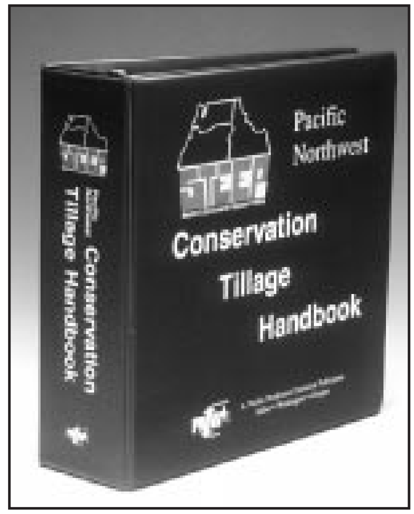
PNW 492

Managing Russian Thistle Under Conservation Tillage in Crop-Fallow Rotations

A Pacific Northwest Extension Publication
Idaho • Oregon • Washington

This publication is a revision of Pacific Northwest Conservation Tillage Handbook Series No. 16 in chapter 5, "Weed Control Strategies." Please file it in your *Pacific Northwest Conservation Tillage Handbook.*

Further readings



Pacific Northwest Conservation Tillage Handbook, $20.00

The handbook consolidates more than 130 in-depth publications on new management technology for conservation tillage systems into an organized resource guide. Its large three-ring binder permits addition of new and revised publications. Purchasers who return the enclosed updating card are added to a mailing list for new series publications and related information on conservation tillage systems.

Managing Downy Brome under Conservation Tillage Systems in the Inland Northwest Crop-Fallow Region, Pacific Northwest Conservation Tillage Handbook Series No. 15, Chapter 5, "Weed Control Strategies," free

Copies can be requested from Roger Veseth, WSU/UI Extension Conservation Tillage Specialist, at (208) 885-6386 or Don Wysocki, OSU Extension Soil Scientist, at (503) 278-4186.

Russian Thistle, PNW 461, $1.00

Reviews the biology and identification of Russian thistle.

Herbicide-Resistant Weeds and Their Management, PNW 437, 50¢

Pacific Northwest Weed Control Handbook, $19.50

This annually revised extension publication gives specific chemical recommendations.

To order publications listed above, contact the extension office in your county or the following:

In Idaho, Ag Publications, University of Idaho, Moscow, ID 83844-2240, (208) 885-7982.

In Oregon, Agricultural Communications, Publications Orders, Oregon State University, Administrative Services A422, Corvallis, OR 97331-2119, (503) 737-2513.

In Washington, Bulletin Office, Cooperative Extension, Cooper Publications Building, Washington State University, Pullman, WA 99164-5912, (509) 335-2857.

Authors

Frank Young, Research Agronomist, USDA-Agricultural Research Service, Pullman, WA; *Roger Veseth,* Extension Conservation Tillage Specialist, Washington State University and University of Idaho, Moscow; *Donn Thill,* Weed Scientist, University of Idaho, Moscow; *William Schillinger,* Area Extension Agronomist, Washington State University, Ritzville; and *Dan Ball,* Weed Scientist, Oregon State University, Pendleton.

Introduction

Russian thistle (*Salsola iberica*) is a summer-annual broadleaf weed commonly found in many of the low precipitation cropland areas of the Pacific Northwest. This weed causes serious production problems in crop, following harvest, and during summer fallow.

Tillage to control Russian thistle after harvest and during the summer fallow season can reduce crop residue on the soil surface and decrease surface roughness, which increases the potential for soil erosion and soil water loss by evaporation and runoff. Use of herbicides in the sulfonylurea family (such as Glean and Finesse) provided effective Russian thistle control in the 1980s, but widespread Russian thistle resistance to these crop protection chemicals has resulted in the need to develop other management options.

Fortunately, research in the Pacific Northwest and the experiences of an increasing number of growers show that good Russian thistle control, effective soil conservation, and profitable farming operations are compatible. Improved cultural and herbicide options for Russian thistle control are providing effective weed control in profitable conservation systems.

This publication reviews aspects of Russian thistle biology as they relate to management and outlines some key considerations for management. The four primary goals for Russian thistle management strategies are to:

(1) Reduce Russian thistle seed production and seedbank in the soil

(2) Reduce wind and water erosion potential

(3) Increase soil water storage and crop yield potential

(4) Increase profitability…the bottom line

More detailed information on the biology and identification of Russian thistle appears in PNW 461, *Russian Thistle*, available through extension offices in the Northwest.

