# Properties and mode of action of glyphosate

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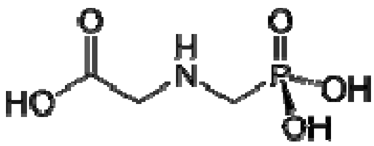
European Glyphosate Environmental Information Source

**Important Notes to users:**
***This document is part of a toolbox which provides independent information on the sustainable use of glyphosate. It cannot however be definitive and users must ensure that they assess local factors and particularly take account of any national or regional legislative requirements. At the end of the document reference sources used in its preparation and links to other relevant documents are provided.***

**Summary**
Glyphosate is slightly soluble in water, but is only used commercially as salt (to improve solubility) in various formulations. Its site of action is the inhibition of the formation of aromatic amino acids in the plant, a pathway not present in animals. It affects all plants and in practice it is only taken up by the aerial part of the plant, because it is tightly bound to the soil, and thus not bio-available for root uptake. There are several genetically modified crops that are made tolerant to glyphosate; and intensive use of glyphosate has made biotypes of some weed species resistant to the compound. Inside the plant, glyphosate is a very stable compound which either stays intact or slowly degraded to the non-herbicidally active compound, AMPA.

**Detailed information**

Glyphosate is a crystalline solid. The molecule is simple as seen below.



It is soluble in water, but its solubility is too low for practical use as a soluble concentrate in water. It has low solubility in fats, oils, lipids, and non-polar solvents. The most common way of formulating glyphosate for commercial purposes is to make it a salt, e.g. isopropylamine, and mix it with various formulating constituents.

The apparent simplicity of the glyphosate molecule does not mean that it is easy to understand the properties and its effect and behaviour in the plant or in the environment. Glyphosate is a weak acid, a so called zwitterion (a molecule that carries some negative and positive charges of different atoms). The acidic properties come from the amino group and the phosphorous. It makes the compound rather unique among herbicides in that it can be tightly bound to certain metal oxides, some of which make the resulting complex molecule insoluble in water and hence renders glyphosate biological inactive.

Glyphosate inhibits the synthesis of three aromatic amino acids in plants, fungi and bacteria. These three aromatic amino acids, phenylalanine, tyrosine and tryptophan, cannot be synthesized in animals and are therefore called essential amino acids. Consequently, its primary site of action in plants is not present in animals and therefore at the rates being used for weed control glyphosate is only toxic to plants and to a very limited extent to fungi and bacteria.

In order to act in the plant it has to be taken up by the aerial parts, leaves and stems, and then transported from the place of uptake to its site of action. Uptake is crucial and unfortunately glyphosate is not the easiest molecule to be readily taken up by plants. This makes glyphosate prone to being washed off from the plant by rain falling within four to six hours after spraying. The producers of commercial formulations have thus tried to formulate the molecule so it becomes more rain fast. This has been successful to some extent but in climates with unpredictable rainfall, glyphosate sensitivity to rain is still an issue for farmers.

The amount of applied glyphosate to plants not washed from the leaves is considered the effective amount. The efficacy of glyphosate is, all other things being equal, dependent upon the concentration in the plant, or more precisely at the very site of action of the compound. Glyphosate is a systemic herbicide, which means that it moves from place of uptake to the site of action in the actively growing tissues (symplast). Glyphosate moves much in the same ways as do sugars from the photosynthesis. The site of action of glyphosate is by blocking the enzyme EPSP inside and outside the chloroplast. This blockage inhibits the synthesis of the aromatic amino acids. Although glyphosate is not considered to be a herbicide directly interfering with photosynthesis, it is possible to measure its effect on the photosynthesis, probably because of lack of supply of aromatic amino acids for important metabolic processes. Agronomic rates of glyphosate in farmer's fields affect the photosynthesis two days after uptake and long before visual symptoms become noticeable. The development of symptoms are rather slow and in cold climate it might take ten days or more before symptoms become visible at normal agricultural rates.

Inside the plant glyphosate is a very stable compound, which either stays intact inside the plant or is slowly degraded to the non biologically active compound AMPA, a compound that is also a degradation byproduct of aminophosphonates, which are common in household detergents.

Generally, glyphosate is considered to be a nonselective herbicide, that is all crops and weed species are by and large equally sensitive to the compound. However, there are some differential tolerance between species, for example some grasses and flowering plants.

Its unique mode of action contributes to the low toxicity to mammals, bird, fish, earthworms and honeybees, and its wide use makes glyphosate one of the most extensively researched herbicides in living organisms and in the environment. Because of it chemical and physical properties it is readily bound to the soils in almost the same ways as is the important plant nutrient phosphorus. Very little glyphosate is thus freely dissolved in the soil water and combined with inefficient root uptake it means that it has no effects on plants through their roots. Glyphosate is only slightly mobile in soils. Because it is tightly bound to very small soil particles it can, however, be washed down in fractured clay soils. Consequently, it can in very rare instances be found in the deeper groundwater.

Genetically modified glyphosate tolerant crops are commercialised in the USA. These crops have their target site, the ESPS enzyme, changed. In some crops the change of the target site was the sole mechanism of resistance and in others it was combined with a degradation gene. A different way of making crops tolerant to glyphosate is to genetically incorporate an enzyme in the crop that rapidly degrades glyphosate to non toxic compounds.

In 1996 the first incidence of a glyphosate resistant weed was documented in Australia.

**Reference for further detailed information:**


1. Gross bard, E., and D. Atkinson, (eds.) 1985. The Herbicide Glyphosate, pp. 1-490pp.Butterworths
2. Pest management Science (2008) vol 64. Special Issue: Glyphosate-Resistant Weeds and Crops. Numerous papers on glyphosate


**See also:**

- Environmental fate and behaviour of glyphosate
- Monitoring results for glyphosate and AMPA in surface and groundwater

**Document status:**

| Author | Document status | |
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