Pesticide Residues—Any recommendations for use are based on currently available data for each pesticide listed. If followed carefully, residues should not exceed the established tolerances. To avoid excessive residue, follow label directions carefully with respect to rate, number of applications, and minimum interval between application and reentry or harvest.

Groundwater—To protect groundwater, when there is a choice of pesticides, the applicator should use the product least likely to leach.

Trade Names—To simplify information, trade names have been used. No endorsement of named products is intended and no criticism implied of similar products not mentioned.

IMPACT OF WEED COMPETITION

Weeds have been a pest to bean growers for as long as beans have been cultivated. Prior to the 1940s, growers were limited to hand pulling and mechanical methods such as cultivation to remove weeds. Modern chemical weed control began in the 1940s with the discovery of 2,4-D; however, selective chemical weed control in dry beans did not begin until the early 1950s with the development of chloroblast and chloropropham. The herbicide EPTC was used extensively in the early 1960s until trifluralin was introduced in the late 1960s. Together, these two herbicides served as the primary selective herbicides in dry beans for many years.

Today, the emphasis is on integrating all available weed control methods. This approach, called integrated weed management (IWM), allows growers to control problem weeds by utilizing preventive, cultural, mechanical, and chemical methods. Reliance on a single method, such as herbicides, to control weeds should be avoided as it often causes a shift to other weed species or the development of resistance within the target weed population, thus diminishing the effectiveness of that particular tool.

PROBLEM WEED SPECIES

Several grass weed species are a problem in Pacific Northwest (PNW) bean fields including green and yellow foxtail (Setaria viridis), barnyardgrass (Echinochloa crus-galli), hairy nightshade (Solanum sarrachoides), and green foxtail (Setaria viridis) reduced dry bean yields 40, 30, 22, 18, 15 and 6 percent, respectively, at densities as low as two plants per 6 feet of row.

Nighshade species are extremely troublesome in an edible dry bean crop. In addition to being poisonous, juice from the nightshade berry stains bean seed coats and causes dirt and other debris to adhere to beans during harvest. The presence of nightshade berries can also render green beans unsuitable for canning.

by Brenda M. Waters and Don Morishita

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PROBLEM WEED SPECIES

Several grass weed species are a problem in Pacific Northwest (PNW) bean fields including green and yellow foxtail (Setaria glauca), barnyardgrass, field sandbur (Cenchrus incertus), wild oat (Avena fatua), wild proso millet (Panicum miliaceum), and witchgrass (Panicum capillare). Broadleaf weeds found in PNW bean fields include common lambsquarters (Chenopodium album), common mallow (Malva neglecta), kochia (Kochia scoparia), prickly lettuce
(Lactuca aralia), redroot pigweed, Powell amaranth (Amaranthus powellii), common cocklebur, prostrate knotweed (Polygonum aviculare), common sunflower, and hairy nightshade. Yellow nuttage (Cyperus esculentus), field bindweed (Convolvulus arvensis), Canada thistle (Cirsium arvense), perennial sowthistle (Sonchus arvensis), and quackgrass (Elytrigia repens) are perennial weeds occasionally found in bean fields. A series of photos of weed species that commonly infect PNW bean fields can be found on pages 4 and 5.

Nightshade—In the PNW, the predominant nightshade species is hairy nightshade. Cutleaf nightshade (Solium trilorum) and black nightshade (Solanum nigra) are also found in PNW bean fields. Unfortunately, poor preventive and cultural weed management practices are a primary cause of spreading nightshade seed from one field to another. It can spread on tillage and harvest equipment, and it can also contaminate various crop seeds planted in the spring. Nightshade plants are unaffected by the shade from the bean canopy and usually continue germinating after preemergence herbicides have begun to lose their effectiveness. One nightshade plant can produce as many as 178,000 seeds that become viable early in the development of the poisonous berries. Nightshade seed can remain viable in the soil for 10 years and sometimes longer.

WHAT IS INTEGRATED WEED MANAGEMENT IN DRY BEAN PRODUCTION?