Russian thistle biology

Seed dormancy and longevity in soil

Management strategies that focus on preventing seed production are effective because Russian thistle seed has both limited dormancy and longevity in the soil. Most newly produced Russian thistle seeds are dormant for a short period of time after they mature in the fall. Seed dormancy decreases over winter and is almost nonexistent by spring, allowing germination to occur over a wide range of temperature and moisture conditions.

Research under irrigated conditions indicates that Russian thistle seed viability in the soil declines greatly within 2 years. Under irrigated conditions at Prosser, Wash., about 99 percent of the seeds either germinated the first year or died before germinating. In dryland wheat-fallow areas, seed longevity in the soil may be longer, and research has been initiated to determine just how long. Russian thistle seed is soft and porous, characteristics that contribute to its lack of longevity and ability to germinate rapidly.

Seed distribution

Russian thistle has a unique mechanism for increasing the area of infestation. Mature plants break at ground level, and they tumble with the wind to disperse seeds.

An experiment was conducted in eastern Washington in 1991 and 1992 to measure seed dispersal and movement of Russian thistle. Plant movement was highly correlated with wind direction. Some plants moved up to 2.5 miles in 6 weeks, while other plants moved only 200 feet because of variable winds and because of being compressed with snow or frozen into wheat stubble. Average estimated seed number per plant at the start of the experiment was 61,700. Average percentage seed loss for the tumbling plants was 57 percent.

A special layer of cells where the stem joins the roots enables plants to break away with the wind during winter months after seeds are mature. Cutting off mature Russian thistle plants with tillage implements in the fall also releases the tumbling plants—a factor to consider when selecting tillage implements and when timing operations. Because undisturbed Russian thistle can produce 150,000 to 200,000 seeds, and seed distribution is rapid and widespread, there is a high potential for future infestations.

Seed germination and emergence

Russian thistle seeds require only a short moist period to germinate rapidly and emerge from the soil. As growers know, Russian thistle can emerge in significant numbers in crop and fallow after very light rains (about 0.1 inch) on dry soil (fig. 1). Germinating seeds also can withstand several wetting and drying cycles until there is sufficient moisture for emergence and establishment. The primary reason for this unique survival trait is that a Russian thistle seed consists of a fully differentiated, coiled "seedling" in the form of a spiral helix (plate 1, page 4), ready to take quick advantage of short periods of favorable environmental conditions (plate 2, page 4).

Plate 1.

Russian thistle seedling developing from the fully differentiated, coiled seed that permits rapid early growth during short periods of favorable growing conditions. (Photo by F. L. Young, USDA-ARS, Pullman, Wash.)

Plate 2.

Russian thistle seedling shortly after emergence. (Photo by F. L. Young, USDA-ARS, Pullman, Wash.)

Plate 3.

Flowering stage of Russian thistle. (Photo by F. L. Young, USDA-ARS, Pullman, Wash.)

Optimal temperatures for Russian thistle germination range between 45° and 95°F. Seeds can germinate under cooler conditions when nighttime temperatures are below freezing, if daytime temperatures are above freezing. However, young seedlings are very susceptible to frost. Emergence typically begins in late March or early April, extending through the summer if sufficient precipitation occurs.

One factor limiting Russian thistle establishment is seed depth in soil (fig. 2). Emergence is optimal at depths less than 1.0 inch, although some seedlings can emerge from depths of 3 inches under favorable conditions.

Russian thistle establishment also can be limited by compacted soils. The roots cannot effectively penetrate compacted soil as the coiled embryo unwinds during germination. In addition, shoot emergence can be restricted by crusted surface soil, even if seeds are buried shallowly. However, seedlings can emerge through cracks in the soil surface.

Plant growth after establishment

Flowering commonly begins around mid-June (plate 3, page 4). To prevent seed production and reduce weed competition, Russian thistle should be controlled within 4 weeks after emergence. Russian thistles usually remain small in a competitive winter wheat crop but grow rapidly immediately after harvest. Russian thistles grow larger in a less competitive crop, such as spring wheat, or in thin stands of winter wheat, particularly under drought conditions. Without adequate control in crop, Russian thistle can cause severe crop losses and harvest problems (plate 4, page 9).

Figure 1.

Russian thistle emergence with increasing amounts of rainfall. (Source: Dwyer, D. D., and K. Wolde-Yohannis. 1972. Germination, emergence, water use and production of Russian thistle. Agronomy Journal 64:52-55.)

