WEED CONTROL IN WHEAT

Effective weed management is one of many critical components of successful wheat production. Weeds compete with wheat for light, nutrients, water, and space. Severe weed infestations can reduce wheat yields by at least 70% if left uncontrolled. Additionally, weeds can harbor deleterious insects and diseases and decrease harvest efficiency. The presence of weedy plant fragments may also reduce the food and feed value of wheat. These factors result in dockage and lower yields thereby reducing profits.

Weeds that most often cause problems in wheat are winter annual broadleaf weeds such as wild radish, common chickweed, and henbit; perennials such as wild garlic and curly dock; and Italian ryegrass. One of the best tools for suppressing weeds in wheat is a healthy, vigorous crop. Good crop management practices that result in rapid wheat stand establishment and canopy development minimize the effects of weeds.

Cultural Control Methods

Weeds are often controlled most effectively through cultural practices that result in rapid wheat stand establishment and canopy development, thus providing an undesirable environment for weed growth. Cultural practices include the following:

1) Planting certified seed (free of weed seeds and garlic bulblets)
2) Good seedbed preparation including free of weeds
3) Proper fertilization
4) Seeding at the proper rate and time
5) Management of diseases and insects

Site selection also can play a significant role in weed management. Rotation away from fields infested with troublesome weed species, such as Italian ryegrass and wild radish, may reduce the presence of these weeds and allow for the use of alternative crops and control methods. Additionally, so as to prevent weed spread from field to field during harvest, equipment should be cleaned when moving from infested areas. This precaution can be of significant consequence in preventing or minimizing the introduction of new weed species into ‘clean areas’ when commercial combine operators who travel long distances are used for harvest.

Planning a Herbicide Program

Before selecting herbicides, growers should know what weeds are present or expected to appear, the soil characteristics (such as texture and organic matter content), the capabilities and limitations of the various herbicides, and how best to apply each herbicide.

Weed Mapping

The first step in a weed management program is to identify the problem; this task is best accomplished by weed mapping. Surveys should be developed each spring to provide a written record of the species present and their population levels.

In-season Monitoring

Fields should be monitored periodically to identify the need for postemergence herbicides. Even after herbicides are applied, monitoring should be continued to evaluate the success of the weed management program and to determine the need for pre-harvest control measures.

Proper weed identification is necessary since weed species respond differently to various herbicides. Primary weeds infesting Georgia wheat include the following: chickweed species, henbit, Italian (annual) ryegrass, wild garlic, wild onion, and wild radish. Table 15 lists some distinguishing characteristics for these weeds. Contact your local Extension office for aid in weed identification.

Managing Weeds with Herbicides

If applying herbicides, read and follow label recommendations. Information concerning weed response to herbicides, herbicide rates, and grazing restrictions for wheat are provided in Tables 16, 17 and 18. Refer to product labels for up-to-date suggestions and restrictions.

Generally, larger weeds are more difficult to control than smaller weeds; therefore, timely herbicide applications are critical. Many of the herbicides used in wheat affect growth processes within the target weed. In essence, the more actively the plant is growing, the better the control. Applications made to stressed weeds (i.e. drought, wet, cold, heat) will often result in decreased control.

Many herbicides should be applied only during certain stages of wheat development to avoid crop injury. Although the stage of development provides a good indicator for application timing, factors such as environmental conditions, health of the crop, and variety (early vs. late maturity) also have an impact on crop tolerance.

Herbicides for Controlling Broadleaf Weeds

2,4-D. This phenoxy herbicide is available in several formulations (amines, esters, and acid + ester mixtures). Ester or acid + ester formulations tend to be more effective under cold conditions as compared to amine formulations. Additionally, ester and acid + ester formulations mix well with liquid nitrogen. Amine formulations can usually be mixed with liquid nitrogen, but the amine herbicide often must first be premixed with water (one part herbicide to four parts water) and then the water-herbicide mixture added to the nitrogen with good agitation. Amines tend to cause less burn on the wheat than esters when nitrogen is used as the carrier.

