Russian Thistle (Salsola iberica) Growth and Development in Wheat (Triticum aestivum) 

FRANK L. YOUNG

Abstract. A 2-yr field study was conducted to measure the growth and development of Russian thistle (Salsola iberica) in the growing crops of winter and spring wheat (Triticum aestivum L.) and after harvest of these crops. In herbicide-free conditions, few Russian thistle seedlings emerged in winter wheat. Only 50% of these plants survived compared to 92 and 95% survival in spring wheat and crop-free treatments, respectively. Compared to growth in the crop-free treatment, both wheat types suppressed oven-dry weight, height, and width of Russian thistles during the crop-growing season and after crop harvest. During the crop-growing season, winter wheat suppressed Russian thistle height and width more than spring wheat. After crop harvest, oven-dry weight of Russian thistle plants grown in winter wheat stubble was suppressed 75% compared to plants grown in spring wheat stubble. Russian thistle plants grown in crop-free, spring wheat, and winter wheat treatments produced 152 100, 17 400, and 4 600 seeds/plant, respectively.

Additional index words. Crop-growing season, postharvest growth period, seedling emergence, seedling survival, seed production, SASKR.

INTRODUCTION

Russian thistle is a serious annual broadleaf weed prevalent in the arid and semiarid regions of North America (7). In the past, references to Russian thistle in the literature have normally associated this plant with habitats such as recently disturbed or overgrazed rangeland, abandoned cropland, fence rows, roadsides, and prairie lands (1, 6). Germination, emergence, seedling establishment, and water use efficiency of Russian thistle have been investigated (2, 4, 5, 6, 11, 15, 17). When the afterripening requirement for Russian thistle seeds is satisfied, germination can occur with subzero nighttime temperatures and 2°C daytime temperatures (17). At constant temperatures, total seed germination is similar at 17, 22, and 3°C (15). Research has also shown that Russian thistle seeds can germinate in a loam soil (wilting point of 70% with a soil moisture content as low as 9.1% and that soil compaction reduces germination and seedling establishment (15). Russian thistle seeds are short-lived in the soil with over 99% of the seeds germinating the first year (2, 11). Russian thistle has also been evaluated as a forage crop (7, 8), as a high-protein seed crop (3), for its allelopathic potential (10), and for its competitive ability (1). Little research has been conducted on Russian thistle as a weed in agricultural crops even though it has been recognized as an important weed in crop production areas of the Pacific Northwest and Central and Great Plains states (14).

Recent weed surveys and studies have indicated that Russian thistle is a severe problem in the small-grain producing areas of North America. A field survey in Saskatchewan, Canada (13), indicated that Russian thistle had infested 42% of the fields planted to fall rye, 40% of the oats, 32% of the wheat, and 29% of the barley. In Washington (4), Russian thistle ranked seventh of all weeds surveyed based on hectares infested. More recently, research in Washington has shown that interference from Russian thistle substantially reduces spring wheat yield (16). In the dryland wheat-summer fallow areas, Russian thistle is a problem during the summer-fallow year, in the growing wheat crop, and following crop harvest (16).

Normally, growers plant winter wheat in these areas because economic returns are greater than with spring wheat. However, spring wheat may be planted if fall-seeded wheat has been winter killed or has become heavily infested with winter annual grass weeds or when sufficient winter and early spring precipitation warrants annual cropping. Russian thistle severely infests sections of winter wheat fields that have been tilled and replanted to spring wheat but not the undisturbed winter wheat in the same fields. Generally, infestations of Russian thistle are severe in winter wheat only where stands of wheat are thin or planting skips have occurred. Russian thistle that is allowed to grow undisturbed after wheat has been harvested may also be a problem. Chepil (2) has suggested that because of the rapid growth and development of Russian thistle in stubble after a crop is harvested, the weed may be a greater problem then when growing directly with the crop.

