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Herbicide Resistant Crops

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Herbicide resistant (HR) or tolerant (HT) crops are created through genetic engineering to tolerate broad-spectrum herbicides, which kill the competing weeds without any effect to cultivated crop. The adoption of HT or HR crops will improve soil retention capacity and surface water quality. These crops will also support the conservation tillage practices.

Introduction

Herbicides cannot differentiate between plants that are crops and plants that are weeds, conventional agricultural systems can only use 'selective' herbicides. Such herbicides do not harm the crop, but are not effective at removing all types of weeds. On the other side 'broad-spectrum' or non-selective herbicides are not always useful. Such non-selective herbicides are effective at killing a wide range of weeds. The problem is, they can also kill valuable crops. Therefore, broad-spectrum herbicides are only useful before seedlings emergence or in special cases like fruit orchards, vineyards, and tree nurseries. If farmers use herbicide resistant/tolerant (HR/HT) crops, 'non-selective' herbicides can be used to remove all weeds in a single, quick application. Consequently, less chemical spraying and operating costs of farming. The adoption of HT or HR crops will improve soil retention capacity and surface water quality. These crops will also support the conservation tillage practices.

Resistant to herbicide in a plant is inherent ability to tolerate and reproduce even after exposure to herbicide at a lethal dose. If natural resistance is absent it can be induced through genetic engineering and crop so created known as HT crop (HTC). HTCs consistently occupied the largest planting area of biotech crops. Across the world, in 2011, HTCs covered more than 93 mha (approx. 60% area of GM crops). Among HTCs, glyphosate and glufosinate tolerant varieties are most common. Glyphosate causes misregulation of the shikimate pathway of aromatic amino acid synthesis by inhibition of 5-enolpyruvylshikimate-3-phosphate (EPSP) synthase (gene AroA). HTCs have been generated in maize, cotton, canola, soybean, sugar beet, rice, etc. Soybean was the first Roundup Ready crop, and was produced at Monsanto Agracetus Campus located in Middleton, Wisconsin.

Strategies to Develop HT Crops

Various strategies may be deployed to engineer the crops for herbicide resistance. Generally, four distinct strategies are used for this purpose: 1) Over-expression of target protein 2) Mutation of target protein 3) Detoxification of herbicide and 4) Enhanced plant detoxification process.

1) Over-expression of target gene: The toxic effect of herbicide can be coped up by overproducing the target protein or enzyme. This overproduction of protein through gene expression can be achieved by integration of multiple copies of target gene and by suing strong promoter along with enhancer.

2) Mutated target gene: The logic behind this approach is to find a modified target protein that substitute the native herbicide sensitive protein and which is resistance to herbicide action. There are several sources of mutated proteins.

Herbicide	Enzyme/protein	Source
Glyphosate	EPSP synthase (*AroA*)	*Salmonella typhimurium*
Sulfonylurea and Imidazolinone	Acetolactate synthase (ALS)	*E. coli & Yeast*
Glyphosate	EPSP synthase (*AroA*)	*Agrobacterium* strain CP4

3) Detoxification of herbicide using single foreign gene: means transformation of chemical to lesser toxic or non-toxic form and eliminating it from system through metabolism. This strategy is independent from prior knowledge of gene sequence and its site of action.

Herbicide	Enzyme/protein	Source
Glyphosate	Oxidoreductase (GOX)	*Ochrobactrum anthropi*
2, 4D	Monoxygenase	*Alcaligenes entrophus*
Bromoxynil	Nitrilase (*Bxn*, plasmid)	*Klebsiella ozaenae* (Metabolize bromoxynil & ioxynil – nitrogen source)
Phosphinothricin/Glufosinate	Acetyl transferase (PAT)	*Streptomyces hygroscopicus and S. viridochromogenes*

Phosphinothricin blocks the GS (glutamine-synthase) enzyme allows toxic ammonia to build up in the plant's cells, causing the plant to die. While bromoxynilis inhibitor photo system (PS) electron transport. The GOX enzyme in canola converts glyphosate in non-toxic forms that is glyoxylate and aminomethylphosphonate. The bar gene, encodes a phosphinothricin acetyl transferase (PAT) which confers resistance in *Streptomyces hygroscopicus* to bialaphos that detoxifies the herbicide through acylation. Transgenic plants showed complete resistance towards high doses of the commercial formulations of phosphinothricin and bialaphos.

4) Plant detoxification enzymes: This is strategy to improve natural defense mechanism of crops against specific herbicide. The detoxification of bromoxynil by endogenous cytochrome P450 Monoxygenase is one of the examples of natural plant defense system. The detailed information about plant's endogenous detoxification pathway/mechanism is essentially required for perfect identification and detoxification of toxic compound.

Conclusion

Though HR/HTCs promote conservation tillage thus reduces soil erosion. However, horizontal gene flow of HR gene(s) from HTC into wild relatives has the potential to intensify problems with existing weed species in HT crops. Gene transfer may also increase the violence of those species that are not generally considered weeds.