Chemical Control of Weeds

Herbicides – chemicals used to suppress or kill unwanted vegetation

Advantages and Disadvantages of Herbicides

Advantages	**Disadvantages**
Important where labor is scarce or expensive. Save labor and energy by reducing need for hand labor and tillage.	Mammalian toxicity
Control weeds in crops rows where cultivation is not effective	Adverse effects on water quality Contamination of surface and ground water
Useful when other methods are less efficient or impossible (eg mechanical cultivation when wet; cultivation can injure crop roots and foliage; cultivation may not be sufficiently cost-effective or timely.	Environmental persistence, carry over can limit rotation options and negatively affect subsequent crops.
Reduce the need for tillage and decrease the number of trips across the field with heavy equipment - preserve soil structure; reduce soil erosion. Suitable for reduced tillage systems.	Herbicide drift. Movement off-target due to volatilization or wind blowing tiny droplets.
Good option for perennial species not well controlled with other options	Weed resistance to herbicides. Decreased response of a species population to a herbicide that was previously well-controlled by the herbicide.
Reduce fertilizer and irrigation requirements by removing competing weeds.	Promotes monoculture and discourages diversity
Reduce harvest costs	Precision required: herbicide selection, when to use, how much to use, how to dispose of surplus chemical.
Reduce grain drying costs - weedy green plant material is absent.	Can cause weed shifts
Other weed control methods may accomplish these things but not as efficiently and not as cheaply.	Herbicides are expensive, equipment for application is also costly, large externalized societal costs.

Formulations: The herbicide preparation as supplied by the manufacturer for use by the public.

Contains: the active ingredient – the actual phytotoxic material, plus inert ingredients (all other ingredients eg solvents, diluents, encapsulating materials, and various adjuvants (substances used to modify the characteristics of a preparation for ease of use and to improve efficacy).

There are 2 main types: sprayable and dry formulations

Sprayable:

Water-soluble formulations
Soluble liquids (SL)
Soluble powders (SP)
Soluble granules (SG)

Emulsifiable formulations
Emulsifiable concentrates (E or EC)
Gels (GL)

Liquid suspensions to be dispersed in water
Suspension concentrates (SC) and aqueous suspensions (AS)
Emulsions of a water-dissolved herbicide in oil (EO) and emulsions of an oil dissolved herbicide in water (EW)
Micro-encapsulated formulations (ME) or capsule suspensions (CS)

Dry solids to be suspended in water
Wettable powders (W or WP)
Water-dispersable granules (WDG, WG, DG) or dry flowables.

Dry
Granules (G)
Matrix granules (G)
Pellets (P)

Classification of Herbicides (Many ways for convenience)

1. Selectivity

Chemical is more toxic to undesirable species that the desirable species. Nonselective herbicides are toxic to all species.
Selectivity is a function of rate but is also influenced by other factors such as plant age and stage of growth, plant morphology, absorption, translocation, time and method of application, herbicide formulation, environmental conditions.

2. Site of Uptake:

Foliar applications are made to the leaves or foliage of the target plants.
Soil applications are made to the soil.

3. Persistence

Residual herbicides injure or kill germinating seedlings over a short period of time – usually cropping season or less.

Persistent herbicides can harm plants after the initial cropping season. Can harm rotational crops and prevent regrowth of native vegetation in noncrop areas.

4. Coverage of target area

Broadcast treatments are applied over the entire target area. Banded applications are done on or along the crop row only so less herbicide is needed to cover the filed.

5. Time of application (Figure)

* Chemical fallow – applied during the period between crops.
* Preplant – applied to soil surface before seeding or transplanting.
* Preplant-incorporated tillage or irrigation used to move the herbicide to a particular soil depth to achieve selectivity (activation) or minimize loss through photodecomposition or volatilization.
* Pre-emergence – herbicide applied before emergence wrt crop or weed but not necessarily both.
* Cracking – when soil above legume seedlings begins to crack just prior to emergence.
* Post emergence – applied after specified crop or weed has emerged. Could also be early or late post. Directed post and shielded applications – directed to the weeds and kept away from a sensitive crop.
* Layby applications – made at the time of the last cultivation.

6. Contact vs systemic

Contact herbicides kill only the plant tissue they come into contact with so proper spray coverage is needed. Systemic – translocated within the plant so that even areas not treated can succumb to the herbicide. Some herbicides move upward (acropetally) only in the xylem - appoplastic. Others downward only (basipetally) in the phloem - symplastic. Or both.

7. Herbicide Chemistry

Classified into groups according to their chemistry. Phenoxy acetic acids, benzoic acids, imidazolinones, sulfonylureas, aryloxyphenoxyproprionates, triazines, diphenylethers, dinitroanilines, and thiocarbamates. The 8th edition of the Herbicide Handbook has 75 chemical families.

8. Site/mechanism of action

Amino acid inhibitors, photosystem II inhibitors, fatty acid biosynthesis inhibitors.

Factors Affecting a Plant's Susceptibility to Herbicides

- Location of growing points:
  - Sheathed by plant structures
  - Located below the soil surface
  - Not affected by contact herbicides.

- Leaf shape
  Spray droplets tend to settle better on broad flat leaves than on narrow upright leaves.

- Waxy cuticles
  - Foliar sprays tend to runoff and penetration is not as good as on leaves with very little wax.

- Hairy leaves
  - Long hairs hold herbicide droplets away from the leaf surface.

- Deactivation or metabolism: weeds may be able to biochemically convert herbicides to less toxic or nontoxic byproducts before occurrence of negative side effects.

- Insensitive target site.

- Stage in the lifecycle: seedlings often more susceptible than mature plants.

- Application timing.

Reasons for a Sustainable Approach to Herbicide Use (Liebman et al., 2001)

- Over time heavy reliance on herbicides reduces their usefulness because they select for tolerant weed species and resistant genotypes. To maintain their effectiveness as weed management tools weeds exposure to herbicides should be infrequent.

- Some herbicides pose a danger to human health and the environment. Less reliance on these reduces the potential for adverse outcomes.

- Herbicides represent an increasing portion of farmers' budgets at a time when they are challenged by serious economic pressure. Lowering input costs by less dependence on herbicide would increase grower profits.

Herbicide Resistant Crops

Extension of the utility of chemical control.

HRCs survive a chemical treatment to which they are normally sensitive.

Most have been developed by insertion of a foreign gene using molecular biology techniques and plant transformation.

Most are resistant to glyphosate “RoundUp” eg canola, corn, cotton, soybean.

Also Liberty-Link canola and corn resistant to glufosinate.

BXN cotton resistant to bromoxynil.

Traditionally bred HRCs: IMI corn and Clearfield rice are resistant to imidazolinones.

Benefits:

Broad spectrum of weeds controlled.

Greater flexibility in application timing.

Eliminates the need for prophylactic preemergent applications (problematic for crop rotation due to residues).

Possible to plant a second crop that season if the first crop fails due to adverse weather.

Allows management of problem weeds.

Reduction in weed control costs – even with higher seed costs.

Decline in herbicide use (10% in soybean).

Applicable to reduced and no tillage systems.

Disadvantages:

Volunteer HR plants in subsequent crops are weeds in other glyphosate resistant crops.

Weed shifts to tolerant species.

Selection pressure for resistant weed biotypes.

Gene-flow to closely related weedy relatives: cultivated rice to red rice, canola to weedy brassicas.

Contamination of organic crops.

There is a need for prudent use and combination with Integrated Weed Management measures to prolong their utility as weed management tools.