ITALIAN RYEGRASS MANAGEMENT IN INLAND PACIFIC NORTHWEST DRYLAND CROPPING SYSTEMS

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Italian Ryegrass Management in Inland Pacific Northwest Dryland Cropping Systems

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Abstract

Italian ryegrass is a problematic weed in the high rainfall zones of the inland Pacific Northwest (PNW). Ryegrass plants readily cross-pollinate, resulting in populations with significant adaptive capacity that has contributed to the extensive development of herbicide-resistant biotypes. Widespread herbicide resistance in Italian ryegrass makes integrated weed management (IWM) strategies critical for effective long-term management of this troublesome weed species. This publication discusses multiple control strategies that can be combined in various ways to build an IWM plan for Italian ryegrass management in wheat-based cropping systems of the inland PNW.

Introduction

Italian ryegrass (*Lolium perenne* L. spp. *multiflorum* [Lam.] Husnot), also known as ryegrass or annual ryegrass, is an introduced cool season, annual or biennial bunchgrass native to southern Europe. It is widely distributed and an important weed of winter wheat cropping systems throughout the United States. Italian ryegrass thrives in the wet, mild climate west of the Cascade Mountains in the PNW; however, it does not tolerate hot, dry weather or severe winters. East of the Cascades, Italian ryegrass is restricted to regions receiving greater than about 16 inches of annual precipitation. Italian ryegrass tends to behave as a spring annual rather than a winter annual east of the Cascades because of the cold winters, although in years with adequate snow cover or mild winter temperatures, fall-emerging plants can survive the winter. Winter survival of fall-emerging Italian ryegrass is common west of the Cascades.

Italian ryegrass is competitive with winter wheat and other annual crops for water, nutrients, space, and light, resulting in substantial reductions in yield and grain quality when not adequately controlled. In a study conducted in western Oregon in the early 1970s, winter wheat yield was reduced by as much as 61% when Italian ryegrass density reached 9 plants/ft^2 (Appleby et al. 1976). In an analysis of data from 11 field studies (two from North Carolina, three from Texas, and six from Oregon), a simple linear regression equation,

> % wheat yield loss = 5.7 + (1.15 × % ryegrass plants in the total plant population),

accurately described the effect of Italian ryegrass competition with winter wheat (Stone et al. 1999). Winter wheat is more competitive with Italian ryegrass than spring seeded crops such as spring wheat, barley, canola, and pulse crops. Consequently, yield losses from Italian ryegrass infestations in spring seeded crops will often be greater than those observed in winter wheat.

Italian ryegrass is a prolific seed producer, capable of producing several thousand seeds per plant. Plants readily outcross, which results in significant adaptive capacity that has contributed to the extensive development of herbicide-resistant biotypes. Italian ryegrass populations in the PNW have developed resistance to the ACCase inhibitors (Group 1), acetolactate synthase or ALS inhibitors (Group 2), glyphosate (Group 9), glutamine synthetase inhibitors (Group 10), and very long-chain fatty acid synthesis inhibitors (Group 15) (Avila-Garcia et al. 2012; Perez-Jones et al. 2005; Rauch et al. 2010). Some populations are resistant to multiple herbicide sites of action, particularly to Groups 1 and 2. Widespread herbicide resistance in Italian ryegrass makes IWM strategies critical for effective long-term management of this troublesome weed species.

Identification

Italian ryegrass is easy to identify by its shiny appearance due to waxy, hairless leaves. Light reflects off the leaf surface, especially in full sun. It has membranous ligules (an outgrowth from the top of the leaf sheath) up to 0.1-inch long and small, conspicuous clasping auricles (small ear-like projections from the base of the leaf) (Figure 1). Leaves are up to 0.25-inch wide and 2 to 8 inches long. Plants grow 1 to 3 feet tall. Mature ryegrass flowering stalks are spikes about 3 to 15 inches long with spikelets arranged alternating edgewise or "shoulder to shoulder" rather than "face to face" as with the wheatgrasses (Figure 2). This gives a more two-dimensional appearance when rotating the spike. It appears as if the spike was pressed flat between pages of a book. A single plant can have several spikes with 10 to 20 spikelets per spike. Italian ryegrass can be differentiated from perennial ryegrass by a few characteristics: Italian ryegrass is generally taller, the leaf blade is wider, and the leaf is longer compared to perennial ryegrass. However, environmental conditions such as temperature, water availability, light intensity, and defoliation can alter these characteristics. The most reliable means of identification between them is on the mature plant. Italian ryegrass usually has awns and a greater number of spikelets compared to perennial ryegrass.

