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Integrated Management of Wild Oat in the Pacific Northwest

Albert T. Adjesiwor, Drew J. Lyon, Judit Barroso, Joan Campbell

Background

Wild oat (*Avena fatua* L.) is a grassy weed (family *Poaceae*) well adapted to most regions of the world where small grain crops are grown. Native to Europe and Asia, wild oat has been introduced worldwide through various means (for example, contaminated seed, farm equipment, etc). It is weedy in several crops, but especially troublesome in small grain cereals (wheat, barley). The characteristics of high reproductive capabilities and persistence over a wide range of environmental conditions have allowed wild oat to become one of the most serious weed problems of cultivated land.

In the United States, more than 28 million acres are infested with wild oat, resulting in yield loss and increased production costs. In the Pacific Northwest (PNW), wild oat is a problem in small grain and rotational crops, including pulse crops, potato, sugar beet, and oilseed crops. In Idaho, more than 3 million acres of cropland are infested with wild oat. Small grain growers in Idaho spend more than 9 million dollars annually for its control. The grass has developed resistance to several herbicides, making chemical control difficult. It is, therefore, critical to curtail its spread in the PNW.

Identification. Mature wild oat is fairly easy to identify from other grassy weeds and cereal crops. However, seedlings can look very similar to cereal crops (barley and wheat) and some grassy weeds. For proactive management, wild oat must be identified at the seedling or early growth stage. The seedling has a counterclockwise leaf twist (Figure 1A) and no auricles (claw-like projections at the base of the leaf blade; Figure 1B). It has hairs on the leaf margins (edge of the leaf) and the ligule (collar-like structure at the point where the leaf blade clasps the stem) is elongated and bluntly pointed and about ⅕ inch long (Figure 1B). Plants may grow up to 4 ft tall. The seed head is 4–18 inches long and often droops (Figure 1C). Seeds have hairs at the base and are yellow to black, narrowly oval (egg-shaped), and ¼- to ½-inch long (Figure 1D). The awns (black, twisted bristle) are bent at a sharp angle (Figure 1D); a horseshoe-shaped scar is located at its base (Whitson et al. 2009). The awn helps the seed with self-burial (Somody et al. 1985).

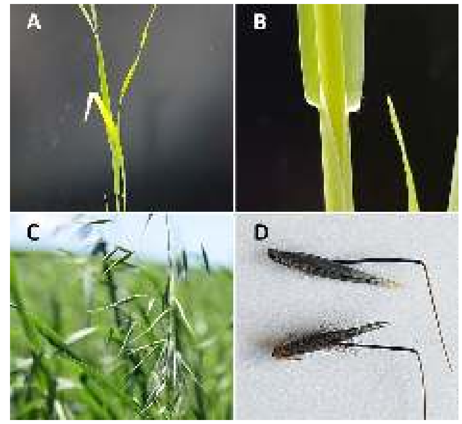

Figure 1. Wild oat seedling (A), stem (B), seed head (inflorescence; C), and seed (D).

Biology and ecology. Wild oat has an annual life cycle and tends to be troublesome wherever cereals are grown in locations with an annual rainfall of 14–29 inches (Holm et al. 1977), although it also infests other crops, roadsides, pastures, and wastes areas. It is well adapted to the life cycle and growth of spring cereals in the PNW.

Germination spreads over several weeks and is initiated when the soil temperature rises to 43°F and there is sufficient moisture. Observations in the PNW indicate that wild oat germination occurs mainly during the spring. It can emerge from depths up to 6 inches; however, the greatest percentage of shoots emerge from seeds planted at 2 inches (Morrow and Gealy 1983). Flowering and seed production occur from June to August.

Seed production, dispersion, and seedbank longevity. In the absence of competition, a single plant can produce around 1,000 seeds (Morrow and Gealy 1983). However, in a cereal crop (heavy competition) the average seed production is 60 seeds per plant. Wild oat seeds shed as they ripen, occurring over an extended period. The later a crop is harvested, the more seed sheds onto the ground.