Integrated Weed Management (IWM) is an environmentally sound system of long-term crop production that uses all available weed management knowledge and tools to grow and harvest a crop free of economically and environmentally damaging weed competition. It is the combination of as many different agronomic and weed management practices as possible. IWM works to minimize the effect of weed competition on the crop and decrease the potential for weed population shifts to weeds that are even more difficult to control than the present population. The objective of IWM is to manipulate the crop-weed relationship so that the growth of the crop is favored over that of the weeds.

Integrated weed management for growers can be broken into four main weed control strategies, which should be used in combination:

1. Preventive
2. Cultural
3. Mechanical
4. Chemical

WEED PREVENTION

Field sanitation, or practices that prevent weeds from entering and spreading through fields, is the first step in prevention. It is also the easiest practice to implement. Wind, irrigation water, livestock, and humans spread most weeds and weed seed.

- Plant certified weed-free bean and other crop seed.
- Properly clean tillage, cultivation, and harvest equipment to remove soil and organic materials to prevent spread of both annual and perennial weeds.
- Properly till and cultivate to eliminate or reduce the number of viable weed seeds before spreading it on a field.
- Control weeds growing on field perimeters and along irrigation ditches to prevent their spread into the field.
- Irrigation water can be a source of weed seed to a weed screen or filter for surface irrigation water to reduce the number of weed seeds introduced into a field. Recent research in Idaho has shown that using polyethylene film (PEM) for reducing soil erosion in furrow-irrigated crops also reduces the movement of weed seed from fields.
- Scout fields to detect patches of newly invading weeds or herbicide-resistant weeds.
- Control small weed patches by spot spraying (annual or perennial weeds) with an appropriate herbicide or by removing the weeds by hand (most effective for annual weeds) before the weed has had the chance to produce seed.

CULTURAL PRACTICES

■ Crop Rotation—Rotating between less competitive annual row crops such as dry beans and sugarbeets and more competitive crops such as small-grain cereals, especially winter cereals, and alfalfa in a growing rotation can decrease disease and insect problems. Crop rotation plan alternates dry beans with crops that have contrasting characteristics and associated weeds in a minimum three- or four-year crop rotation. An effective way to grow wheat, followed by dry beans, followed by sugarbeets, onions, or alfalfa. Crop rotation not only decreases weed populations but increases harvest quality and yield, improves soil conditions, and can decrease disease and insect problems.

■ Crop Competition—The first four to five weeks after a bean crop emerges is the critical weed-free period. During this period it is essential to prevent weed competition in order to attain the maximum crop yield. Once the bean canopy becomes established, late-emerging weed growth will slow. Paying attention to the management of soil fertility, water, insects, and disease is critical for competitive dry bean production. Optimal fertilizer placement, plant spacing, cultivation, and irrigation timing all contribute to giving beans the competitive edge.

■ Fertilization—Use soil sampling and soil tests to determine what kind of fertilizer is needed and how much. Optimal fertilizer placement such as banded or chink-injection should make more

FURTHER READINGS


WEB SITES OF INTEREST

Lethbridge Research Centre, for crop and pest management information. http://www.etsr2.ag.cal/lethbridge
Manitoba Agriculture and Food, for crop and pest management information. http://www.gov.mb.ca/agriculture
North Dakota State University Extension, for crop and pest management information. http://www.ext.nodak.edu/extpubs/
University of California Davis Integrated Pest Management, for crop and pest management information. http://www.ipm.ucdavis.edu
University of Idaho Cooperative Extension System, for crop and pest management information. http://www.uidaho.edu/ag/extension/
Oregon State University Extension Publications for crop and pest management information. http://ext.orst.edu/agcom/LEMaTe/edmat/EdmatIndexAg.html

ORDERING PACIFIC NORTHWEST EXTENSION PUBLICATIONS

The following publications can be ordered from the University of Idaho, Oregon State University, or Washington State University:

Herbicide-Resistant Weeds and Their Management, PNW 437, $2
Pacific Northwest Weed Management Handbook, $25

University of Idaho
Agricultural Publications
University of Idaho P.O. Box 442404
Moscow, ID 83844-2240
(208) 885-7982
email: cme@uidaho.edu
http://www.ag.uidaho.edu