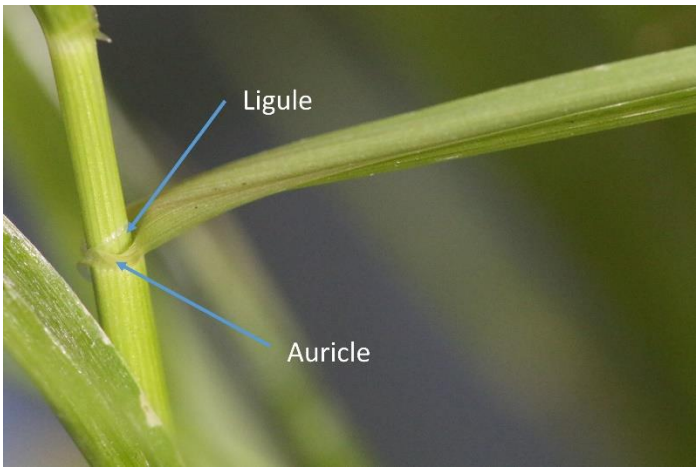

Figure 1. Italian ryegrass has membranous ligules (an outgrowth from the top of the leaf sheath) up to 0.1-inch long and small, conspicuous clasping auricles (small ear-like projections from the base of the leaf). Photo by Joan Campbell.

Figure 2. Italian ryegrass spikes (left) are about 3 to 15 inches long with spikelets arranged alternating edgewise or "shoulder to shoulder" rather than "face to face" as with the wheatgrasses (right). Photo by Joan Campbell.

Biology

Italian ryegrass was introduced into North America from Europe as a forage grass. It is cultivated as a forage crop throughout the world. Italian ryegrass establishes, grows, and reproduces well as a weed in cultivated crops, orchards, vineyards, and rights-of-way. Italian ryegrass can hybridize with perennial ryegrass and some fescues. Populations maintain significant adaptive capacity that facilitates evolution of resistance to many herbicide sites of action.

Italian ryegrass reproduces only by seed, and a single plant can produce as many as 45,000 seeds. However, common production is about 300 seeds per plant. Seed is generally mature at the time of crop harvest. At maturity, approximately 60% of the seed can shatter to the soil before a wheat crop is harvested.

Seed life in the soil is generally short-lived, but a small percentage of seed can last several years. Persistence of seed in the soil can be affected by tillage and soil water drainage. However, even in no-tillage situations where the seed does not last as long, the sheer volume of seed in the soil can result in highly competitive weedy populations and a rapidly increasing seed bank.

Freshly produced seed has variable primary dormancy that can last four months or longer. Some of the dormancy is broken with moisture and mild, cool temperatures. In the PNW, this allows for plants to establish at the time of fall rains and overwinter or establish in the spring as long as the weather is cool to moderately warm and the soil is moist.

Italian ryegrass plants tolerate acidic soils with pH levels of 5 and below, but growth is better when soil pH is increased by liming to pH levels between 5.5 and 7. Italian ryegrass also responds favorably to high N application rates. High salinity and alkaline stress can reduce germination. The extent of these effects can be influenced by temperature.

Integrated Weed Management

The three principles of IWM are: (1) prevent the weed from becoming established, (2) grow competitive crops, and (3) keep weeds off balance by altering management practices.

Prevention

Because Italian ryegrass is a prolific seed producer and the seed is generally thought not to be long-lived in the soil (see discussion on seed viability below), eliminating seed sources can be an effective preventative control strategy. However, it is a strategy that requires a sustained effort. Use a combination of the following methods that fit best:

- Plant crops with clean, certified seed.
- Seed perennial, cool-season grasses adapted to your area in waste areas and field borders. Vigorous stands of perennial grasses or grass-legume combinations are highly competitive with annual weeds such as Italian ryegrass.
- Where perennial grass borders are not feasible, consider: (1) using herbicides or tillage to kill Italian ryegrass and (2) cropping field borders and roadside ditches.
- Destroy Italian ryegrass plants before they produce seed.
- Control small patches or infested areas before they spread.
- Mow or swath small infestations close to the ground in pastures, roadsides, and waste areas where tillage or herbicides are not feasible. Plan to complete mowing or swathing before viable Italian ryegrass seeds are produced. More than one operation may be necessary to prevent tillers from producing seed.

