EM 8833
May 2003

Weed Management in Clearfield™ Wheat with Imazamox

Jed Colquhoun, Carol Mallory-Smith, and Dan Ball

Pacific Northwest wheat growers soon will have an additional option for weed control, but the new tool differs greatly from those traditionally used in cereal production. Clearfield wheat has been selected that is tolerant to the herbicide imazamox. When integrated with traditional weed management tools, imazamox will control several weed species that are difficult to manage in wheat production.

Clearfield wheat

Clearfield wheat varieties were developed with traditional plant breeding methods. No DNA was inserted into Clearfield wheat, and therefore the varieties are not considered to be genetically modified organisms (GMO). Scientists induced a mutation in a conventional wheat cultivar that resulted in tolerance to the herbicide imazamox. The herbicide-tolerant wheat has since been crossed with several commercial wheat varieties, with subsequent generations selected for those plants that survived imazamox applications. This methodology is very similar to that used to create many of the crop varieties that are grown worldwide today.

Varietal tolerance of Clearfield wheat to imazamox

Commercial and University trials conducted in the Pacific Northwest generally have shown that the Clearfield wheat cultivars in development have a good level of tolerance against injury from imazamox. However, field applications of twice the labeled application rate have produced crop injury under certain conditions of plant stress. Anecdotal observation of research trials suggests that injury is more pronounced when imazamox application is followed by cool, wet weather.

Imazamox herbicide

Imazamox selectively controls several annual grass and broadleaf weed species. It is registered for use in several legume crops and is sold under the trade name Raptor. In the Clearfield wheat system, imazamox is sold under the trade name Beyond, but it is the same active ingredient as that used in legume crops.

Mode of action

Imazamox is absorbed by the foliage and/or roots and moved throughout the plant. The herbicide blocks the production of the essential amino acids valine, leucine, and isoleucine by inhibiting the enzyme acetolactate synthase (ALS), which is found in plant chloroplasts. The production of these three amino acids is essential for the production of plant proteins.

In Clearfield wheat, the mutated selection that is tolerant to imazamox has an altered ALS enzyme, which prevents the herbicide from binding to the target site. The enzyme functions normally, and amino acid and protein synthesis are not affected.

Jed Colquhoun, Extension weed specialist; Carol Mallory-Smith, associate professor of weed science; and Dan Ball, associate professor of weed science, Columbia Basin Agricultural Research Center; Oregon State University.

OREGON STATE UNIVERSITY
EXTENSION SERVICE

Weed resistance and the acetolactate synthase (ALS) inhibitor herbicides

The ALS inhibitors include two herbicide families, sulfonylureas and imidazolinones, that are used on the majority of crops grown in the Pacific Northwest. The reliance on and repeated application of these herbicides have resulted in development of several herbicide-resistant populations of weed species. Seventy-nine weed species have been documented to be resistant to ALS-inhibitor herbicides worldwide. In the Pacific Northwest, Russian thistle, prickly lettuce, kochia, smallseed falseflax, mayweed chamomile, spiny sowthistle, and downy brome populations have been documented to be resistant to the ALS-inhibitor herbicides.

Development of resistant weed populations can be delayed or prevented with proper weed management practices as described in "Imazamox use recommendations," page 4.

Imazamox soil persistence and crop rotations

The long-term benefit of residual weed control from a single herbicide application often is balanced by rotational restrictions when planning for subsequent crops. Therefore, it is important to follow the rotational restrictions after imazamox application when developing future cropping plans. The rotational restrictions after imazamox application in the Pacific Northwest are summarized in Table 1.

Herbicide persistence in soil is affected by several climate and soil factors. The imidazolinone category of ALS-inhibitor herbicides, including imazamox, persist longer in undisturbed soils (no-till or reduced-tillage production systems), low pH soils, and where moisture is limited.

These factors are particularly important when considering rotations to barley after imazamox applications. When soil pH is greater than 6.2 and rainfall and irrigation total more than 10 inches after imazamox application, barley can be planted 9 months after application. If either of these conditions is not met, fields must be moldboard plowed to qualify for the 9-month rotational restriction. Without moldboard plowing, barley cannot be planted within 18 months of application if the pH or moisture conditions are not met. Research conducted in eastern Oregon conditions confirms the accuracy of these restrictions.

Table 1. Rotational intervals following application of imazamox herbicide.

Plant-back interval	Crop
Anytime	Clearfield canola
	Clearfield wheat
	Edible legumes
	Soybeans
3 months	Alfalfa
	Wheat (non-Clearfield)
4 months	Rye
8½ months	Corn
9 months	Barley
	Cantaloupe
	Cotton
	Grain sorghum
	Lettuce
	Millets
	Oat
	Onion
	Peanut
	Pumpkin
9 months (cont.)	Rice
	Squash
	Sunflower
	Tobacco
	Watermelon
18 months	Barley
	Broccoli
	Cabbage
	Cucumber
	Pepper
	Potato
	Tomato
	Turnip
	All other crops not listed
26 months	Sugar beet
	Table beet
	Canola (non-Clearfield)

Weed control with imazamox

With proper application, imazamox can provide effective control of several weeds commonly found in wheat-production systems, including jointed goatgrass, Italian ryegrass, downy brome, California brome, rattail fescue, feral rye, and many broadleaf weeds. Use of imazamox for control of each of these weeds is discussed in this section.