Oregon State University
Publication Orders
Extension & Station Communications
Oregon State University
222 Kerr Administration
Corvallis, OR 97331-2119
email: puborders@orst.edu

Washington State University
Bulletins Office
Cooper Publications Building, Dept. WB
P.O. Box 645912
Pullman, WA 99164-5912
(509) 335-3006
Fax: (509) 335-3006
email: bulletin@coopext.cahe.wsu.edu

The authors—Brenda M. Waters, former Graduate Student, and Don W. Monshita, Extension Weed Scientist, Department of Plant, Soil, and Environmental Sciences, University of Idaho

Integrated Weed Management in Dry Edible Beans Integrated Weed Management in Dry Edible Beans
Table 1. Susceptibility of weeds to herbicide use in dry beans.

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Annual grasses

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Annual broadleaf weeds

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Nutrient availability to the bean crop and less availability to the weeds. Banding near the bean row or lay-by applications of fertilizer may help to make soil nutrients less available to the weeds than a broadcast application.

**CHEMICAL CONTROL**

Selecting the proper herbicide for the weeds present in the field is essential. Keep annual records on each field and use them to anticipate the spectrum of weeds you will need to control. Preplant herbicide selection is usually based on records from previous years, while selection of a postemergence herbicide is based on the population of emerged weed seedlings. A preplant herbicide application normally controls weeds for the first 4 to 6 weeks, depending on the herbicide and weather conditions.

Identify weed seedlings as they emerge in the field (see pages 4-5), and apply an appropriate selective herbicide. In drier climates of the Pacific Northwest, postemergence herbicides sometimes do not control weeds as effectively as in more humid or wetter climates (table 3).

Dry edible beans are a minor crop, and therefore fewer herbicides are registered for use in beans than in major crops because companies cannot economically afford to pay for registration of new selective herbicides. This means that bean producers will probably rely more heavily on programs such as IR-4, which facilitates registration of pesticides for minor crops.

Herbicide Recommendations—Herbicides and recommendations for their use in dry beans change periodically. Up-to-date information is contained in the annually revised Pacific Northwest Weed Management Handbook. (see ordering information on page 7).

In addition, specific herbicides and their effectiveness for controlling individual weed species can be found in the same publication. Be sure to check herbicide labels for the most current information relative to timing and rate recommendations for your state. Do not apply herbicides that are not labeled for use in your area.

**Preventing Herbicide Resistance—** Unfortunately, the repeated use of a particular herbicide, or of herbicides with similar modes of action, on the same field has produced weed biotypes that are herbicide resistant. In order to prevent selection for herbicide-resistant weed biotypes, a good resource is Herbicide Resistance Weeds and Their Management, PNW 437 (see ordering information). This bulletin helps growers select herbicides from different modes of action group every year, which reduces the selection pressure for herbicide-resistant weeds.

Parts of a grass seeding

- **Sheath types**
  - Hairy sheath surface
  - Hairy sheath margin
  - Ligule margin
  - Ligule types
    - Blade
    - Blade margin
    - Blade collar
    - Blade sheath
    - Blade node

Note: E = excellent, G = good, F = fair, P = poor, — = no information


*Number of months after application to plant a non-labeled crop.*
Barnyardgrass (Echinochloa crus-galli). Sheath is flattened and sometimes reddish. Ligule is absent.

Foxtail, green (Setaria viridis). Sheath margin is hairy. Ligule is hairy. (Neither is visible in this image.)

Millet, wild-proso (Panicum miliaceum). Sheath is very hairy. Hairs are soft. Ligule is hairy. (The ligule is not visible here.) Seed often remains attached to seedling.

Wild oat (Avena fatua). Leaf blades twist counter-clockwise and have hairs on the margins. Ligule, not visible here, is membranous.

Witchgrass (Panicum capillare). Sheath is very hairy. Hairs are rigid. Ligule, not visible here, is hairy. Seed easily detaches from seedling.

Bindweed, field (Convolvulus arvensis). Cotyledons are kidney shaped. Leaves are alternate and arrowhead shaped.