Italian ryegrass seed can move in flowing water in rills, gullies, and ditches. These are places that should be watched carefully for new Italian ryegrass infestations, especially if Italian ryegrass is present uphill or upstream. Any new infestations discovered should be controlled before seed is set.

Growing Competitive Crops

Crop competition is critical for the control of any weed, including Italian ryegrass. A uniform stand of a competitive crop will decrease weed seed production and improve the effectiveness of herbicides that may be applied. The following management practices have been shown to increase crop competitiveness with weeds:

- Select competitive crop varieties adapted to your region. Competitive varieties emerge quickly and have vigorous early growth. They are often taller in stature or shade the row better than other varieties.
- Use the highest crop seeding rates recommended for your region.
- Use the narrowest row spacing feasible.
- Use high-quality seed. Larger seed tends to produce more vigorous, competitive seedlings than smaller seed (Stougaard and Xue 2004).
- Set drill or planter depth as shallow as conditions allow. The more quickly the crop seedlings emerge, the more competitive the crop will be with early emerging weeds.
- Plant as early as possible, but soil temperatures should be warm enough to allow rapid germination and emergence of the crop.

- Place fertilizer near the crop seed so that the crop can access the fertilizer more quickly than the weeds. Some forms of fertilizer cannot be placed with the seed or injury will occur.

Keeping Weeds Off Balance

Using the same cultural practices tend to select weed species that thrive under those specific practices. If these cultural practices do not change over multiple seasons, those species that thrive in that management system will come to dominate. Italian ryegrass has come to be a dominant weed species in part because of a lack of diverse cultural practices, including nondiverse crop rotations, planting dates, and other cultural practices.

Crop Rotation

Wheat is the dominant rainfed crop grown in much of the PNW. Winter wheat is well adapted to the climate in the region, and in most years, it is the crop that makes growers the most money. Consequently, winter wheat is grown as frequently as possible. One of the most common rotational crops with winter wheat in the higher rainfall zones is spring wheat. Spring wheat is less competitive with Italian ryegrass than winter wheat or spring barley and it offers no alternate herbicide options from those available in winter wheat. The heavy reliance on a narrow range of herbicides labeled in wheat has resulted in the development of Italian ryegrass populations resistant to many of the herbicides used in wheat to control this weed, such as the ACCase inhibitors (Group 1), ALS inhibitors (Group 2), and very-long-chain fatty acid synthesis inhibitors (Group 15). See discussion on resistance management in the Herbicides section below.

A very common rotation in the high rainfall zones of the PNW east of the Cascades is winter wheat–spring wheat–pulse crop. The pulse crop, usually either dry pea, lentil, or chickpea, adds some diversity to the wheat-centric cropping system, which allows the use of some effective herbicides for Italian ryegrass that are not labeled in wheat. It also allows for a slightly later planting date than spring wheat, especially chickpeas, which can provide an opportunity to kill off later flushes of Italian ryegrass before planting. However, a single year of a nonwheat crop is insufficient to make a significant reduction in the soil seed bank.

In a buried seed study conducted in Oregon, annual ryegrass (likely, but not specifically identified as, Italian ryegrass) seed viability dropped from 20 to 35% one year after burial, depending on depth of burial, to less than 10% two years after burial in well-drained soil, and no seed viability remained four years after burial (Rampton and Ching 1970). Adding a second year of a nonwheat crop in the rotation has the potential to decrease Italian ryegrass seed viability significantly compared to a single year out of wheat production. One crop with potential to add to the rotation is spring canola. Spring canola acreage has increased rapidly in eastern Washington and northern Idaho in recent years. A major factor contributing to the increase in spring canola plantings is the availability of glyphosate-resistant, a.k.a. Roundup Ready, varieties. Although Italian ryegrass biotypes resistant to glyphosate (Group 9) are known to exist in PNW orchards and in wheat fields west of the Cascade Mountains, as of this writing, glyphosate provides effective control of Italian ryegrass in wheat production regions east of the Cascades. To delay the development of glyphosate-resistant Italian ryegrass biotypes, growers should include other herbicide sites of action with glyphosate for Italian ryegrass control, such as the microtubule assembly inhibitors (Group 3).