Specific objectives of this research were to: a) determine the effect of spring wheat and winter wheat on emergence, survival, and growth and development of Russian thistle; and b) measure the postharvest growth of Russian thistle plants that had been established in the growing crops.

MATERIALS AND METHODS

General experimental procedures. Experiments were conducted during the 1981–82 and 1982–83 growing seasons at the Lind Dry Land Research Unit at Lind, WA, on a Shano silt loam (coarse-silty, mixed, mesic Xerollic Camborthids)
with pH 6.5 and 1.8% organic matter. Precipitation was recorded monthly for the 2-yr study. The treatments were three environments in which Russian thistle was grown: winter wheat, spring wheat, and crop-free. Each treatment was replicated four times in a randomized complete block design. Plots were 4.9 m wide and 12 m long. Data from the 2 yr were combined because the treatment by year interaction was not significant. All data were subjected to an analysis of variance with mean separation by Duncan’s multiple range test.

All plots received 56 kg/ha of N in August 1981 and 1982. An additional 6 kg/ha of N and 14 kg/ha of P were applied as starter fertilizer each year at the time of seeding. In March of 1982 and 1983, 17 kg/ha of N were broadcast and incorporated in the soil in the crop-free plots.

Before planting, winter wheat plots were roed weeded (7.5 cm deep) and harrowed in the fall, and spring wheat and crop-free plots were rototilled (7.5 cm deep) in the spring. ‘Wanser’ hard red winter wheat was seeded at 50 kg/ha on September 30, 1981, and September 14, 1982. ‘Dirkwine’, a soft white spring wheat, was seeded on March 17, 1982, and March 10, 1983, at 78 kg/ha. Both wheat varieties were seeded with a deep-furrow drill in rows spaced 40 cm apart. In the crop-free plots, drill rows were made without planting wheat seed so the furrow environment would be similar for all three treatments. All weeds except Russian thistle that were transplanted or naturally located inside the quadrats were removed weekly from all plots by hand.

**Emergence and survival of Russian thistle seedlings.** Before the natural Russian thistle population began to emerge, three 50- by 50-cm quadrats were randomly marked in each of the spring wheat, winter wheat, and crop-free plots already described. For both years, beginning the first of May and continuing through the end of July, the newly emerged shoots, dead shoots, and total shoots present were counted on a weekly basis. Percent survival was calculated and data reported are the means of the three quadrats/plot averaged over replications and years.

**Establishment of Russian thistle plants.** Each year Russian thistle seeds were planted in 5- by 5- by 6-cm pots in the greenhouse. Plants were started in the greenhouse to ensure emergence and uniformity of plants and to avoid late spring-killing frosts. On April 27, 1982, and May 3, 1983, Russian thistle were transplanted in winter wheat, spring wheat, and crop-free plots on a 1.2-m grid. In this design, space-planted Russian thistle were 1.2 m apart the entire length of every fourth drill row, with each row containing Russian thistle 1.2 m from the previous row. In all wheat plots, plants were placed in the furrow, within 2.5 cm of the wheat row. In both years the transplanted Russian thistle were 6 to 8 cm tall and similar in size to the natural thistle population. Spring wheat stages of growth were two- to three-leaf stage (10 cm tall) in 1982 and three- to four-leaf stage (15 cm tall) in 1983. Winter wheat stages of growth were late-tilling (28 cm tall) and stem elongation (3-node, 55 cm tall) in 1982 and 1983, respectively.

**Measurement of Russian thistle growth, development, and seed production.** Beginning on June 2 each year, approximately 4 weeks after transplanting (WAT), two Russian thistle plants/plot were randomly selected for harvest. Plant height and width were measured and the transplanted plants were excised at the soil surface. Dry weights of the total aboveground portion of the plants were recorded after the plant material was oven dried at 50°C for 3 days. Plants were harvested 7 and 10 WAT and then at 2-week intervals until the first killing frost (20 WAT each year). Winter wheat and spring wheat were harvested with a plot combine at 11 and 13 weeks, respectively, after transplanting the Russian thistle. Winter wheat stages of growth for the 4-, 7-, and 10-week harvest intervals were anthesis, milk stage, and physiological maturity, respectively. Spring wheat stages of growth for the 4-, 7-, 10-, and 12-week harvest intervals were tillered, head emergence to early anthesis, milk stage, and physiological maturity, respectively.