Common cocklebur (Xanthium strumarium). Cotyledons are lanceolate (much longer than wide and pointed). Leaves are alternate, toothed, and hairy. Cultivar nightshade (S. triflorum) cotyledons are linear. First leaves are toothed and later leaves are deeply lobed.

Pigweed, redroot (Amaranthus retroflexus). Cotyledons are linear. Leaves are alternate, red-tinged, and often have notched leaf tips.

Puncturevine (Tribulus terrestris). Cotyledons are oblong (2 to 4 times longer than wide). Leaves are alternate, compound (have multiple leaflets), and hairy.

Purslane, common (Portulaca oleracea). Cotyledons, not visible in this image, are linear. Leaves are alternate, reddish-tinged, and succulent.

Sowthistle, annual (Sonchus oleraceus). Plants emerging from rootstock are toothed like dandelion leaves and have a white milky juice.

Sowthistle, perennial (Sonchus arvensis). Plants emerging from rootstock are toothed like dandelion leaves and have a white milky juice.

Sunflower, common (Helianthus annuus). Cotyledons are oval to round. First leaves are opposite, rough, and hairy.

Thistle, Canada (Cirsium arvense). Plants emerging from rootstock have wavy leaves with prickles on the leaf margins.
### Identifying Weed Seedlings

**Barnyardgrass** (*Echinochloa crus-galli*), Sheath (stem) is flattened and sometimes reddish. Ligule is absent.

**Foxtail, green** (*Setaria viridis*). Sheath margin is hairy. Ligule is hairy. (Neither is visible in this image.)

**Millet, wild-proso** (*Panicum miliaceum*). Sheath is very hairy. Hairs are soft. Ligule is hairy. (The ligule is not visible here.) Seed often remains attached to seedling.

**Wild oat** (*Avena fatua*). Leaf blades twist counter-clockwise and have hairs on the margins. Ligule, not visible here, is membranous.

**Witchgrass** (*Panicum capillare*). Sheath is very hairy. Hairs are rigid. Ligule, not visible here, is hairy. Seed easily detaches from seedling.

**Bindweed, field** (*Convolvulus arvensis*). Cotyledons are kidney shaped. Leaves are alternate and arrowhead shaped.

**Cocklebur, common** (*Xanthium strumarium*). Cotyledons are lanceolate (much longer than wide and pointed). Leaves are alternate, toothed, and hairy. Cultivated nightshade (*S. triflorum*) cotyledons are linear. First leaves are toothed and later leaves are deeply lobed.

**Pigweed, redroot** (*Amaranthus retroflexus*). Cotyledons are linear. Leaves are alternate, red-tinged, and often have notched leaf tips.

**Puncturevine** (*Tribulus terrestris*). Cotyledons are oblong (2 to 4 times longer than wide). Leaves are alternate, compound (have multiple leaflets), and hairy.

**Purslane, common** (*Portulaca oleracea*). Cotyledons are linear. Leaves are alternate, reddish-tinged, and succulent.

**Perennial sowthistle** (*Sonchus arvensis*). Plants emerging from rootstock are toothed like dandelion leaves and have a white milky juice.

**Common sunflower** (*Helianthus annuus*). Leaves are opposite, rough, and hairy.

**Thistle, Canada** (*Cirsium arvense*). Plants emerging from rootstock have wavy leaves with prickles on the leaf margins.

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### Identifying Weed Seedlings

**Lettuce, prickly** (*Lactuca serriola*). Leaves are alternate, true green, and toothed, with spiny margins and a white milky juice. Cotyledons, not visible in this image, are ovate (egg shaped with broader part at the base).

**Mallow, common** (*Malva neglecta*). Cotyledons are ovate to heart-shaped. Leaves are alternate, round, and fine toothed on the margins.

**Nightshades, hairy** (left) and **cutleaf** (right). Hairy nightshade (*Solanum sarrachoides*) cotyledons are lanceolate. Leaves are alternate, toothed, and hairy. Cultivated nightshade (*S. triflorum*), cotyledons are linear. First leaves are toothed and later leaves are deeply lobed.