Rampton and Ching (1970) did find that in a poorly drained soil, annual ryegrass seed viability did not fall below 10% at all burial depths (one to seven inches) until the fifth year, with no viable seed by the seventh year. In poorly drained soils, such as low-lying flats, growers have had success controlling Italian ryegrass in alfalfa. Three to five consecutive years of alfalfa, which is managed to not allow any seed production by Italian ryegrass, can greatly reduce the soil seed bank and allow a return to annual cropping with much lower, although seldom eliminated, Italian ryegrass infestations.

It would be very helpful to be able to grow a crop that was not planted until late May or early June that could yield well and be profitable. This would provide more time for Italian ryegrass to germinate and emerge before planting, which would allow the flushes to be controlled with non-selective herbicides

or tillage before planting. Once soils start to dry and temperatures increase, Italian ryegrass seedlings struggle to survive. Although the lack of summer rains makes growing a summer crop challenging in the PNW, there is some evidence to suggest that a deep-rooted summer crop such as sunflower, safflower, or sorghum could be successfully grown in the PNW if there is sufficient stored soil water at the time of planting. Some growers may wish to experiment with such crops on a limited basis to see if they could work into their farming operations.

Tillage and Mechanical Weed Management

Although the shift to reduced tillage and no-till systems has been very helpful for soil health, it has increased the reliance on herbicides for weed control. As discussed earlier, this heavy reliance on a relatively narrow range of herbicide sites of action has resulted in the widespread evolution of Italian ryegrass populations resistant to one or more herbicide sites of action.

Tillage can refer to a wide range of activities that cause soil disturbance. Most reduced or minimum tillage systems discard the use of primary, or aggressive, tillage used for seedbed preparation. There are noninversion mechanical tillage implements that could be deployed that would be compliant with residue load requirements, add very little to erosion potential, and contribute to weed control outcomes. The removal of primary tillage and mechanical weed control as a tool for weed management requires growers to be much more sophisticated with their crop rotations and cultural practices than when tillage is an option. While a return to a heavy reliance on tillage is not desirable, infrequent tillage can play an important role in the management of troublesome weeds like Italian ryegrass, particularly if the seed bank can be targeted.

As previously discussed, the relatively short duration of Italian ryegrass seed in well-drained soils makes deep plowing to bury a large proportion of the seed bank a viable option for areas heavily infested with Italian ryegrass. However, in their buried seed study, Rampton and Ching (1970) found that seed placed at a depth of seven inches maintained viability longer than seed buried less than six inches deep. Consequently, if deep tillage is used to bury seed, deep tillage should not be repeated for at least four years in well-drained soils or seven years in poorly drained soils.

Light, shallow tillage can be used to increase seed-to-soil contact and increase germination and emergence of Italian ryegrass seedlings. These seedlings can then be killed with additional tillage or herbicides.

As with herbicides, sticking with the same tillage regime year after year will select for weed species and biotypes that thrive in that system. Rotating tillage practices, including switching from high to low disturbance seeding systems, keeps weeds off balance and can prevent any one weed species or biotype from dominating.

Harvest Weed Seed Control

Rigid ryegrass (*Lolium rigidum* Gaudin) is a close relative of Italian ryegrass that is a major weed issue in Australian wheat production systems because it has developed widespread resistance to most herbicides available for use in wheat and to glyphosate (Neve et al. 2004). Consequently, the Australians have looked for other tools for the control of this very troublesome weed. One approach that has gained acceptance in Australia for the control of rigid ryegrass is harvest weed seed control, whereby weed seed that enters the combine at harvest is collected and not widely distributed out the back of the combine (Walsh et al. 2018). Since most weed seeds collected during harvest exit the combine in the chaff fraction, harvest weed seed control methods have been developed to manage the chaff fraction to allow the removal or destruction of weed seeds in the chaff that would have otherwise been spread across the field from the back side of the combine.

Chaff carts, narrow-windrow burning, bale direct systems, chaff tramlining, chaff lining, and mechanical impact mill systems are examples of harvest weed seed control methods used in Australia for the management of rigid ryegrass and other troublesome weeds (Walsh et al. 2018). A study by Lyon et al. (2016) found narrow-windrow burning to be highly effective (99%) at destroying Italian ryegrass seed in the windrow. Unfortunately, field burning has several negative effects on air quality and soil health, and also poses risks for fires escaping containment.

