Genetics and breeding of herbicide tolerance in sunflower

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ABSTRACT

- Herbicides are the most desirable method for weed control, especially under no-tilling conditions. Nevertheless, the availability of selective herbicides for sunflower is quite limited and, due to the high cost of herbicide registration, new molecules of herbicides are unlikely to be specifically developed for weed control in sunflower. Growers have traditionally relied on preemergence herbicides for weed control in this crop. However, soil-active preemergence herbicides are expensive and require timely rainfall or irrigation for activation. Also, some are marginally effective because of the narrow spectrum of weeds controlled. For this reason, gene discovery and trait development for herbicide resistance in this crop, particularly imidazolinones (IMI) and sulfonylureas (SU), was an active area of research during the past decade.

- There are three primary mechanisms of herbicide tolerance (HT) in sunflower: (i) tolerance caused by mutations in target sites of the herbicide (*target-site tolerance*), (ii) tolerance caused by mutations in non-target sites (*non-target site tolerance*), (iii) tolerance caused by the additive interaction of both target and non-target site tolerances. Although there are some examples of gene discovery for non-target site mechanisms of tolerance in sunflower, the main focus of research and development during the last decade was directed to the discovery of altered acetohydroxyacid synthase (AHAS) genes and enzymes. In this way, several natural or induced mutant alleles of the sunflower *Ahasl1* locus were reported and characterized. Four of them were utilized to develop different traits and technologies of weed control: Clearfield®, Clearfield Plus®, Sures, and ExpressSun®. Each one is described briefly, with their own characteristics, cross-tolerance, benefits and drawbacks. Some methods to speed up the introgression of these traits into the breeding program are described, as well as the dominance relationships between some members of the multiallelic *Ahasl1* locus. The possibility of broomrape control by using these technologies is also highlighted.

- Several herbicide resistant genes were discovered, and many HT traits and technologies for weed control were developed for the sunflower crop in the last decade. Proper utilization of these technologies allowed, and will continue to allow, an excellent weed control for the sunflower crop. However, some of these genes and their allelic interactions remain to be tested and developed in the next years in order to create novel technologies. Additionally, it is clear that only one mode of action —the inhibition of the AHAS enzyme— is being exploited until the present. This will prompt the rapid selection of tolerant weeds that will jeopardize the sustainability of all these technologies. Selection over cultivated germplasm, wild *Helianthus* species and mutagenized libraries will allow the discovery of new sources of HT, especially to other modes of action apart from the inhibition of AHAS, in order to complement the current technologies. In addition, new interactions between target and non-target site tolerance mechanisms should be explored as potential novel HT traits for the sunflower crop.

Key words: Clearfield®, ExpressSun®, imidazolinone, Imisun, sulfonylurea, Sures, weed control.