Russian thistle plants harvested 20 WAT were threshed and the seed lots were cleaned and weighed. To determine the total number of seeds produced/plant, five 100-seed samples/plant were counted, weighed, and averaged. The average weight of the five samples was then divided into the total seed weight of the plant and multiplied by 100. Plant height, width, dry weight, and seed production were calculated as the means of two plants/plot averaged over replications and years.

**RESULTS AND DISCUSSION**

Annual precipitation and crop yield. Precipitation accumulated during the 1981–82 and 1982–83 winter wheat growing seasons was 22 and 35 cm, respectively. For the spring wheat growing seasons, precipitation was 9 cm for 1982 and 13 cm for 1983. The 60-yr averages for the growing seasons are 23 cm for winter wheat and 9 cm for spring wheat. Winter wheat grain yield was 1430 kg/ha in 1982 and 2890 kg/ha in 1983. Spring wheat yield was 990 and 2000 kg/ha for 1982 and 1983, respectively.

**Emergence and survival of Russian thistle seedlings.** Emergence of a natural population of Russian thistle was suppressed by winter wheat compared to the spring wheat and crop-free environments (Table 1). In all three environments, most plants germinated and emerged from April to mid-May. No further emergence was observed after the first of June, late June, and mid-July in the winter wheat, spring wheat, and crop-free environments, respectively. This emergence pattern was similar both years and is later than previously noted for Russian thistle (11). At Prosser, WA, under irrigation, very few seedlings emerged after May 1 (11) and the difference in emergence patterns for the two studies may be due to the supplemental irrigation at Prosser.

Once emerged, only 50% of the Russian thistle seedlings in the winter wheat survived while 92 and 95% survived in the spring wheat and crop-free areas, respectively (Table 1). The reduction in seedling emergence and survival in winter wheat compared to spring wheat may be due to differences in the microenvironments such as soil moisture, temperature, relative humidity at the soil surface, and soil condition (4,
Table 1. Effect of spring wheat and winter wheat on emergence and survival of natural Russian thistle and seed production of transplanted Russian thistle at Lind, WA.a

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Emergenceb</th>
<th>Dead plantsb</th>
<th>Survivalb</th>
<th>Seeds/plantc</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(no./2500 cm²)</td>
<td>(%)</td>
<td></td>
<td>(no.)</td>
</tr>
<tr>
<td>Crop-free</td>
<td>4.2 a</td>
<td>0.2 a</td>
<td>95 a</td>
<td>152 100 a</td>
</tr>
<tr>
<td>Spring wheat</td>
<td>3.6 a</td>
<td>0.3 a</td>
<td>92 a</td>
<td>17 400 b</td>
</tr>
<tr>
<td>Winter wheat</td>
<td>2.0 b</td>
<td>1.0 a</td>
<td>50 b</td>
<td>4 600 c</td>
</tr>
</tbody>
</table>

aMeans within a column followed by the same letters are not significantly different at the 5% level by Duncan’s multiple range test.
bMeans are the average of three 50- by 50-cm quadrats/replication in each of four replications for 2 yr.
cMeans are the average of 16 plants (two plants in each of four replications for 2 yr).

At the time of germination and seedling emergence, moisture near the soil surface would be less in winter wheat due to the extraction of soil moisture from the growth of the winter wheat. Also, the recently disturbed seed bed in the crop-free and spring wheat treatments would be a more favorable environment for germination, emergence, and survival compared to the hard, dry soil in the winter wheat (5, 15). The suppression of Russian thistle emergence and survival by winter wheat compared to spring wheat would explain why tilled sections of winter wheat fields replanted to spring wheat have a severe Russian thistle problem.