Several impact mill systems are now available in the PNW. These mill systems shatter weed seed by slamming the seed against a solid surface at high velocity multiple times, resulting in greater than 95% destruction of most weed seeds tested, including rigid ryegrass. The impact mill systems return all harvest residues to the field, which is desirable for soil water and nutrient retention, as well as for reducing the risk of soil erosion. Preliminary field studies conducted in the PNW, however, indicated that close to 60% of Italian ryegrass seed had shattered out of the head by the time of winter wheat harvest. This level of seed shatter reduces the efficacy of harvest weed seed control for Italian ryegrass, but as one component of an integrated weed management strategy, it has a useful role to play. It has been noted that the Italian ryegrass seed that is retained in the head at harvest is heavier, and thus likely more robust, than the seed that shatters prior to harvest. Larger, heavier seed has been shown to produce more competitive plants than smaller, lighter seed in many plant species. This indicates that the efficacy of harvest weed seed control may be greater than the seed shatter rate might suggest.

More information on harvest weed seed control can be found in *Harvest Weed Seed Control: Applications for PNW Wheat Production Systems* (Lyon et al. 2019).

Herbicides

Resistance Management

No-till and minimum tillage have increased reliance on postemergence herbicide applications in winter wheat production to manage Italian ryegrass and broadleaf weeds. As a result, Italian ryegrass populations in the PNW (and other regions) have developed cross- and multiple-herbicide resistance to several herbicide groups, including Group 1, Group 2, photosystem II inhibitors (Group 5), Group 9, and Group 15.

Consequently, management of Italian ryegrass must include a diversity of cultural, chemical, and mechanical inputs and be based on an understanding of the biology of the weed (Burke et al. 2017). Monitoring the weed seed bank over time, minimizing the return of new weed seed to the soil, and diversifying the crop rotation to include canola and de-emphasize wheat are approaches that have yielded short-term success. Long-term management of Italian ryegrass will likely require zero tolerance.

Herbicides are classified by their site of action. Site of action refers to the biochemical function that an herbicide targets in a plant. Inland PNW crop protection systems rely on a very narrow subset of the available herbicide sites of action: the growth regulators, the amino acid synthesis inhibitors, the fatty acid synthesis inhibitors, the photosystem inhibitors, the PROTOX inhibitors, and the seedling growth inhibitors. Knowledge of herbicide modes of action is useful for managing the risk of developing herbicide resistance (see Table 1 to assess likelihood of herbicide resistance development on a per species basis). Managing herbicide resistance is very important, as no new herbicide sites of action have been discovered since the early 1990s. It is critical to know how many herbicide active ingredients in a pre-mixture or herbicide mixture have activity on Italian ryegrass, and ultimately how many sites of action are employed for the control of this species.

Table 1. Risk of resistance.

Management Option	Low	Moderate	High
Herbicide mix or rotation in cropping system	> 2 modes of action	2 modes of action	1 mode of action
Weed control in cropping system	Cultural, mechanical, and chemical	Cultural and chemical	Chemical alone
Use of same mode of action per season	Once	More than once	Many times
Cropping system	Full rotation	Limited rotation	No rotation
Resistance status to mode of action	Unknown	Limited	Common
Weed infestation	Low	Moderate	High
Control in last 3 years	Good	Declining	Poor

Source: Adapted from Moss et al. (2019).

Resistance has not been reported for dimethenamid-P (Outlook, Group 15) or pyroxasulfone (Zidua SC/Anthem Flex; Group 15) (Table 2). Outlook can be used in pulse crops, but not cereals. Zidua SC is labeled for use in wheat and chickpea. Anthem Flex is labeled for wheat, chickpea, dry pea, and lentil. Herbicides can be combined for a two-prong approach to help prevent herbicide-resistant populations. Clethodim (Select Max and other trade names; Group 1) and S-metolachlor (Dual Magnum; Group 15) can be used in chickpea, and flufenacet + metribuzin (Axiom DF; Group 15 + 5) can be used in wheat. Resistance is low for these Group 1, 5, and 15 herbicides.