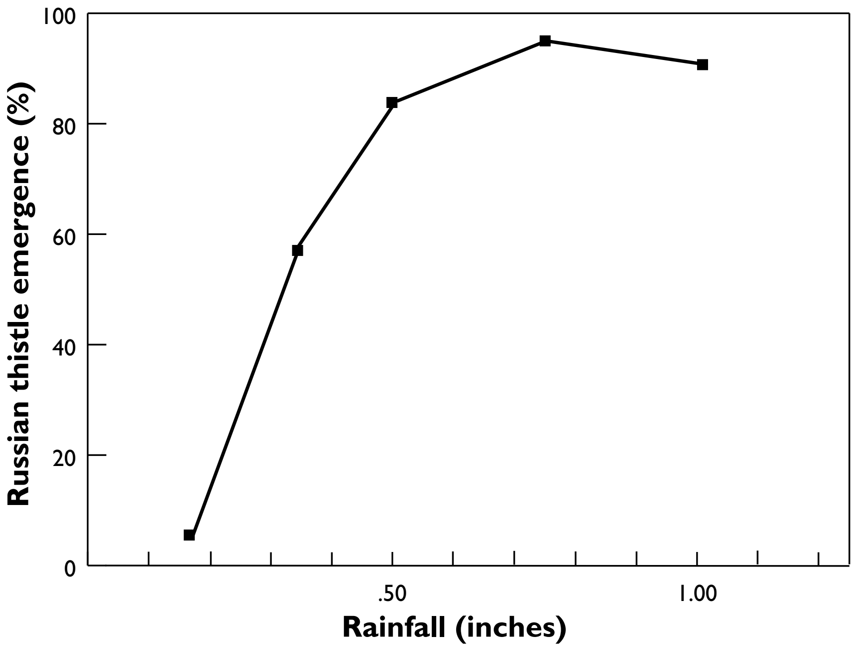
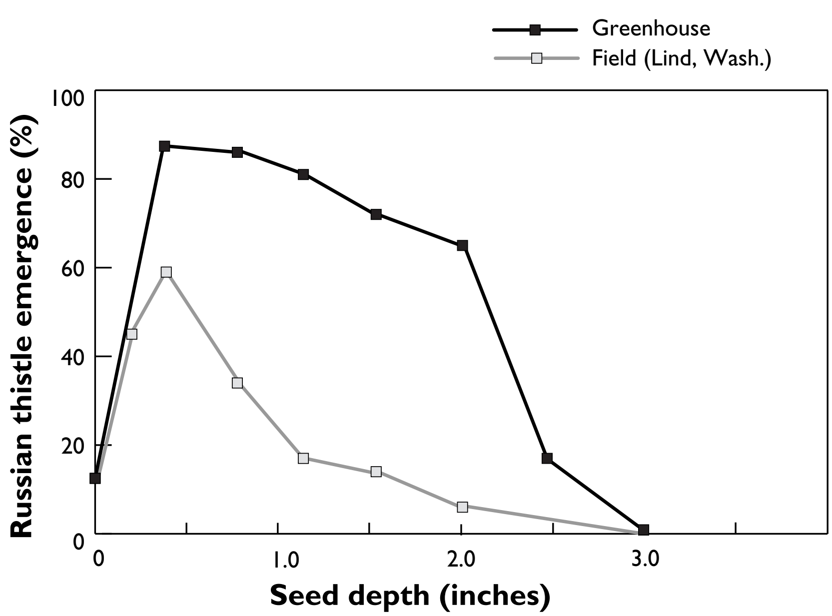


Figure 2.

Russian thistle emergence from seeds buried at increasing depths in sandy loam soil compacted to a bulk density similar to that of a planted field. (Source of greenhouse data: Evans, R.A., and J.A. Young. 1972. Germination and establishment of *Salsola* in relation to seedbed environment - II. Seed distribution, germination, and seedling growth of *Salsola* and microenvironmental monitoring of the seedbed. Agronomy Journal 64:219-224. Source of field data from Lind, Wash.: Young, F.L.. 1982. Unpublished data.)



Flowering increases greatly after small grain harvest, when about 90 percent of Russian thistle growth and most of the seed set commonly occur. Russian thistles can regrow quickly after harvest even though their top portions are cut by the combine. This rapid growth after harvest is why Russian thistle not controlled in crop should be controlled within about 2 weeks after harvest to reduce seed and biomass production and soil water use (plate 5, page 9). Russian thistle is indeterminate, therefore it continues to flower and produce seed as long as conditions allow, typically until a killing frost at around 25°F or less, or until several successive frosts just below freezing occur.