An amine formulation is MUCH safer to use when plants that are sensitive to 2,4-D are nearby. Ester and acid + ester formulations of 2,4-D will more likely volatilize and move off target to susceptible species compared to amine formulations.

2,4-D controls several common winter broadleaf weeds such as buttercups, cornflower, cutleaf eveningprimrose, wild mustard, and wild radish (see Table 16). However, 2,4-D often does not adequately control chickweed and henbit. Mixtures with Harmony or Express are advised for these weeds.

Timing of application of 2,4-D is critical to avoid injury to wheat. The critical period for 2,4-D applications is after wheat is fully tillered but before jointing (Feekes stages 4 and 5, Figure 1). Application before this growth stage may cause a "rat-tail" effect whereby the leaf does not form and unfurl properly. The crop may appear stunted and delayed in maturity, and tiller development may be adversely affected. Conversely, application after jointing has commenced may result in malformed seed heads.

MCPA. Similar to 2,4-D, MCPA is a phenoxy herbicide that controls a broad spectrum of broadleaf weeds (Table 16). Timing of application of MCPA is after wheat tillers (preferably 2+ tillers) but before jointing (Figure 1). Injury, similar to 2,4-D injury, can be observed if applied before or after the critical period of application for wheat. In general, MCPA causes less injury to wheat than 2,4-D, but it is also less effective on larger weed species. MCPA and Express or Harmony tank mixtures are very effective on most Georgia broadleaf weeds.

Harmony Extra. Harmony Extra is a prepackaged mixture of the sulfonylurea herbicides thifensulfuron-methyl and tribenuron-methyl.

Harmony Extra controls most of the common winter annual broadleaf weeds (Table 16). However, cornflower is a major exception. Wild radish must be small (less than three inches diameter) for adequate control by Harmony Extra. 2,4-D or MCPA at 0.25 to 0.375 pound active ingredient per acre may be mixed with Harmony Extra for improved wild radish control and for control of cornflower. Harmony Extra is very effective on curly dock and wild garlic (see section on wild garlic).

A nonionic surfactant at the rate of 1 quart per 100 gallons of spray solution is recommended when Harmony Extra is applied in water. Harmony Extra also may be applied using liquid nitrogen as the carrier. In this case, premix the herbicide in water and add the mixture to the nitrogen with agitation. Adding surfactant when using nitrogen as a carrier will increase burn on the wheat foliage. Thus, when applying Harmony Extra in nitrogen, reduce the surfactant rate to 0.5 to 1.0 pint per 100 gallons of spray solution. For easy-to-control weeds, consider eliminating the surfactant when nitrogen is the carrier. However, do not eliminate surfactant when treating wild garlic or wild radish. Do not use surfactant when mixtures of Harmony Extra and 2,4-D are applied in nitrogen.

An advantage of Harmony Extra compared to 2,4-D is the wide window of application. Harmony Extra can be applied in wheat after the two-leaf stage but before the flag leaf is visible (Figure 1). Application no later than the fully tillered stage is recommended for better spray coverage on weeds.

Express (tribenuron) and **Peak** (prosulfuron)**.** Similar to Harmony Extra, Express and Peak are sulfonylurea herbicides that are effective on many winter annual broadleaf weeds (Table 16). Comparing these herbicides to Harmony Extra, Harmony Extra is superior to Express in controlling henbit, shepherd's-purse, cutleaf eveningprimrose, and wild garlic. Peak is often the most effective in controlling wild garlic but, as mentioned later, there are significant rotational restrictions for Peak.