Herbicides are currently applied to entire fields with little knowledge of the status of Italian ryegrass resistance within the fields. Herbicide resistance testing and understanding mechanisms of resistance to herbicides is critical to future weed managers and IWM systems. Employing herbicides where they are effective based on knowledge of the resistance status of the weed being managed has the potential for reducing the economic cost of managing weeds. Selecting herbicides based just on their cost to control Italian ryegrass populations is not the best solution. If herbicide resistance is suspected in a field, seed from surviving plants can be sent to a weed scientist at your state land-grant university for testing.

Table 2. Italian ryegrass resistance in 2023 to herbicides documented by state.

Common Name	Example Trade Name	Mode of Action Group	State
Clethodim	Select Max, Shadow	1	ID, OR, WA
Pinoxaden	Axial XL, Axial Bold	1	ID, OR, WA
Quizalofop	Aggressor, Assure II	1	ID, OR, WA
Sethoxydim	Poast	1	ID, WA
Mesosulfuron	Osprey	2	ID, OR, WA
Pyroxsulam	PowerFlex HL	2	ID, OR, WA
Triasulfuron	Amber	2	ID, OR, WA
Pronamide	Kerb SC	3	OR
Glyphosate	Roundup PowerMAX	9	OR
Glufosinate	Liberty 280 SL	10	OR
Dimethenamid	Outlook	15	**NONE**
Flufenacet	Axiom DF	15	ID, OR, WA
Metolachlor	Dual Magnum	15	ID, WA
Pyroxasulfone	Zidua, Anthem Flex	15	**NONE**
Paraquat	Gramoxone SL 3.0	22	OR
Indaziflam	Alion	29	**NONE**

Control in Wheat (Winter and Spring)

Effective Italian ryegrass management entails the use of herbicides, with an optimal approach typically incorporating both preemergence and spring-applied postemergence herbicides. It is crucial for growers to confirm that the Italian ryegrass they are dealing with is not resistant to the chosen herbicides. To successfully control Italian ryegrass in winter wheat, products containing pyroxasulfone or flufenacet are necessary, as Italian ryegrass has not developed widespread resistance to these herbicides (Figure 3). These products are typically applied in the fall following label instructions. Notably, Axiom DF contains both flufenacet and metribuzin. Metribuzin can enhance the control achieved with pyroxasulfone. As for pyroxasulfone, it can be applied immediately after planting winter wheat as a preemergence treatment. For the long-term effectiveness of pyroxasulfone, integrated Italian ryegrass management strategies are essential (Burke at al. 2017).

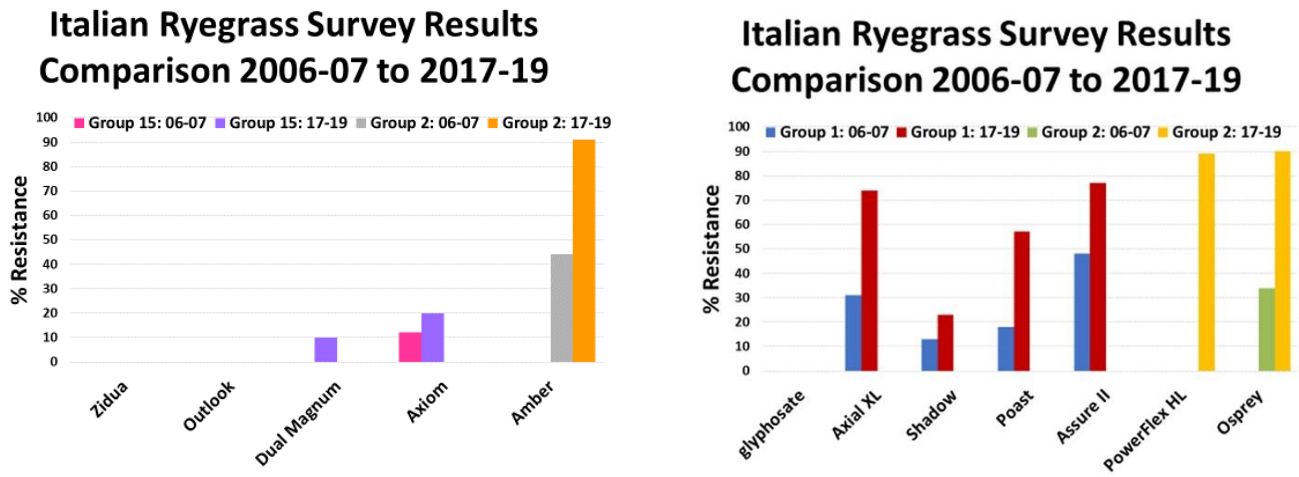

Figure 3. Italian ryegrass resistance screening results from studies conducted at the University of Idaho in 2006–2007 and 2017–2019.