Studies indicate that Russian thistle is one of the most efficient plants in the world at producing plant dry matter per unit of water used. Russian thistle roots extract water from the soil very efficiently and can extend to a depth of 5 feet with a lateral spread of 6 feet.

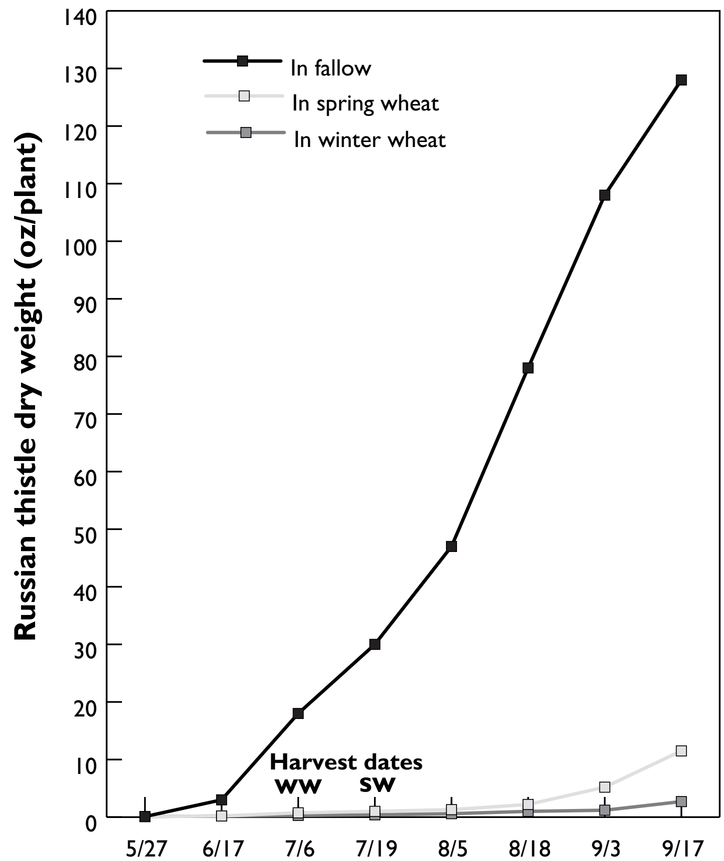
Winter wheat grown on silt loam soils in the Inland Northwest commonly extracts water down to 4.5 percent (by volume) by harvest time. Russian thistle roots will continue to extract soil water when it is no longer available to the wheat plants. It is important to control Russian thistle postharvest to prevent excessive soil water loss.

Crop competition

Growing a competitive crop is a very important management tool to reduce Russian thistle growth and seed production. Growth of Russian thistle is suppressed greatly when the crop establishes first, overtops the weed, and has adequate moisture and nutrients. Russian thistle causes the greatest yield losses during drought conditions, in poor stands, and in crops planted late.

Figure 3.

Russian thistle growth in fallow, in spring wheat, and in winter wheat at Lind, Wash. Russian thistle emerged in early April. Winter and spring wheats were harvested at points marked *ww* and *sw*, respectively. (Source: Young, F.L. 1986. Russian thistle (*Salsola iberica*) growth and development in wheat. Weed Science 34:901-905.)



Russian thistle usually reduces crop yield more in spring wheat than in winter wheat. A study of Russian thistle growth and development in summer fallow, spring wheat, and winter wheat was conducted at Lind, Wash., in 1982 and 1983. Russian thistles were established in early April and allowed to grow until killed by frost in October.

Dry weight of Russian thistle grown in winter wheat was about 75 percent less than that of Russian thistle grown in spring wheat and 98 percent less than under fallow with no weed or crop competition (fig. 3). After harvest Russian thistle that had grown in spring wheat used about four times more water than plants grown in winter wheat. Results from these and other experiments at Lind show that winter wheat reduced Russian thistle emergence 44 percent, seedling survival 42 percent, and seed production 74 percent compared with spring wheat.

When Russian thistle was not controlled through the growing season or after harvest, single plants produced 150,000 seeds in undisturbed fallow, 17,400 in spring wheat, and 4,600 in winter wheat.

