

PPO Inhibiting Herbicides: What are They and How do They Work

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Herbicides play a vital role in sustaining crop production throughout the world. There are literally hundreds of different herbicides on the market, each with a unique set of chemical and physical characteristics. Herbicides are classified into different families based according to their modes of action. One of the important herbicide families is the “Protox” inhibitors. The primary herbicides in this group include oxyfluorfen (Goal), carfentrazone (Shark), and flumioxazin (Chateau). While Goal has been used in California for more than 25 years, Shark, and Chateau are relatively new to agriculture in the state. Some common uses of these herbicides in agronomic crops are shown in table 1. They are used primarily for controlling broadleaf weeds.

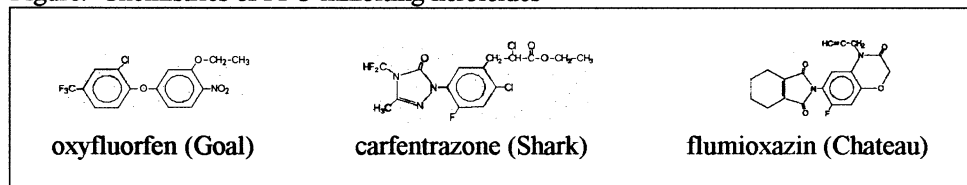
Table 1. Some use patterns for Protox inhibiting herbicides in agronomic crops in California

Oxyfluorfen (Goal 2XL, GoalTender, etc.)
Cotton – fallow bed and early postemergence directed 6” tall
Garbanzo –preemergence
Carfentrazone (Shark)
Cereals – 30 days before planting to early jointing stage by ground or air
Rice – 2-4 leaf stage by air
Cotton, corn, dry beans – postemergence directed with hooded sprayer
Flumioxazin (Chateau)
Cotton, field corn, sorghum, wheat, sunflower – 30 days before planting

While these herbicides have different chemistries (see figure), they all kill weeds by the same mode of action. They are readily absorbed into leaf tissue where cell membranes are destroyed. Little or no absorption occurs by roots. The primary target site of these herbicides is in the chlorophyll synthesis pathway, where they inhibit the enzyme protoporphyrinogen oxidase. Hence, they are referred to as “Protox” or “PPO” inhibitors (named after the enzyme affected). These herbicides kill ultimately by lipid peroxidation. In other words, they break down cell membranes, causing the cells to break open, killing the leaves and stems.

Common symptoms associated with these herbicides include rapid leaf bleaching, desiccation, and necrosis, usually localized around the site of contact with the herbicide. Death of leaf tissue may be observed in as few as 3-5 days after contact. Since these herbicides do not translocate in susceptible plants, complete coverage of the weed foliage is necessary for control.

Figure. Chemistries of PPO inhibiting herbicides



Of the PPO inhibiting herbicides discussed, Goal and Chateau have both foliar contact and soil activity. Shark is thought to have only minimal soil activity. Consequently, Goal and Chateau can be applied both to the soil, and as a contact spray for killing weeds. These materials are fairly strongly adsorbed to the soil, and not readily desorbed. Adsorption generally increases as soil organic matter increases. When applied to the soil as preemergence herbicides, both Goal and Chateau kill weeds through direct contact with the emerging weed hypocotyl. If the soil is disturbed following application, weed control will be significantly reduced, since the “barrier” of treatment has now been broken.

Of these herbicides, only Goal is known to have the potential to “lift-off” from the soil following application. This process is called codistillation and occurs when molecules of oxyfluorfen are trapped in water molecules evaporating from the soil surface. Rainy or foggy conditions following application can lead to an increased risk of “lift-off”, whereby the molecules can be deposited onto nearby susceptible crop and non-crop foliage. Table 2 shows some differences between these herbicides regarding potential soil residues, “lift-off” potential, and potential for drift.

Table 2. Comparisons of PPO inhibiting herbicides and paraquat (a bipyridylium herbicide)

Factor	Goal	Shark	Chateau	paraquat
Soil residues	Long	Short	Long	None
Lift-off Potential	Yes	No	No	No
Drift concerns	Yes	Yes	Yes	Yes

Since these herbicides do not translocate, but require direct contact with the developing weed foliage (or with the emerging seedling as in the case of Goal or Chateau), uniform coverage of the target site is critical for control of susceptible weeds. In some cases, it is necessary to use shielded sprayers when making within-crop treatments to protect the crop. Since most crops grown in California are sensitive to damage from these “Protox” or “PPO” inhibiting herbicides, extreme care should be used to prevent off-target injury.