Control in Pulse Crops

The addition of broadleaf crops, such as chickpea, dry pea, and lentil, allows the use of grass herbicides that are not available to use in wheat and barley. These include the Group 3 herbicides pendimethalin (Prowl H_2O and other trade names), trifluralin (Treflan HFP and other trade names; dry pea only), and ethalfluralin (Sonalan HFP; dry pea only). Several Group 15 herbicides are also labeled for use in pulse crops and provide good control of Italian ryegrass. These include S-metolachlor, dimethenamid-P (chickpea and lentil only), and pyroxasulfone. Pyroxasulfone is available as Zidua SC (chickpea only) or in a premix of sulfentrazone + pyroxasulfone and sold as Authority Supreme (chickpea and dry pea only). Pyroxasulfone is also labeled for use in wheat, so growers that use a product containing pyroxasulfone in wheat (Zidua or Anthem Flex) should not use a pyroxasulfone product in pulse crops to reduce the risk of selecting Italian ryegrass biotypes resistant to this effective herbicide. Triallate (Far-Go or Avadex MicroActiv) is a Group 8 herbicide that can improve Italian ryegrass control when used in combination with the herbicides discussed above. By itself, it provides inadequate control of Italian ryegrass. Using two different modes of action together also reduces the risk for developing herbicide resistance to either herbicide.

There are several Group 1 herbicides that are labeled for postemergence use in pulse crops. These are clethodim, quizalofop (Assure II and other trade names), and sethoxydim (Poast and other trade names). Unfortunately, most Italian ryegrass biotypes in the PNW are resistant to these herbicides, rendering them ineffective for the control of most Italian ryegrass populations.

Winter pea acreage in the PNW is currently small, but expectations are for increased acreage over time. While much of this increased acreage is likely to be in the drier regions of the PNW, some will be planted in the wetter areas where Italian ryegrass is problematic. Pronamide (Kerb SC and other trade names) is a Group 3 herbicide that is labeled for use in winter pea only. It can provide effective control of Italian ryegrass, particularly at the higher labeled use rates. However, small grain crops like wheat and barley should not be planted for at least a year following Kerb application in the inland PNW as there is significant risk of crop injury.

Control in Spring Canola

Spring canola acreage has increased rapidly in the Palouse in recent years. Some of this increase has been driven by canola prices relative to other crop rotation options such as the pulse crops, but much of it has been driven by herbicide-resistant Italian ryegrass. Glyphosate-resistant, a.k.a. Roundup Ready, canola allows growers to apply glyphosate to control Italian ryegrass. The technology has been very effective. However, as we have seen many times before, the more we rely on a single herbicide option for weed control, the more quickly herbicide resistance is likely to develop to that herbicide.

Italian ryegrass biotypes resistant to glyphosate and glufosinate (Group 10) have developed in PNW orchards that relied heavily on these two chemistries for weed control. This fact does not bode well for the long-term sustainability of glyphosate for the control of Italian ryegrass in canola.

In 2022, a field research trial was conducted at the Cook Agronomy Farm near Pullman, Washington, to look at ways to incorporate more than one herbicide site of action into spring canola production. Glyphosate (PowerMAX) was found to be a very effective tool for controlling Italian ryegrass in glyphosate-resistant canola (Table 3). However, the addition of trifluralin (Treflan HFP and other trade names; Group 3) as a preemergence herbicide greatly reduced the quantity of Italian ryegrass that was subsequently treated with glyphosate (Figure 4). Herbicide resistance is a numbers game; that is, the more plants you treat with an herbicide, the more likely you are to find that rare individual with the mutation that confers resistance. *Having a preemergence herbicide down to reduce the number of individuals treated with glyphosate lowers the probability of selecting a biotype resistant to glyphosate, thus extending the life of this useful technology.*

Figure 4. A preemergence application of trifluralin reduces early crop competition from Italian ryegrass and reduces the number of Italian ryegrass plants subsequently treated with glyphosate in Roundup Ready spring canola, which reduces the risk of selecting biotypes resistant to glyphosate and thereby extending the useful life of glyphosate for the control of Italian ryegrass. Photo by Drew Lyon, taken at the WSU Cook Agronomy Farm near Pullman, WA.