Even though spring wheat competes less well against Russian thistle than winter wheat does, management practices that increase its competitiveness can help suppress Russian thistle. Research data on weed-crop competition in spring wheat in 1983-85 at Lind reveal the importance of early spring wheat establishment (table 1). Although Russian thistle density was highest in 1984, wheat yield loss was much lower than in 1983 or 1985. This can be attributed partially to seeding wheat 1 week earlier in 1984 and to the crop's emerging 2 weeks ahead of Russian thistle, compared with 1 week ahead in 1983 and 1985. Although weed densities were similar in 1983 and 1985, Russian thistle was much more competitive in 1985 when rainfall was low.

Wheat and Russian thistle residue

The erosion control challenge in the very dry areas is threefold: (1) not enough crop residue is produced; (2) soils are generally coarse textured and seldom retain adequate soil cloddiness; and (3) traditional soil management techniques often reduce soil roughness and bury most of the crop residue. By the end of the fallow period the surface soil mulch is often powdery and lacks surface residue. In these areas, Russian thistle skeletons can provide an important source of residue for water conservation and erosion control.

A residue management experiment was initiated at Lind, Wash., during the 1993-94 fallow cycle to determine how much tillage could be reduced while maintaining an agronomically feasible production system. Traditional, minimum, and delayed minimum tillage systems were evaluated (table 2).

Preliminary results of this study indicate that significantly more win

Table 1.

Spring wheat yield losses from Russian thistle competition, 1983-85, WSU Dryland Research Unit, Lind, Wash.

Year	Russian thistle density (plants/ sq ft)	Seeding date	Wheat emergence ahead of Russian thistle	March-June rainfall (inches)	Wheat yield loss (%)
1983	5	March 18	1 week	3.9	31
1984	10	March 9	2 weeks	5.5	11
1985	4	March 15	1 week	1.8	55

Source: Young, F.L. 1988. Effect of Russian thistle (*Salsola iberica*) interference on spring wheat. Weed Science 36:594-598.

Table 2.

Field operations in the tillage management experiment, 1993-94 fallow cycle, WSU Dryland Agricultural Research Unit, Lind, Wash.

Date	Traditional tillage	Minimum tillage	Delayed minimum tillage
8/93	Sweep 12" spacing	Herbicide-Landmaster @ 48 oz	Herbicide-Landmaster @ 48 oz
10/93	Chisel 24" spacing	Chisel 72" spacing	Chisel 72" spacing
2/94	Herbicide-Roundup @ 12 oz	Herbicide-Roundup @ 12 oz	Herbicide-Roundup @ 12 oz
3/94	Cultivator + harrow (2 passes)	Undercutter + rolling harrow	
4/94	Anhydrous N injection @ 40 lb		
5/94	First rodweeding	First rodweeding	Undercutter + rolling harrow
6/94	Second rodweeding	Second rodweeding	First rodweeding
7/94	Third rodweeding	Third rodweeding	Second rodweeding
9/94	Seeding	Seeding + aqua N @ 40 lb	Seeding + aqua N @ 40 lb

Source: W. Schillinger, WSU, Ritzville. Unpublished data.

ter wheat and Russian thistle residue can be retained through the fallow cycle in the minimum tillage systems and that Russian thistle skeletons can be an important contributor to the total surface residue (fig. 4).

Where Russian thistle roots were severed by postharvest sweeping under traditional tillage, most Russian thistle skeletons had blown away by November 7 (plate 6, page 9). In the two minimum tillage treatments, a postharvest herbicide application for Russian thistle control and fall chiseling with 72-inch shank spacing left most Russian thistle skeletons anchored overwinter and resulted in a higher percentage of overwinter precipitation stored in the soil. In general, leaving more residue on the soil surface overwinter increases soil water storage.

Herbicide resistance

In the early 1980s, the registration of sulfonylurea herbicides provided a great advancement in Russian thistle control. However, the development of extensive Russian thistle resistance to this herbicide family has set back control efforts. About 70 percent of sites infested with Russian thistle in eastern Washington now contain plants that are resistant to sulfonylurea herbicides. Resistance has also been confirmed throughout the Columbia Basin in Oregon and in Idaho. Sulfonylurea herbicides used in wheat and/or fallow cropland have included Glean, Ally, Finesse, Express, Harmony-Extra, and Amber.

While the tumbling of Russian thistle plants contributed to the rapid spread of the problem within and between fields, a key reason for rapid development of Russian thistle herbicide resistance is the “same” syndrome:

(1) Same herbicide or herbicide family used once or more each year for successive years

Figure 4.

Average weight of wheat residue (top) and Russian thistle skeletons (bottom) as affected by tillage method, 1993-94 fallow cycle, WSU Dryland Agricultural Research Unit, Lind, Wash. Averages followed by the same letter are not significantly different at the 5% probability level. (Source: W. Schillinger, WSU, Ritzville. Unpublished data.)