**Common purslane** (*Portulaca oleracea*). Plants emerging from rootstock are toothed like dandelion leaves and have a white milky juice.

**Common sunflower** (*Helianthus annuus*). Leaves are opposite, rough, and hairy.

**Thistle, Canada** (*Cirsium arvense*). Plants emerging from rootstock have wavy leaves with prickles on the leaf margins.
Table 1. Susceptibility of weeds to herbicide use in dry beans.

<table>
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Note: E = excellent, G = good, F = fair, P = poor, — = no information.

Cultural Practices

- **Crop Rotation** — Rotating beans with less competitive annual row crops such as dry beans and sugar beets and more competitive crops such as small-grain cereals, especially winter cereals, and alfalfa aids in preventing the build-up of troublesome weeds in dry beans. In contrast, planting the same crop year after year is more prone to the movement of weed seed from one field to another. It can spread on tillage and harvest equipment, and it can also contain seed that remains in the soil the next growing season. The growth of weeds planted in the spring. Nightshade plants are unaffected by the shade from the bean canopy and usually continue germinating after preemergence herbicides have begun to lose their effectiveness. One nightshade plant can produce as many as 178,000 seeds that become viable early in the development of the poisonous berries. Nightshade seed can remain viable in the soil for 10 years or longer. Nightshade plants are mostly weeds of the PNW bean fields. Unfortun-

**WHAT IS INTEGRATED WEED MANAGEMENT IN DRY BEAN PRODUCTION?**

Integrated Weed Management (IWM) is an environmentally sound system of long-term crop production that uses all available weed management knowledge and tools to grow and harvest a crop free of economically and environmentally damaging weed competition. It is the combination of as many different agronomic and weed management practices as possible. IWM works to minimize the effect of weed competition on the crop and decrease the potential for weed population shifts to weeds that are even more difficult to control than the present population. The objective of IWM is to manipulate the crop-weed relationship so that the growth of the crop is favored over that of the weeds. IWM integrated weed management for growers can be broken into four main weed control strategies, which should be used in combination:

1. **Preventive**
2. **Cultural**
3. **Mechanical**
4. **Chemical**

**WEED PREVENTION**

Field sanitation, or practices that prevent weeds from entering or spreading through fields, is the first step in prevention. It is also the easiest practice to implement. Wind, irrigation water, livestock, and humans spread most weeds and weed seeds.

- **Plant certified weed-free bean and other crop seed.**
- **Properly clean tillage, cultivation, and harvest equipment to remove soil and organic materials to prevent spread of both annual and perennial weeds.**
- **Properly till or mow to reduce the number of viable weed seeds before spreading it on a field.**
- **Control weeds growing on field perimeters and along irrigation ditches to prevent their spread into the field.**
- **Irrigation water can be used to source weed seed.**
- **Use a weed screen or filter for surface irrigation water to reduce the number of weed seeds introduced into a field.**
- **Use crop rotation with non-host crop species** — In the PNW, the predominant nightshade species is hairy nightshade. Cutleaf nightshade (Solonum trilolum) and black nightshade (Solonum nigram) are also found in PNW bean fields. Unfortunately, poor preventive and cultural weed management practices are a primary cause of spreading nightshade seed from one field to another. It can spread on tillage and harvest equipment, and it can also contain seed that remains in the soil the next growing season. The growth of weeds planted in the spring. Nightshade plants are unaffected by the shade from the bean canopy and usually continue germinating after preemergence herbicides have begun to lose their effectiveness. One nightshade plant can produce as many as 178,000 seeds that become viable early in the development of the poisonous berries. Nightshade seed can remain viable in the soil for 10 years or longer. Nightshade plants are mostly weeds of the PNW bean fields. Unfortun-

**FURTHER READINGS**


**WEB SITES OF INTEREST**


Lethbridge Research Centre, for crop and pest management information. http://www.re2.ag.ca/lethbridgel


University of California Davis Integrated Pest Management, for crop and pest management information. http://www.ipm.ucdavis.edu