Express can be applied after the wheat has two leaves but before the flag leaf is visible (Figure 1). Peak can be applied after wheat has reached the three-leaf stage but before the second detectable node of stem elongation. These herbicides also have an advantage over the phenoxy-type compounds such as 2,4-D because they can be used later in the season. However, they may not be the most economical treatment. Similar to Harmony Extra, Express may be tank mixed with 0.25 to 0.375 lb active ingredient of 2,4-D or MCPA for improved control of wild radish. Express may be slurried with water and then added to liquid nitrogen solutions. Use 0.5 pt to 1.0 qt of surfactant per 100 gallons of spray solution.

Wild Radish Control

Tables 13 and 14 outline herbicide activity on wild radish and their injury potential to wheat.

Table 13. The Effect of Stage of Growth on Wild Radish Control in Wheat.

	Stage of Growth[1]			
Herbicide	0-4 inches	4-8 inches	8-12 inches	Bolting/Flowering
2,4-D	>95%[2]	>95%	>85%	60-75%
MCPA	>95%	>90%	>70%	50-60%
Peak	>90%	>85%	75-85%	<40%
Express	85-95%	>60%	50%	<40%
Harmony Extra	85-95%	70-80%	50%	<40%
Express + MCPA	>95%	>95%	>85%	60-75%
Osprey	>95%	70-80%	60-70%	50-60%
PowerFlex	>95%	>85%	>80%	60-75%

[1]Wild radish size in diameter of leaf rosette.
[2]Percent control as compared to untreated areas.

Table 14. The Effect of Stage of Growth on Wheat Injury by Various Herbicides.

	Stage of Growth[1]			
Herbicide	0-1 tiller	2-3 tillers	full tiller	Jointing
2,4-D	>80%[2]	35%	0-10%	70-90%
MCPA	>30%	10%	0-5%	50-70%
Peak	0-5%	0-5%	0-5%	5-10%
Express	0-5%	0-5%	0-5%	5-10%
Harmony Extra	0-5%	0-5%	0-5%	5-10%
Express + MCPA	>30%	5%	0-5%	50-80%
Osprey	0-5%	0-5%	0-5%	0-5%
PowerFlex	0-5%	0-5%	0-5%	0-5%

[1]Refer to Figure 1 and the small grain production guide for growth stages.
[2]Percent injury (visual chlorosis or necrosis or tiller malformation).

Wild Garlic

Wild garlic is virtually noncompetitive with small grains. However, the aerial bulblets harvested with the grain imparts a garlic flavor to flour made from infested wheat. Off-flavor milk products result when dairy cows are fed infested small grains. Growers receive a substantial discount for garlicky wheat.

A combination of adequate nitrogen fertilization and herbicide application is needed for wild garlic control. Application in wheat of 2 pints per acre of an ester formulation of 2,4-D will reduce aerial bulblet formation and bend over the tops of wild garlic plants so that a combine header can be set high enough to pass over most of the aerial bulblets. Control by 2,4-D, however, can be inconsistent. Additionally, 2,4-D at 2 pints per acre can injure wheat.

Harmony Extra with TotalSol (50 SG) at 0.75 to 0.9 ounce per acre is very effective on wild garlic. Wild garlic should be less than 12 inches tall and should have 2 to 4 inches of new growth (if treated in the spring) when Harmony Extra is applied. Temperatures of 50^0 F or higher will enhance control. Add nonionic surfactant according to the label.

Peak will also control wild garlic very well. It is at least as effective on wild garlic as Harmony Extra, but it is less effective on several broadleaf weeds. Add a nonionic surfactant or crop oil according to label directions.

There are no rotational restrictions following wheat treated with Harmony Extra. **There is a 10-month rotational restriction for all soybeans, cotton, peanuts, and tobacco following application of Peak.** Soybeans should not be double-cropped behind small grains treated with

Peak.

Italian Ryegrass

Research has shown that wheat yields are reduced 0.4% for every ryegrass plant per square yard. Heavy infestations, if uncontrolled, can reduce yields 70% or more.