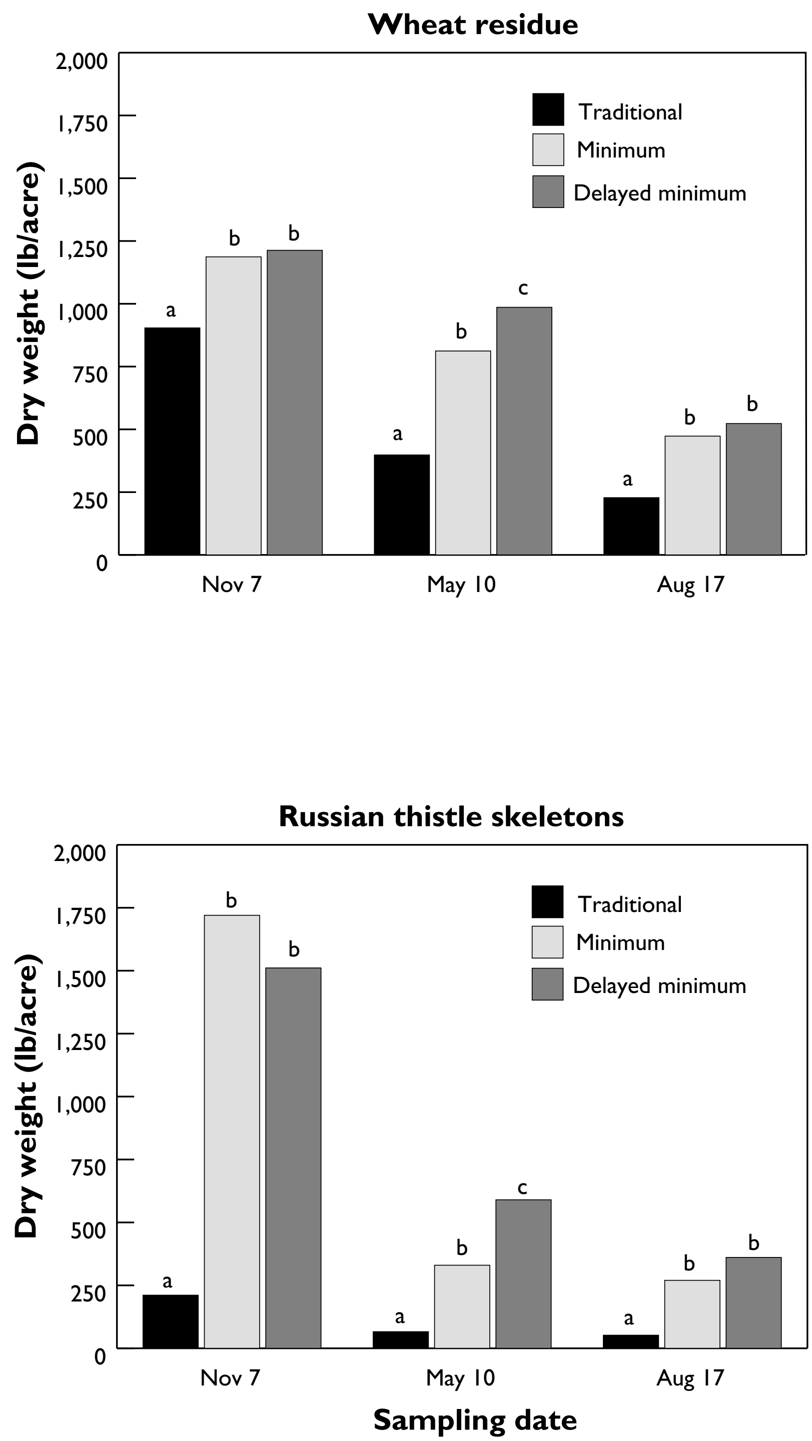


Plate 4.

Russian thistle emerging above the crop canopy in winter wheat, presenting harvest problems and reducing yield potential due to competition with the crop. (Photo by F. L. Young, USDA-ARS, Pullman, Wash.)

Plate 5.

Growth of Russian thistle by early September, 7 weeks after winter wheat harvest. (Photo by F. L. Young, USDA-ARS, Pullman, Wash.)

Plate 6.

Lind research trial in March 1994 prior to spring tillage. Russian thistle skeletons have blown from plots that were tilled postharvest with sweeps (left), but are still anchored in untilled plots, which received postharvest herbicide application (right). (Photo by W. Schillinger, WSU, Ritzville.)

