Herbicidal Selectivity and Phytotoxicity

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Herbicides play a pivotal role in modern agriculture by aiding in weed control, a critical aspect of successful crop management. However, the indiscriminate use of herbicides can lead to unintended consequences, causing damage to non-target plants and the environment. Herbicide selectivity, therefore, emerges as a fundamental concept in agricultural practices. It refers to the ability of a herbicide to effectively control target weeds while minimizing harm to the desired crops. Achieving selectivity is a delicate balance, requiring an understanding of the biochemical, physiological, and genetic factors that differentiate crops from weeds.

In the pursuit of sustainable and environmentally conscious agriculture, herbicide selectivity has gained prominence. Farmers and researchers alike seek herbicides that exhibit a high degree of selectivity to optimize weed management without compromising the health and yield of the cultivated crops. This introduction explores the significance of herbicide selectivity, the challenges associated with achieving it, and the advancements in research and technology driving the development of more selective herbicides. As we delve into this crucial aspect of weed management, we uncover the intricate mechanisms that make herbicide selectivity both a challenge and an opportunity in modern agricultural practices.

What is herbicide selectivity?

Selectivity refers to the phenomenon by which in a mixed stand of plants, some plant species (e.g. weeds) are preferentially controlled or killed, while other (e.g. crop plants) remain unaffected when a herbicide is applied to them. When one plant species is more tolerant to the herbicide than another plant species, the herbicide is considered to be selective

Selectivity results from the differential response of plant species to herbicides and is a complex phenomenon achieved by complex interaction between plant, herbicide and environment (climate and soil). Selectivity is a relative property of a herbicide and is dependent largely on the time, method, rate and formulation of herbicide application, environmental conditions (e.g. soil moisture, temperature, texture, humidity, rainfall etc.), plant species and the stage of growth of crop and weeds. A herbicide is selective to a particular crop only within certain limits. It is more herbicide rate-dependent, environment dependent and crop-specific.

Selectivity index (SI)

SI is the ratio of maximum dose of herbicide tolerated by the crop to the minimum dose of herbicide required to control weeds. The higher the selectivity index, the greater is the safety to a crop. If SI is greater than 2, the herbicide is safer for use without much fear of crop damage.

Kinds of selectivity

Four major types of selectivity

1. Physical
2. Chemical
3. Biological
4. Chronological

Physical selectivity

It could be achieved due to manipulation of a number of factors, e.g. sowing depth of crops, modifying application devices, etc.

- Depth protection selectivity of pre-emergence herbicides
- Externally-working antidote-mediated selectivity

- Application device protection selectivity of non-selective herbicides
- Selectivity to non-selective herbicides achieved due to other means

Chemical selectivity

Selectivity achieved due to structural changes of herbicides is called chemical selectivity. Chlortoluron has -CH_3 group, while diuron has –Cl group on the fourth carbon position of the phenyl ring. Otherwise, they both have similar structures and belong to phenylurea group. Due to this difference, diuron is selective to cotton, while chlortoluron is selective to wheat.

Biological selectivity

Selectivity achieved due to metabolism/reverse metabolism of herbicides inside plants is called biological selectivity. Differential physiology across plants is exploited to attain this kind of selectivity. For example, propanil is selective to rice, but not to the grassweed *Echinochloacolona*.

Chronological selectivity

Selectivity achieved due to manipulation of the time of application of a herbicide is called Chronological selectivity. The selectivity results from the application of same herbicide as pre-planting, preemergence or post-emergence are chronological selectivity. For example, pendimethalin is selective to most crops, when applied as pre-emergence, but not as post-emergence.

Factors affecting selectivity

plant factors

It includes anatomy, morphology and physiology of plants. Varying plant architecture, growth behaviour, bio-chemical and bio-physical processes across plants are highly responsible for imparting herbicide selectivity to plants.

Morphology of plants

- Location of growing points of plants
- Leaf/canopy
- Root system
- Age/stage of the plants

Physiology of plants

- Uptake
- Translocation
- Metabolism of herbicide

Herbicide factors

- Class of a herbicide
- Formulation of herbicide
- Time of herbicide application
- Dosage of herbicide
- Method of herbicide application

Environmental factors

- Climatic factors
- Temperature
- Relative humidity
- Sunlight
- Rainfall

Soil factors

- Organic matter content
- Texture and structure of soil
- Soil temperature
- Soil moisture
- Soil pH

What is phytotoxicity?

Phytotoxicity is a toxic effect by a compound on plant growth.

Phytotoxic means harmful or lethal to plants

Phytotoxicity is the degree to which a chemical or other compound is toxic to plants

Phytotoxic effects can be from spray droplets, soil residues or vapours contacting sensitive plants. Plants can also be harmed by herbicides which move off target in water or soil or when sensitive crops are planted in fields too soon after a herbicide treatment was applied.

Phytotoxicity of herbicides

Sr. No.	Herbicide type	Symptoms
1.	Pre-emergence	Reduce germination
		Suppressed crop growth
		Produces deformility in crop plants
2.	Post-emergence	Leaf injury
		Wilting
		Vein clearing
		Necrosis
		Epinasty

- Phytotoxicity is not necessarily caused by the active ingredient.
- Plant damage can also be caused by: the solvents in a formulation, impurities in spray water, using more pesticide than listed on the label, or poorly mixing of the spray solutions.
- Condition of the plant at the time of treatment can affect phytotoxicity; stressed plants may be more susceptible.
- The variability of the weather is a major cause of unreliable herbicide performance resulting in either inadequate control of weeds or crop damage.
- In order to meet the most economic use of herbicides, with minimal adverse effect on the environment, it is important to know how light, temperature, humidity and rain affect herbicide performance

Minimize the risk of phytotoxic effects by

- Reading and following label directions, especially the correct rates and timing, and being aware of potential weather effects
- Avoiding application when drift is likely to happen waiting for the correct planting times if unsure, conduct a simple field bioassay by treating only a few plants, before the treating whole block to check for phytotoxic effects, especially when growing new cultivars
- Incorporating organic matter, such as compost or manure helps adsorb the herbicides into the organic matter rendering it unavailable or inactive.

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