Italian ryegrass is an annual and is spread by seed. Management practices to reduce seed spread will greatly decrease ryegrass problems. Such practices may include the following: cleaning equipment from field to field, maintaining clean fence rows and ditch banks surrounding the fields, avoiding those fields with heavy ryegrass populations, and avoiding saving and then planting seed harvested from fields infested with ryegrass the previous season. Burning after harvest may help to reduce seed numbers, but little research has been performed in that area.

Axial

Axial, active ingredient pinoxaden, at 8.2 fl oz/A plus Adigor adjuvant at 9.6 fl oz/A can be applied postemergence to wheat having at least two leaves up to pre-boot stage. Alternatively, Axial XL at 16.4 fl oz can be used instead of Axial plus Adigor to provide the same level of control. Ryegrass resistant to Hoelon may be cross resistant to Axial, although in many cases Axial will control Hoelon-resistant ryegrass.

Apply in a water volume of 10 gallons per acre. Rain falling 30 minutes after application will not impact control. Axial can be applied only once per crop and will not provide residual control.

Axial may be mixed with Harmony Extra for broadleaf weed control. Add the Harmony first, then Axial or Axial XL, and then adjuvant (if using Axial). Axial may also be applied in mixture with liquid nitrogen fertilizers with up to 50% liquid nitrogen by volume. Add water to the tank, then add Axial, then add adjuvant; mix thoroughly and then add nitrogen.

Labeled rotational crop restrictions include 30 days for leafy and root crops and 120 days for all other crops including other cereal grains.

Axiom

Axiom, active ingredients flufenacet and metribuzin, can be applied to wheat after the spike stage of growth up to the 3 leaf stage. Preemergence applications can cause severe crop injury, especially on sandier soils. If Axiom is activated prior to ryegrass emergence then control will be good, but if ryegrass emerges prior to Axiom being activated then control will be poor. Axiom will also control several problematic broadleaf weeds including wild radish and henbit.

Axiom may also be used as part of a resistance management program because it has an alternate mode of action for the control of ryegrass compared to typically used products such as Axial, Hoelon, Osprey and PowerFlex.

Those wanting to use Axiom need to review the label very carefully. First there are specific cultivars that are listed on the label as being tolerant. Second, application rates vary greatly based on soil type. Most GA growers will be using 6 to 8 oz of product per acre but again this

should be determined from the label.

Onions and sugar beets can be planted 18 months after applying Axiom; cotton 8 months; and potato 1 month. No plant back issues for corn or soybean. For other crops refer to most recent label.

Hoelon

Hoelon, containing the active ingredient diclofop-methyl, can be applied in wheat to control annual ryegrass. Hoelon does not control broadleaf weeds, wild garlic, or annual bluegrass.

Hoelon is an aryloxyphenoxy propionate-type herbicide. Herbicides of this type work slowly. It is not unusual for two to three weeks to pass before Hoelon symptoms appear, and up to eight weeks before the ryegrass is dead.

Hoelon can be applied postemergence in any variety of wheat anytime before the first node, or joint, develops (up to Feekes stage 6, Figure 1).

Timely application of Hoelon to annual ryegrass is essential for good control. Best control is obtained when treating one- to three-leaf ryegrass (about 2 to 3 inches tall). Higher rates are required for larger ryegrass, and even then control decreases.

Postemergence Hoelon rates for ryegrass

Ryegrass growth stage	Hoelon rate (pints per acre)
1 to 3 leaves	1.33
3 to 4 leaves	1.33 to 2.0
5 leaves to 2 tillers	2.0 to 2.67

Postemergence Hoelon effectiveness

Ryegrass height	Percent control
2 inches	100
4 inches	70-80
6 inches	40

It is typically best to apply Hoelon postemergence from mid-November through December; during this period of time, the weather is generally more favorable for field operations as well as herbicide activity as temperature has a significant impact on Hoelon activity on ryegrass. Better activity is obtained under warmer temperatures; night-time temperatures should be above 35^0 F for three days before and three days after application.