Other herbicides that could be used for Italian ryegrass control in spring canola include ethalfluralin (Sonalan HFP and other trade names) and glufosinate (Liberty 280 SL). Ethalfluralin and trifluralin require mechanical incorporation immediately after application. Glufosinate can only be used in varieties that are bred to be resistant to glufosinate—that is, Liberty Link canola varieties.

In the short-term, relying on just glyphosate for Italian ryegrass control in glyphosate-resistant canola is effective; however, this approach is likely to quickly result in the selection of Italian ryegrass biotypes that can no longer be controlled with glyphosate. *Growers who wish to retain this effective technology for as long as possible should consider adding another effective herbicide to the program.*

Table 3. Italian ryegrass control in 2022 spring canola with multiple sites of action near Pullman, WA.

	04/25	04/25	04/29	06/02	06/15	06/02	06/15	7/01	09/02
				----Canola stages----		-------Italian ryegrass control ratings[1]-------			
Trt	PPI[2]	PRE[3]	Canola Planted[4]	3–4 leaves EPOST[5]	6 leaves–bolting LPOST[6]	39 DAT PPI, PRE	14 DAT EPOST	17 DAT LPOST	Final rating at harvest
				(oz/acre)	(oz/acre)	---------- (% of nontreated check)[7] ----------			
1	-	-		PM (44)	-	-	99 a	99 a	100 a
2	Treflan	-		PM (44)	-	90 ab	98 a	95 ab	97 a
3	Treflan	-		-	-	94 a	84 b	83 bc	83 b
4		-		-	PM (22)	-	-	92 ab	100 a
5	Treflan	-		-	PM (22)	94 a	82 b	97 ab	100 a
6	-	-		PM (22)	PM (22)	-	95 a	99 a	100 a
7	Treflan	-		PM (22)	PM (22)	92 a	97 a	99 a	100 a
8	-	-		Liberty	Liberty	-	11 d	47 de	73 bc
9	-	Kerb		Liberty	-	84 c	59 c	34 ef	49 cd
10	Treflan	-		Liberty	-	93 a	80 b	64 cd	79 b
11	-	Kerb		-	-	85 bc	50 c	19 f	24 d
12	Nontreated check			-	-	-	-	-	-
13[8]	Treflan	-		Liberty	Liberty	91	76	91	96

Notes: Some of the pesticides listed in this table were tested under an experimental use permit granted by Washington State Department of Agriculture (WSDA). Application of a pesticide to a crop or site that is not on the label is a violation of pesticide law and may subject the applicator to civil penalties up to $7,500. In addition, such an application may also result in illegal residues that could subject the crop to seizure or embargo action by WSDA and/or the U.S. Food and Drug Administration. It is your responsibility to check the label before using the product to ensure lawful use and obtain all necessary permits in advance.

[1]DAT = days after treatment, PPI = preplant incorporated, PRE = preemergence, EPOST = early postemergence, LPOST = late postemergence.

[2]Treflan HFP (trifluralin) was applied at 24 fl oz/acre PPI (2× cultivator at 180°).

[3]Kerb SC was applied at 20 fl oz/acre PRE to both the canola and the Italian ryegrass. Kerb SC is not labeled for use in canola.

[4]InVigor LR344 PC is resistant to both PowerMAX (PM) (glyphosate) and Liberty 280 SL (glufosinate) herbicides and was planted at 10 seeds/ft^2 with a Monosem drill on 10-inch row spacing.

[5]EPOST PowerMax was applied at 44 and 22 fl oz/acre, and Liberty was applied at 22 fl oz/acre. All PowerMAX and Liberty 280 SL applications included $NH_4 SO_4$ at 17 lb/100 gal.

[6]LPOST Liberty 280 SL and PowerMAX were applied at 22 oz/acre.

[7]Numbers followed by the same letter in each column are not statistically different ($p \leq 0.05$).

[8]Treatment 13 was in a separate trial adjacent to the main trial and therefore is not comparable statistically.

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