University of Idaho Cooperative Extension System, for crop and pest management information. http://www.uidaho.edu/ag/extension/

Oregon State University Extension Publications for crop and pest management information. http://ext.orst.edu/acomwebb/edu/mt/EdmatIndexAg.html


**ORDERING PACIFIC NORTHWEST EXTENSION PUBLICATIONS**

The following publications can be ordered from the University of Idaho, Oregon State University, or Washington State University:

Herbicide Resistant Weeds and Their Management, PNW 437, $2 Pacific Northwest Weed Management Handbook, $25

University of Idaho
Agricultural Publications
University of Idaho P.O. Box 442400
Moscow, ID 83844-2240
(208) 885-7982
email: cking@uidaho.edu
http://info.aguidaho.edu

Oregon State University
Publication Orders
Extension & Station Communications
Oregon State University
242 Kerr Administration
Corvallis, OR 97331-2119
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Cooper Publications Building, Dept. WB
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Pullman, WA 99164-5912
(509) 732-7163
Fax: (509) 335-2006
email: bulletin@coopext.cahe.wsu.edu

The authors—Brenda M. Waters, former Graduate Students, and Don W. Morshita, Extension Weed Scientist, Department of Plant, Soil, and Entomological Sciences, University of Idaho
Integrated Weed Management in Dry Edible Beans

by Brenda M. Waters and Don Morishita

INTRODUCTION
Weeds have been a pest to bean growers for as long as beans have been cultivated. Prior to the 1960s, growers were limited to hand pulling and mechanical methods such as cultivation to remove weeds. Modern chemical weed control began in the 1940s with the discovery of 2,4-D; however, selective chemical weed control in dry beans did not begin until the early 1950s with the development of clomazone and chlorproprom. The herbicide EPTC was used extensively in the early 1960s until trifluralin was introduced in the late 1960s. Together, these two herbicides served as the primary selective herbicides in dry beans for many years.

Today, the emphasis is on integrating all available weed control methods. This approach, called integrated weed management (IWM), allows growers to control problem weeds by utilizing preventive, cultural, mechanical, and chemical methods. Reliance on a single method, such as herbicides, to control weeds should be avoided as it often causes a shift to other weed species or the development of resistance within the targeted weed population, thus diminishing the effectiveness of that particular tool.

IMPACT OF WEED COMPETITION
Weed control costs bean producers more money than any other pest management practice. Bean plants compete poorly against weeds. Weeds compete with bean plants for water, nutrients, and sunlight and thereby decrease crop yield and quality.

Heavy weed densities can increase humidity within the canopy, thus reducing airflow and increasing the possibility of disease development. Weeds that are green at cutting increase bean drying time in the field, resulting in yield losses due to shattering and also increased disease potential. Even at low weed densities, bean yields are reduced from shading by weeds. In studies conducted in western Nebraska, eastern Wyoming, and Colorado, common sunflower (Helianthus annuus), common cocklebur (Xanthium strumarium), redroot pigweed (Amaranthus retroflexus), barnyardgrass (Echinochloa crus-galli), hairy nightshade (Solanum sarrachoides), and green foxtail (Setaria viridis) reduced dry bean yields 40, 30, 22, 18, 15 and 6 percent, respectively, at densities as low as two plants per 6 feet of row.

Nightshade species are extremely troublesome in an edible dry bean crop. In addition to being poisonous, juice from the nightshade berry stains bean seed coats and causes dirt and other debris to adhere to bean seed during harvest. The presence of nightshade berries can also render green beans unsuitable for canning.

PROBLEM WEED SPECIES
Several grass weed species are a problem in Pacific Northwest (PNW) bean fields including green and yellow foxtail (Setaria glauca), barnyardgrass, field sandbur (Cenchrus incertus), wild oat (Avena fatua), wild-proso millet (Panicum miliaceum), and witchgrass (Panicum capillare). Broadleaf weeds found in PNW bean fields include common lambsquarters (Chenopodium album), common mallow (Malva neglecta), kochia (Kochia scoparia), prickly lettuce (Lactuca serriola), and Canada thistle (Cirsium arvense).