The Hoelon label allows for addition of crop oil concentrate. A crop oil is usually not necessary, and it may increase the risk of crop injury under stressful conditions. However, a crop oil can improve control under dry conditions or when treating large ryegrass.

Hoelon should NOT be applied postemergence in nitrogen or tank mixed with other herbicides. Either of these situations can reduce ryegrass control. Additionally, to avoid reduced ryegrass control, do not apply 2,4-D within five days of applying Hoelon. Hoelon may be tank mixed with fungicides, but fungicides are typically applied in the spring, which is after the optimum

timing of Hoelon application.

Hoelon may be applied preemergence in wheat. Applied preemergence, Hoelon can be very effective if adequate rainfall for activation is received prior to ryegrass emergence. However, Hoelon is consistently more effective applied postemergence. Injury may occur if Hoelon is applied after the use of an at-planting organophosphate insecticides.

Ryegrass resistant to Hoelon has been confirmed in Georgia.

Prowl H20

Prowl H_20, active ingredient pendimethalin, at 1.5 to 2.5 pt/A can be applied postemergence to wheat as long as the wheat is between the 1st leaf stage and the flag leaf being visible. Prowl does not control emerged weeds but can provide residual control of sensitive weed species if the herbicide is activated by rainfall or irrigation in a timely manner. For ryegrass, Prowl can provide 70 to 80% control at 30 d after application, as long as the Prowl was activated prior to ryegrass germination. Research results on Prowl's ability to control broadleaf weeds like henbit, chickweed, etc. is currently limited. The Prowl H_20 label does allow for mixtures with any labeled wheat postemergence herbicide.

The two greatest uses for Prowl H_20 would include the following: First, a mixture of Prowl H_20 with a postemergence annual ryegrass herbicide. In theory with this application, the postemergence herbicide would control the emerged ryegrass and the Prowl H_20 would provide residual control. However, it is worth mentioning that most of the ryegrass seen at harvest is not ryegrass emerging after their postemergence herbicide treatment but rather from ryegrass that was not controlled with their postemergence herbicide because the ryegrass was too large when treated……Prowl H_20 will not help in this situation.

A second use for Prowl H_20 in wheat would be in a situation where the wheat emerges while the ryegrass is late to emerge. One could apply the Prowl H_20 over one leaf wheat and if activated by rainfall or irrigation it would provide residual control into the season improving the likelihood of making "timely" postemergence applications.

PowerFlex

PowerFlex, active ingredient pyroxsulam, can be applied in wheat at 3.5 oz/A from the three-leaf stage until jointing. Apply after the majority of the ryegrass has emerged but before it exceeds the two-tiller stage.

Add crop oil concentrate at 1% v/v (1 gal crop oil per 100 gal spray solution).

In addition to ryegrass, the PowerFlex label claims control of several broadleaf weeds including Carolina geranium, common chickweed, hairy vetch, wild mustard and suppression of henbit. The label does not mention wild radish but numerous Georgia studies suggest good to excellent control of radish up to 8 inches in height.

For additional broadleaf control, PowerFlex may be mixed with Harmony Extra. Do not mix with dicamba, 2,4-D, or MCPA. Also, do not mix with organo-phosphate insecticides.

Do not fertilize with an independent liquid ammonium nitrogen application within 7 days before or after a PowerFlex application. However, Powerflex can be applied in water-nitrogen mixtures containing up to 50% liquid nitrogen. When PowerFlex is applied with nitrogen use a nonionic surfactant at 1 pt per 100 gallon (0.25% v/v) of solution instead of a crop oil. No research has been conducted in GA regarding applications of PowerFlex in nitrogen solutions.

PowerFlex is a sulfonylurea-type herbicide, and similar to other sulfonylureas, PowerFlex works slowly. Symptoms appear two to four weeks after application; and four to eight weeks may pass before ryegrass dies.