(2) Same crop (for example, the wheat-fallow-wheat rotation)

(3) Same field

(4) Same target weeds

For more information on preventing and controlling herbicide-resistant weeds, see PNW 437, *Herbicide-Resistant Weeds and Their Management*.

Management strategy for Russian thistle infestations

Management strategies for Russian thistle that focus on preventing seed production throughout the crop rotation can reduce a serious Russian thistle infestation to a manageable one.

The following is a series of chronological management strategy considerations for a heavy Russian thistle infestation in a crop-fallow rotation, beginning in the crop year. It is assumed that Russian thistle is controlled on neighboring fields and field borders so reinfestations do not occur.

Crop year 1

1 **Plant winter wheat rather than spring wheat, if possible.** Winter wheat is more competitive and will help reduce Russian thistle emergence, survival, growth, and seed production. Practices that further increase winter wheat competitiveness also would be important Russian thistle management tools.

2 **If spring wheat is planted, due to winterkill or other production problems, use management practices that optimize its competitiveness with Russian thistle**. These include (1) seeding early (late February, early March) so wheat emerges ideally at least 2 to 3 weeks before Russian thistle; (2) seeding as shallow as possible to encourage rapid emergence; (3) placing fertilizer below and near seed rows for early wheat root access and vigorous crop growth; (4) using conservation tillage systems to minimize water evaporation and optimize water availability to the crop. If possible, use 6- to 7-inch row spacings to increase crop competition with Russian thistle.

3 **Use broadleaf herbicides to control Russian thistle in crop**. A tank mix of herbicides with different modes of action can reduce populations and the development of herbicide resistance, but only if all partners in the herbicide mix control the weed equally. At least spot apply herbicides in areas where Russian thistle may concentrate, such as drill skips, winter-killed areas, and draws where wind-blown Russian thistle skeletons collect.

Herbicides should be applied before the Russian thistles exceed 2 inches in height. Remember that the first Russian thistle plants to emerge will be the most competitive.

The goal is to kill or suppress Russian thistle in order to minimize competition with the crop, improve harvest efficiency, and reduce the potential for seed production later in the season. Complete control is not required. Lower-cost treatments may be fine as long as they provide a reasonable level of control. However, in a severe Russian thistle infestation it may be more effective to strive for optimal control rather than suppression.

4 **Consider a preharvest nonselective herbicide if Russian thistles were not controlled effectively early in the growing season**. Russian thistle will already have competed with the crop, but seed production can be reduced greatly and soil water conserved for the following crop. A preharvest application of a nonselective herbicide often controls Russian thistle better than postharvest applications. A preharvest treatment has several advantages:

(1) It saves time at harvest and improves harvest efficiency.

(2) It reduces Russian thistle size, seed production, and soil water use.

(3) It may eliminate the need for postharvest tillage for Russian thistle control or at least the need for intensive tillage to chop Russian thistle residue.

Fallow year 1, beginning after harvest

The Russian thistle management goal during fallow is to stop seed production for a second year, while optimizing seed zone soil water and retaining surface residue and roughness.

1 **Consider a postharvest herbicide application if in-crop and preharvest applications were not used or were not effective**. Herbicides should be applied within 10 to 14 days after harvest to minimize Russian thistle water use and seed production.

2 **Select postharvest herbicides that facilitate management of Russian thistle residue**. Nonselective herbicides applied preharvest or postharvest generally result in dry, brittle Russian thistle skeletons, which help reduce weed residue problems at harvest and during fall tillage operations. Other postharvest herbicides, such as 2,4-D, can leave the Russian thistle plants tough, leathery, and more difficult to manage.

3 **If a postharvest herbicide is not applied, consider tillage within about 2 weeks after harvest to minimize water use, seed set, and spread of severed plants in the wind**. Tillage with a sweep or wide-blade undercutter implements

can kill Russian thistle without excessive loss of surface residue.

Effective weed control in crop and preharvest can help avoid the use of more intensive tillage operations, such as discing, to control Russian thistle after excessive growth occurs following harvest. Discing can reduce surface residue and roughness significantly, and consequently reduces erosion protection and water storage potential during the fallow season and next winter wheat crop.

4 In areas where overwinter runoff on frozen soils occurs commonly, consider chiseling, subsoiling, or other noninversion tillage operations to increase water infiltration. Shank spacings of 4 to 6 feet can achieve this goal with minimal disturbance of anchored Russian thistle plants and standing stubble, thus optimizing residue benefits for trapping snow and reducing evaporation.