Wild oat has relatively large seeds, the majority of which fall close to the parent plant. The dispersal of wild oat is closely associated with the cultivation of cereal crops (Barroso et al. 2006). Seed movement is often in the direction of cultivation and harvesting. Movement over longer distances is most likely the result of the importation of contaminated grain. Germination of dispersed seeds often account for only 15% of annual seedbank losses (Barralis and Chadoeuf 1987). Thus, variability in wild oat seed germination determines to a large extent how long an area is reinfested with wild oat. Freshly produced seeds tend to be dormant but its intensity varies among populations. It is difficult to generalize the dormancy behavior of wild oat because of the many interacting environmental factors and the high genetic variability. However, freshly produced seeds can remain dormant for 3–8 years (Conn and Farris 1987; Miller and Nalewaja 1990). Temperature and moisture levels during seed development seem to affect the level of dormancy. In the fall, the level of dormancy declines and is induced again in late spring. Damage to the seed coat can relieve dormancy at any time by allowing oxygen to reach the seed embryo.

Wild Oat—Crop Competition and Impacts

Wild oat is an economic burden because it reduces crop yield, increases production costs (e.g., herbicide and application, seed cleaning, etc.), delays harvest due to slowed crop maturity, increases harvest time, produces dockage due to seed contamination (especially in malt barley), acts as host to other pests, decreases grain quality, and increases transportation fees for contaminated grain. The grass can host cereal cyst nematode, stem nematode, rhizoctonia, crown rot, and root lesion nematode.

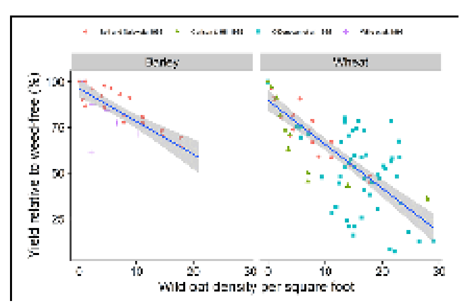

Figure 2. Relationship between wild oat density on barley and wheat yield. The solid line

The degree of impact on wheat and barley depends primarily on wild oat density, the time of wild oat emergence relative to the crop, and the duration of wild oat–crop competition. As wild oat density increases, crop yield declines due to increasing competition for limited growth resources (e.g., water, light, and soil nutrients). Just ten wild oat plants per square foot can reduce barley yield by 18% and wheat yield by more than 24% (Figure 2). One wild oat plant per square foot can reduce wheat and canola yield by 10%. Barley yield loss has been reported between 7% and 50% with populations ranging from 9 to 19 wild oat plants every day per square foot.

The greatest yield loss occurs when wild oat plants emerge at the same time as the crop. A yield loss of 3% for everyday wild oat that emerges ahead of barley has been reported in Canada (O'Donovan et al. 1985). Thus, wild oat impact on yield is reduced when weeds are removed early. This is especially important if wild oat emerges when wheat and barley are at the early growth stages. Wild oat that emerges late in the season has less impact on wheat and barley yield. However, late-emerging wild oat can still interfere with grain harvest and produce seeds that could impact subsequent crops.

Herbicide resistance in wild oat. Aside from the competitiveness against small grains, one other factor influencing the spread and impact of wild oat in the United States is herbicide resistance. There have been more than fifteen cases of herbicide-resistant wild oat populations reported in several states including California, Colorado, Idaho, Minnesota, Montana, North Dakota, Oregon, South Dakota, and Washington. In the PNW, wild oat has developed resistance to at least four herbicide sites of action, including ACCase inhibitors (group 1), ALS inhibitors (group 2), microtubule inhibitors (group 3), and lipid synthesis inhibitors (group 8) (Table 1). Populations with resistance to more than one herbicide site of action have also been reported.

represents the linear regression line and the gray band the 95% confidence interval.

Table 1. Herbicide resistance in wild oat in the Pacific Northwest, 2021.

Active ingredient (Trade Name)	Site of Action (group number)	Idaho	Oregon	Washington
pinoxaden (Axial XL) *quizalofop* (Aggressor, Assure II) *fenoxaprop* (Acclaim, Tacoma)	ACCase inhibitor (1)	Yes	Yes	Yes
mesosulfuron-methyl (Osprey) *imazamox* (Beyond) *pyroxsulam* (PowerFlex) *flucarbazone* (Everest 3.0 AG)	ALS inhibitor (2)	Yes	Yes	Yes
pendimethalin (Prowl H2O) *ethalfluralin* (Sonalan HFP) *trifluralin* (Treflan HFP)	Microtubule inhibitor (3)	No	Yes	Yes
EPTC (Eptam) *triallate* (Far-GO) *ethofumesate* (Nortron)	Lipid synthesis inhibitor (8/15*)	Yes	Yes	Yes

Data from: Heap (2021) and Burke (2021).
*Group 8 herbicides have now been reclassified as group 15.