Russian thistle growth, development, and seed production. For a short period of time (while in the greenhouse), Russian thistle seedlings were grown without competition from wheat. However, transplanted seedlings rather than natural seedlings were used for the duration of the growth, development, and seed production experiment because winter wheat severely reduces Russian thistle emergence and survival (Table 1).

In general, Russian thistle height increased very little during the initial 4-week growth period in all of the environments (Figure 1). This lack of growth in height as well as width (Figure 2) and dry weight (Figure 3) during the first 4 WAT is partially due to normal slow growth early in the spring and possibly shock imposed by transplanting the seedlings to the field. However, during the next 6 weeks (by 10 WAT), the crop-free Russian thistle grew to 70% of its total height. By 4 WAT, both crops significantly suppressed Russian thistle height compared to the Russian thistle in the crop-free environment (Figure 1). This height suppression continued for the duration of the crop-growing season and postharvest growth period. By 7 WAT, winter wheat further suppressed plant height compared to spring wheat and this suppression continued until harvest of the spring wheat. The height of Russian thistle in spring wheat was reduced at harvest because the Russian thistle was taller (40 cm) than the cutter bar height (24 cm) of the combine.

Fourteen WAT heights of Russian thistle were similar in both winter and spring wheat and remained similar thereafter (Figure 1). Russian thistle in the winter wheat stubble grew 57% of its total height after wheat harvest, and Russian thistle in the spring wheat stubble was equal to its height prior to spring wheat harvest (12 WAT). The postharvest height increase of Russian thistle in winter wheat stubble was due to continued growth of the uncut terminal shoot, whereas the height increase of Russian thistle in spring wheat stubble was due to growth of the uncut lower branches.

As with plant height, crop-free Russian thistle grew rapidly in width (Figure 2). These plants accumulated 60% of their total width by 10 WAT. By 4 WAT, both crops suppressed the width of Russian thistle, with winter wheat suppressing the most (Figure 2). The suppression in plant width by winter wheat compared to spring wheat continued throughout both the crop-growing season and the postharvest growth period. Growth in width of Russian thistle in spring wheat was approximately equal for both growth periods. In contrast, growth in width of Russian thistle in winter wheat was 30% in the crop and 70% after crop removal.

In contrast to plant height and width growth (Figures 1 and 2), crop-free Russian thistle accumulated 77% of its dry matter between 10 and 20 WAT (Figure 3). This growth period began shortly after flowering and continued through plant maturity. Both spring and winter wheat suppressed plant dry weight by 4 WAT and this suppression was similar through 14 WAT (Figure 3). Data for the 16-, 18-, and 20-

Figure 1. Effect of spring wheat, winter wheat, and crop harvest on Russian thistle height 4 to 20 weeks after transplanting. * denotes time of crop harvest. Solid line does not imply continued relationship between points. Means within each harvest interval followed by the same letters are not significantly different at the 5% level by Duncan’s multiple range test. Means are the average of 16 plants (two plants in each of four replications for 2 yr).
Figure 2. Effect of spring wheat, winter wheat, and crop harvest on Russian thistle width 4 to 20 weeks after transplanting. * denotes time of crop harvest. Solid line does not imply continued relationship between points. Means within each harvest interval followed by the same letters are not significantly different at the 5% level by Duncan’s multiple range test. Means are the average of 16 plants (two plants in each of four replications for 2 yr).

WAT harvests had treatment variances that were not homogeneous, which may have masked differences that were due to spring wheat and winter wheat treatments. Therefore, for these three dates, confidence limits were computed for both wheat types and are given in Figure 3. Duncan’s multiple range test is also shown for these dates in Figure 3 only to show that there is a significant difference between Russian thistle in the crop-free environment and both wheat types.