5 Delay primary or first spring tillage as long as possible. Consider using herbicide treatments for Russian thistle and other broadleaf or grass weeds to delay spring tillage. On fields known to have Russian thistle infestations, delay herbicide application and tillage until after the first heavy flush of emerging Russian thistle in the spring.

Crop year 2

The field should have a reduced Russian thistle population after 2 years of seedbank depletion if Russian thistle control efforts have been effective in crop year 1 and fallow year 1 and Russian thistle plants have not moved in from neighboring fields, field borders, and nonfield areas. Strive for good control again in crop year 2.

Windows of opportunity for Russian thistle control

There are several opportunities to reduce Russian thistle competitiveness and seed production during the crop-fallow rotation in the low rainfall zones. Making the best use of each window of opportunity throughout the rotation will provide the best overall control.

In crop

Several herbicides, with various degrees of effectiveness and costs, are available for control of Russian thistle. See the product label and the current year *Pacific Northwest Weed Control Handbook* for specific herbicide recommendations. Most recommended herbicides control Russian thistle best when applied to 2-inch-tall or smaller plants. Minimize the potential for increasing problems with herbicide resistance through rotation of herbicides with different modes of action (see PNW 437). Remember that production management practices that increase crop competitiveness also reduce Russian thistle growth and seed production.

Preharvest

Appropriate nonselective herbicides registered for preharvest application can accelerate dry-down of Russian thistle, improve harvest efficiency, and effectively control Russian thistle for about 60 days after harvest.

Postharvest

Control Russian thistle with nonselective or broadleaf herbicides or with tillage by 2 weeks after wheat harvest. Sweeping kills most Russian thistles but will likely result in less surface residue and less overwinter water storage than control by herbicides.

It is important to compare herbicide applications and tillage based on residue retention, soil water storage for the next crop, cost, Russian thistle control, and effectiveness at reducing seed production.

Summer fallow

Control Russian thistle before seed set with herbicides, tillage, or both, but avoid excessive tillage, which reduces surface residue and roughness. Delay initial tillage and subsequent rodweedings for Russian thistle control as long as possible after a rain. Rodweeding too soon after a heavy rain may form a tillage pan, which grain drill openers may have difficulty penetrating at planting time. Research has shown that operating rodweeders at 4 inches causes less pulverization of soil clods than operating at 2 inches. This may be an important management factor on soils prone to wind erosion.

Field borders and roadways

Control Russian thistle along field borders, roadways, and other noncropped areas to prevent introduction or reinfestation of Russian thistle. Because of the high mobility of Russian thistle skeletons in the wind and their extensive seed distribution potential, an area-wide Russian thistle control strategy, including cooperation by neighboring upwind producers, is needed to achieve and maintain effective control.

Spot spray areas of the field infested with dense populations of Russian thistle. Russian thistle should not be a harvest problem in the second crop year, but a nonselective preharvest herbicide could be used, if warranted. If Russian thistle problems require postharvest attention to prevent Russian thistle seed production and soil water loss, consider a nonselective herbicide application or tillage soon after crop harvest at least as spot treatments for small Russian thistle areas and along field borders.

Fallow year 2

Management considerations are basically the same as in fallow year 1, but there is a potential for fewer rodweedings for Russian thistle control since the Russian thistle seedbank in the soil should be reduced significantly. Another year of Russian thistle seed production should be prevented through the summer fallow. Maintain control of Russian thistle in fencerows and field margins.

Crop year 3

A Russian thistle maintenance control program should keep the problem in check. Continue a good, general in-crop broadleaf weed control program. Russian thistle suppression may be all that is required. Spot treat small Russian thistle areas in draws and along field borders postharvest, and continue to monitor adjacent fields and noncropped areas to reduce the potential for reinfestations.

Pacific Northwest Extension publications are jointly produced by the three Pacific Northwest states—Idaho, Oregon, and Washington. Similar crops, climate, and topography create a natural geographic unit that crosses state lines. Since 1949, the PNW program has published more than 400 titles. Joint writing, editing, and production have prevented duplication of effort, broadened the availability of faculty specialists, and substantially reduced costs for the participating states.

Published and distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914, by the University of Idaho Cooperative Extension System, the Oregon State University Extension Service, and Washington State University Cooperative Extension, and the U.S. Department of Agriculture cooperating.

Published November 1995 $2.00/$2.00/$2.00