Management

Integrated weed management (IWM) strategies for wild oat are based on preventing the weed from becoming established in new areas, limiting seed production, growing a competitive crop, and keeping weeds off balance by changing management practices.

All the practices discussed here can be effective against wild oat, provided the associated cautions are taken. Unless using narrow-windrow burning as part of a harvest weed seed control (HWSC) system (discussed below in the subsection on HWSC), field burning is not considered part of IWM for wild oat because the many undesirable consequences of burning crop residue far outweigh the questionable benefits.

Sanitation

Because wild oat is a prolific seed producer, eliminating seed sources and preventing wild oat from getting established in clean fields is often the most economical control method. However, this often requires sustained effort over time. Apply a combination of the following methods that fits best in your situation:

- Plant crops using clean, certified seed.
- Use clean machinery, including combine harvesters, before entering an uninfested field; start field operations in clean fields before entering infested fields.
- Destroy wild oat seedlings/plants in cultivated fields before they produce seed.
- Control small patches or infested areas before they spread.
- Seed perennial, cool-season grasses in noncrop areas and field borders. Vigorous stands of grasses or grass-legume combinations are highly competitive with wild oat and other annual weeds.
- Where perennial grass borders are not feasible, consider a) using herbicides or tillage to kill wild oat and b) cropping field borders.
- Use herbicides that do not kill established perennial grasses around field borders.
- Mow small infestations close to the ground in pastures, roadsides, and waste areas where cultivation or herbicides are not feasible. Plan to complete mowing before viable wild oat seeds are produced. More than one mowing may be necessary to prevent tillers from producing seed.

Tillage

Plowing is generally considered less effective for wild oat control due to the fact that seedlings can emerge from seeds buried at 4–6 inches depth or more. Buried seed tends to survive longer than seed on the soil surface. Frequent plowing will bring buried dormant seed back to the soil surface, which can result in a large flush of wild oat seedlings.

Postharvest tillage operations should be delayed for as long as possible to encourage the loss of freshly shed wild oat seed lying on the soil surface. Minimizing soil disturbance before and during seeding of spring crops may reduce the number of wild oat plants that germinate in the crop.

Cultural

Crop Diversity and Competition

Crop rotation can be an effective control measure for wild oat by extending the length of time between cereal crops, which helps to reduce the soil seedbank. Crop rotation also allows the use of more effective grass herbicides in broadleaf crops such as canola or pulse crops. Including crops such as alfalfa with different seeding and/or harvest dates than cereals would also help to reduce wild oat seed production and allow the use of different management practices than with cereals. Practices that ensure a full stand of a vigorously growing crop is one of the best weed management strategies. Good crop stands leave few open spaces for wild oat to invade. The following practices may help to increase crop competitiveness:

- Prepare a firm, moist seedbed. Good seed-to-soil contact is key to maximizing seed germination.
- Seed at an optimum time for rapid germination and emergence. Avoid seeding into cool and excessively wet soil.
- Choose varieties that emerge quickly, grow rapidly, and swiftly form a dense canopy.

- Choose a larger crop seed with the highest possible germination rates from a known source, such as certified seed.
- Use crop seed that is treated with appropriate fungicides and insecticides to prevent stand loss.
- Use seeding rates at the high end of the recommended range to increase crop competitiveness with weeds.
- Use the narrowest feasible row spacing to allow for quicker canopy closure.
- Seed on the shallow side of the recommended seeding depth to promote faster crop seedling emergence.
- Apply fertilizer to promote early crop growth and competitiveness. Deep banding instead of broadcasting can help achieve this goal.

Herbicides

Several herbicides are labeled for selective control or suppression of wild oat in wheat. Some of the most effective herbicides have been Group 1 (ACCase inhibitors) herbicides, such as pinoxaden (Axial XL, Axial Bold) and clodinafop-propargyl (Discover NG); and Group 2 (ALS inhibitors) herbicides, including sulfosulfuron (OutRider), mesosulfuron-methyl (Osprey, Osprey Xtra), propoxycarbazone-sodium (Olympus), flucarbazone-sodium (Everest 3.0 AG), and pyroxsulam (PowerFlex HL, GoldSky). These herbicides pose little risk for injuring wheat. They provide excellent control of wild oat; however, wild oat biotypes resistant to these herbicides are now commonly found throughout the PNW region.

