures, or a pre-emergence followed by post-emergence herbicide applications as needed for each HRC. HRCs provide greater flexibility in application timing. For example, glyphosate can be applied from emergence to flowering in GR crops.

Reduced crop injury

Herbicidal weed management either with selective and non-selective broad-spectrum herbicides often results in phytotoxicity to the cultivated crops, even when applied with utmost care and thus causing injury to the crops. Such crop injury may recover depending on the degree, type and duration of toxicity but there will be considerable loss in crop yield. This limitation is generally reduced with the used of herbicide resistant-crops as such crops have been genetically designed to withstand and resist to the herbicides. Both glyphosate and glufosinate cause almost no crop injury compared to some traditional herbicides (*e.g.*, lactofen, clorimuron), especially on soybean.

Reduced herbicide carry-over

Glyphosate and glufosinate have been reported to have almost no soil residual activity because they tend to tightly bound to the organic particles of soil as soon as they are applied. Due to this property, there are few restrictions for planting or replanting intervals and few injuries to subsequent crops. This trait facilitates crop rotation by providing flexibility in selection of potential rotation crops which is generally impossible in case of selective herbicides.

Less environmental impact

Use of glyphosate and glufosinate will have less toxicity effects on humans, animals and other environmental surroundings. Unlike other selective herbicides, these herbicides are known adsorbed and bound tightly to organic materials in the soil and decompose rapidly, they pose less danger and concern of herbicide soil residual and its leaching in soil, toxicity to wildlife or contamination of ground water.

Less labor intensive

The chief attraction of HR crops to farmers is making weed control more flexible, simpler, and less labor-intensive. The herbicide-resistance trait allows the associated herbicide to be applied through much or all of the season without damaging the crop whereas the same herbicide can only be applied before planting or seed-sprouting with conventional crops.

Reduced cost of cultivation

Herbicide resistant crops helps in reducing the cost of production through various effective weed management practices. Even with the increased seed cost associated with a technology fee, HR crops still reduced the cost to manage weeds and ultimately improved farm productivity.

Negative impacts:

Weed shifts

Wide spread adoption and monoculture of HRCs has resulted in the evolution of herbicide resistant weeds as well as shift in weed spectrum towards non-native and non-cropland weeds in agronomic crop environments. A weed species shift can involve a change in density or diversity in weed flora in a crop production system as a consequence of prevailing weed management practices. Over reliance on herbicides for weed management leads to shift of weed species composition. In case of glyphosate-resistant crops, sequential application of glyphosate and the proper timing relative to emergence of weeds is imperative for favourable optimum weed control (Swanton *et al*., 2000). When glyphosate is sprayed 2-3 times annually at high rates it imposes a high selection pressure on the weed flora. In 5-8 years, this may cause shifts in weed composition towards species that naturally tolerate glyphosate (Benbrooke, 2001).

Gene flow and development of super weeds

Gene flow is defined as "the incorporation of genes from one or more other populations into the genepool of one population." Transferring genes from one population to another can have unintended consequences for weed management and the environment. Resistance genes may be able to move between HR and non-HR varieties via gene flow, polluting a GM-free crop. HR-genes may be stacked as a result of years of cross-pollination of HRCs, posing problems for farmers in controlling volunteer crops in the field.

Herbicide-resistant weeds via cross-pollination

By cross-pollinating with sexually compatible weeds, HR crops can also produce herbicide-resistant weeds. However, few problematic weeds have been generated in this manner as of yet, owing primarily to the fact that the HR crops grown thus far (soybeans, corn, and cotton) have few weedy relatives with which to interbreed. By passing the resistance trait to feral (wild) alfalfa, Roundup Ready alfalfa is very likely to cause serious weed problems. Because alfalfa is cross-pollinated by bees over long distances, this is going to be a major issue for both conventional and organic alfalfa growers.

Herbicide-resistant crops as weeds

In the form of "volunteers," which are plants that sprout in subsequent seasons from seed left in the field after harvest, the HR crop itself can act as a weed. Volunteer Roundup Ready corn has been identified as a serious weed in RR soybean fields in the United States, with the potential to cause significant yield losses if not controlled (Morrison, 2012).

CONCLUSION

The introduction of HRCs, particularly GR crops, has transformed weed management. HRCs as weed management tools have enabled farmers to manage weeds more effectively and economically. Herbicide resistant crops have provided the agricultural growers with agronomic, financial, and environmental advantages, including time and cost savings for production and an increase in the use of conservation tillage techniques more easily. Herbicide-resistant crop technology enabled the use of broad-spectrum herbicides like glyphosate and glufosinate to control of specific problematic weeds and weeds that had evolved resistance to other herbicide MOAs. On the contrary, widespread adoption of HRCs has dramatically increased herbicide use, leading to an increase in resistant weeds and weed species shifts. It must be underlined, nonetheless, that the risk posed by HRCs should be carefully assessed before the HRC is released into a cropping system, particularly if the HRC possesses weedy traits or has the potential to cross with related weeds.

Prospects of Herbicide-Resistant Crops

Despite the numerous advantages of HRCs and other transgenic crops, there are some unavoidable drawbacks as well, some of which are clear while others are less so. The development of herbicide resistance in weed populations has been the most significant issue requiring attention since the launch of HRCs. The development of the next generation of HRCs (and other transgenic crops) has received the majority of funding from the agrochemical industry, seed companies, and related organisations. This is done in an effort to diversify growers' crop portfolios and combat weed resistance by developing cropping technologies that enable the use of multiple modes of action herbicides. Several of these technologies might be indefinitely shelved due to the strict regulatory oversight and clearance needed, either for reasons that are not made public or are out of the scope. For instance, a new method of glyphosate resistance was created (Castle et al., 2004) and combined with a high resistance phenotype from a different mechanism of action of herbicides, but it was abandoned just before it was ready for commercialization.

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