By 16 WAT, Russian thistle in winter wheat stubble accumulated less dry weight than in spring wheat stubble, and by 20 WAT, Russian thistle dry weight was 75% less in winter wheat stubble than spring wheat stubble. The greater competitiveness of winter wheat compared to spring wheat, which is shorter and has fewer tillers, may be due to shading and possible reduction in soil moisture. In a study using barley (Hordeum vulgare L.), Kannangara and Field (9) found growth and development of yarrow (Achillea millefolium L. #3 ACHMI) to be substantially decreased. This decrease in growth was attributed to reduced light availability and possibly other factors. In Nebraska, Challiah6 found that wheat varieties with larger canopy diameters and greater tiller numbers significantly reduced dry weight of downy brome (Bromus tectorum L. #3 BROTE) and field pennycress (Thlaspi arvense L. #3 THLAR). In this Russian thistle study, winter wheat was 56 cm tall with five tillers by 4 WAT and spring wheat was 29 cm tall with one tiller. By 7 WAT, winter wheat was 64 cm tall with five tillers and spring wheat was 50 cm tall with two tillers. The greater growth in height and width by Russian thistle in spring wheat compared to winter wheat suggests that Russian thistle would have a larger area of interference, especially for light interception, and therefore be more competitive in spring wheat.

Russian thistle growing in stubble from both wheat types accumulated over 93% of its dry matter during the postharvest growth period (Figure 3). During this growth period when precipitation is limited and interspecific competition for light no longer exists, Russian thistle continues to deplete moisture from the soil. Data from Dwyer and Wolde-Yohannis (4) indicate that Russian thistle used 98 g of water/g of shoot dry weight produced when moisture was limiting. Using this figure, each Russian thistle growing in spring wheat and winter wheat stubble used an average of 31.4 and 8.0 kg of water/plant, respectively, during the postharvest growth period. Therefore, heavy infestations of Russian thistle, if allowed to grow undisturbed after harvest, could severely reduce soil moisture.

Russian thistle grown in the crop-free environment was massive and elliptical shaped beginning at 4 WAT through 20 WAT. Plants were always approximately twice as wide as they were tall (Figures 1 and 2). This growth is characteristic of plants grown along roadsides, ditches, and

Figure 3. Effect of spring wheat, winter wheat, and crop harvest on Russian thistle dry weight 4 to 20 weeks after transplanting. * denotes time of crop harvest. Solid line does not imply continued relationship between points. Means within each harvest interval followed by the same letters are not significantly different at the 5% level by Duncan’s multiple range test. Confidence limits for P = 0.05 are shown for spring and winter wheat for 16, 18, and 20 weeks after transplanting. Means are the average of 16 plants (two plants in each of four replications for 2 yr).

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other noncrop areas. In contrast, plants grown in both wheat types were either slightly shorter (spring wheat) or slightly taller (winter wheat) than they were wide (Figures 1 and 2). Until the crop canopy was removed at harvest, these Russian thistle plants were very open in growth form with only a few branches on each plant.

Crop-free undisturbed Russian thistle produced an average of 152,100 seeds/plant (Table 1). Seed production in this study was similar to production previously reported in that a single plant is capable of producing 100,000 to 200,000 seeds (12). Seed production was only 17,400 and 4600 seeds/plant for Russian thistle grown in spring and winter wheat, respectively (Table 1).

Because winter wheat reduced seedling establishment, suppressed plant growth, and reduced seed production of Russian thistle more than spring wheat did, winter wheat should be planted where Russian thistle is a severe problem. Russian thistle should be controlled within 2 weeks after harvest, before its postharvest growth begins. By controlling Russian thistle shortly after harvest, growers can conserve soil moisture, decrease weed seed production, and reduce aboveground shoot production that interferes with subsequent tillage operations during the summer-fallow season.

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LITERATURE CITED