Imazamox (Beyond) is another Group 2 herbicide that has provided excellent control of wild oat when properly applied, but it is specific to Clearfield wheat varieties that contain the gene or genes that confer tolerance to imazamox. Tolerance means that the winter wheat variety with the gene(s) is able to withstand a recommended rate of Beyond herbicide with minimal risk of crop injury. Wheat varieties that do not contain this gene/s are either killed or seriously injured by Beyond. Unfortunately, wild oat biotypes resistant to imazamox are also commonly found throughout the PNW region.

Quizalofop (Aggressor) is a Group 1 herbicide that can be used in the CoAXium wheat production system to control wild oat. CoAxium wheat cultivars contain a gene that confer tolerance to quizalofop. At the time of this writing, there are no commercially available wheat cultivars with the AXigen trait bred for adaptation to the PNW, although breeding efforts are underway, with adapted cultivars expected to be released to the market by 2022 or 2023.

Careful stewardship of the CoAXium wheat production system is critical if this technology is to last for more than just a few years. Do not use CoAXium wheat more than two out of six years. Consider diversified crop rotations where wheat is grown only once every three or four years. Avoid the use of quizalofop (Assure II) in broadleaf crops grown in rotation with CoAXium wheat. Consider rotating the use of the CoAXium wheat production system with the Clearfield wheat production system, where imazamox is effective. Always rogue and remove wild oat plants that survive herbicide treatments.

Herbicides with other mechanisms of action should be rotated or used in combination with Group 1 and 2 herbicides. Zidua and Anthem Flex herbicides both contain pyroxasulfone (Group 15) and provide control of wild oat. Anthem Flex also contains carfentrazone (Group 14), which can provide effective burn down of some small broadleaf weeds. Crop injury is a potential concern with these herbicides, so it is critical to consult the labels for seeding and application restrictions. Other herbicides labeled for use in wheat, such as triallate (Avadex or Far-GO; Group 8) and trifluralin (Group 3), can be used for wild oat control, but require mechanical incorporation.

In pulse crops, Group 1 herbicides such as sethoxydim (Poast), clethodim (Select Max), or quizalofop (Assure II, Targa); Group 3 herbicides (microtubule assembly inhibitors), such as ethalfluralin (Sonalan HFP), pendimethalin (Prowl H2O), and trifluralin (Treflan HFP); and Group 15 herbicides (inhibitors of very-long-chain fatty acid synthesis), such as dimethenamid-P (Outlook) and S-metolachlor (Dual Magnum), can be used to manage wild oat. These same herbicides, with the exceptions of pendimethalin, dimethenamid-P, and S-metolachlor, may also be used to control wild oat in canola.

There are several herbicide resistance traits available in some canola varieties that can be useful in the management of wild oat. These include Roundup Ready (glyphosate tolerant), LibertyLink (glufosinate tolerant), and Clearfield (imazamox tolerant). To minimize the risk of developing biotypes resistant to these herbicides, growers should always use a preemergence herbicide in addition to glyphosate, glufosinate, or imazamox. As with Clearfield and CoAXium wheat, these herbicide-resistance traits should not be used more than once every three years to minimize the risk of developing herbicide-resistant wild oat biotypes.

For current herbicide control strategies for wild oat, refer to the *Pacific Northwest Weed Management Handbook* and contact your local County Extension educators or agricultural professionals. As with all crop-protection chemicals, read and follow label directions and understand their proper use. Always remember that the label is the law.

Harvest Weed Seed Control (HWSC)

HWSC is an innovative, nonchemical weed management approach developed in Australia to help control herbicide-resistant weeds (Lyon et al. 2019). These methods focus on managing the chaff material in which most weed seeds reside. Research conducted in the northern Great Plains found that on average, less than 40% of wild oat seed was retained in the panicle at harvest time (Walsh et al. 2018). This low seed-retention rate makes wild oat a poor candidate species for using HWSC as part of an IWM program. To learn more about HWSC and its application in the PNW, see Lyon et al. 2019.

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About the Authors

Albert T. Adjesiwor—University of Idaho (UI) Weed Scientist, Kimberly Research and Extension Center, Kimberly, ID

Drew J. Lyon—Washington State University Weed Scientist, Pullman, WA

Judit Barroso—Oregon State University Weed Scientist, Columbia Basin Agricultural Research Center, Pendleton, OR

Joan Campbell—UI Weed Scientist, Moscow, ID

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