It is important to follow several key use recommendations (page 4) to delay or prevent the development of herbicide-resistant weeds.

Jointed goatgrass

Jointed goatgrass causes severe yield loss and crop dockage when competing with and contaminating wheat. Few control measures, except for Clearfield wheat, effectively manage jointed goatgrass in winter wheat. In eastern Oregon, imazamox applied postemergence in the early spring controlled 61 to 97 percent of the jointed goatgrass.

On the negative side, jointed goatgrass and wheat are closely related and both have the D genome where the tolerance to imazamox is located in Clearfield wheat. Wheat and jointed goatgrass occasionally cross to produce hybrids (Figures 1 and 2). These hybrids are male sterile, but can backcross to wheat and jointed goatgrass and produce seed at low levels in nature. The crossing of wheat and jointed goatgrass may increase the risk that the characteristics that make wheat tolerant to ALS-inhibitor herbicides eventually could be expressed in jointed goatgrass, rendering imazamox ineffective.

Italian ryegrass

Italian ryegrass causes severe yield losses in wheat, particularly in western Oregon, where diclofop (Hoelon) resistance is common. In both western and eastern Oregon trials, postemergence herbicides used alone, without a preemergent application of another herbicide, are not adequate for season-long Italian ryegrass control. Imazamox applied postemergence to young Italian ryegrass plants will result in similar control as sulfosulfuron (Maverick) or flucarbazone (Everest). In research trials, late-November to early-December imazamox applications controlled about 80 percent of the Italian ryegrass.

Downy brome

Downy brome control with imazamox has been good in research trials. Herbicide application timing is critical to successful control. In research trials in western and eastern Oregon, November imazamox application controlled 95 to 100 percent of the downy brome. However, when imazamox was applied in January, control was only 25 to 35 percent in western Oregon. Spring applications made under eastern Oregon conditions resulted in good downy brome control.

Recently developed models of resistance development suggest that downy brome is a likely candidate for developing resistance to imazamox.

California brome

California brome is a short-lived perennial that rapidly develops an extensive root system. Herbicides must be applied when California brome is young, prior to weed establishment. Imazamox, when applied after emergence but before California brome has two leaves, will control more than

Figure 1.—Jointed goatgrass (left), jointed goatgrass–wheat hybrid (middle), and wheat (right).

Figure 2.—Jointed goatgrass–wheat hybrid.

90 percent of the weeds. Control drops rapidly when imazamox is applied to older, more established California brome.

Rattail fescue

Rattail fescue is an increasing problem in wheat production areas west and east of the Cascades. The increase in populations will continue as direct-seed production expands because rattail fescue is poorly controlled with glyphosate. Again, early imazamox applications have controlled more than 90 percent of the rattail fescue, but later applications are largely ineffective (60 to 75 percent control).

Annual bluegrass

Imazamox does not control annual bluegrass.

Feral rye

Imazamox will control feral rye if applied before the weed is tillering, usually in early fall. In research conducted in eastern Oregon, 90 percent of the feral rye was controlled when imazamox was applied when the weed had one to six leaves. Late-fall (one- to five-tiller feral rye) and spring applications provided 35 and 60 percent control, respectively.

Broadleaf weeds

Imazamox controls an array of broadleaf weeds, such as lesser snapdragon, little bittercress, mustard species, and shepherdspurse. In research trials, it has not provided adequate control of mayweed chamomile, common groundsel, or prickly lettuce.

Imazamox use recommendations

The long-term utility of the Clearfield wheat system and imazamox depends on responsible use of the technology. Several recommendations should be followed to delay or prevent the development of herbicide-resistant weeds.

- Purchase certified seed each year from a Clearfield seed retailer. This practice ensures that only imazamox-tolerant wheat is planted in fields that will be treated with the herbicide and that no seed from previously treated fields is present.
- Do not plant Clearfield wheat more frequently than two out of every four wheat crops. Limited use of imazamox will avoid or delay selection of resistant weeds.
- Reduce the reliance on ALS-inhibitor herbicides in crop rotations. If possible, rotate herbicides with multiple modes of action. Consult the publication *Herbicide-Resistant Weeds and Their Management* (PNW 437, available from the Idaho, Oregon, and Washington Extension Services) for more information on herbicide families and resistance management.
- Control weeds in fallow years with non-ALS herbicides and/or tillage.
- Control jointed goatgrass in noncropland areas such as roadsides, fencerows, and surrounding rangeland areas. The potential for outcrossing can be reduced when weed seed production is prevented. Outcrossing between Clearfield wheat and jointed goatgrass has the potential to spread the herbicide resistance trait from wheat to jointed goatgrass.

For more information

Many OSU Extension Service publications may be viewed or downloaded from the Web. Visit the online Publications and Videos catalog at **http://eesc.oregonstate.edu**.

Copies of our publications and videos also are available from OSU Extension and Experiment Station Communications. For prices and ordering information, visit our online catalog or contact us by fax (541-737-0817), e-mail (puborders@oregonstate.edu), or phone (541-737-2513).

Published May 2003.