Labeled rotational restrictions include 1 month for wheat; 9 months for grasses including barley, field corn, grasses, millet, oats, popcorn, seedcorn, sweet corn, sorghum and for broadleaves including alalfa, canola, chickpea, soybean, dry bean, field pea, flax, lentil, mustard, potato, safflower, sugar beet, and sunflower. All crops not listed have a 12 month rotational restriction. Several studies in Georgia have shown no problem with double-cropped soybean or cotton planted behind wheat treated with PowerFlex in December or January.

PowerFlex is rain safe in 4 hours.

PowerFlex is an ALS herbicide similar to Osprey. Growers should rotate PowerFlex OR Osprey with alternative chemistry; never treat the same piece of land two years in a row with these herbicides.

Resistance to Osprey has been documented in Georgia and is becoming more common rapidly. Ryegrass resistant to Osprey is almost certainly resistant to PowerFlex since both Osprey and PowerFlex are ALS herbicides. Growers should rotate PowerFlex OR Osprey with alternative chemistry; never treat the same piece of land more than once in a two year time period with either of these herbicides.

Osprey

Osprey, active ingredient mesosulfuron-methyl, is a postemergent herbicide that should be applied to young actively growing ryegrass. For adequate annual ryegrass control, applications must be made from 1-leaf to the 2-tiller stage of ryegrass growth. If applied properly and timely, Osprey controls ryegrass very well and very consistently, including Hoelon-resistant ryegrass.

Osprey is a sulfonylurea-type herbicide, and similar to other sulfonylureas, Osprey works slowly. Symptoms appear two to four weeks after application; and four to eight weeks may pass before ryegrass dies.

Osprey is formulated as a water dispersible granule. It should be applied at a rate of 4.75 ounces per acre in winter wheat from emergence up to the jointing stage of wheat growth (Figure 1).

An adjuvant is required with Osprey. Although the Osprey label suggests several possible types of adjuvants, the manufacturer is recommending a nonionic surfactant containing at least 80%

surface-active agents plus an ammonium nitrogen source for wheat in Georgia. The nonionic surfactant should be used at a rate of 0.5% by volume (2 quarts per 100 gallons spray solution). In addition to the nonionic surfactant, also include 1 to 2 quarts per acre of urea ammonium nitrogen fertlizer (28-0-0, 30-0-0, or 32-0-0) or ammonium sulfate fertilizer at 1.5 to 3 pounds per acre (21-0-0-24).

Do NOT apply Osprey within 14 days of topdressing. Occasionally, significant injury has been observed when wheat has been topdressed shortly after Osprey application. Separate Osprey and 2,4-D applications by at least 5 days.

Osprey should be applied in 10 or more gallons of water per acre while using at least 15 gallons of water in densely populated ryegrass areas. Do not use liquid nitrogen as a carrier.

Osprey may be mixed with Harmony Extra to improve control of broadleaf weeds. The label also allows a mixture with MCPA ester at 0.25 to 0.375 lb active per acre; however, antagonism (reduced ryegrass control) with Osprey/MCPA mixtures has been noted in several Georgia trials.

Osprey will also provide good control of henbit, wild radish, and common chickweed if applied when these weeds are small ($\leq$2 inch) at time of application. Osprey is also effective on small bluegrass but does not control little barley.

The rotational restriction following Osprey application is 30 days for barley and sunflower, 90 days for cotton, peanut, soybean, rice, lentils, peas, and dry beans, 12 months for corn, and 10 months for other crops.

Resistance to Osprey has been documented in Georgia and is becoming more common rapidly. Ryegrass resistant to Osprey is almost certainly resistant to PowerFlex since both Osprey and PowerFlex are ALS herbicides. Growers should rotate PowerFlex OR Osprey with alternative chemistry; never treat the same piece of land more than once in a two year time period with either of these herbicides.

Herbicide Resistance Management

Herbicide resistance is a natural inherited ability of a plant to survive and reproduce following exposure to a dose of herbicide that normally controls that plant species. Resistant plants are not responsive to a particular herbicide because of a change or genetic shift within the plant population. Herbicides do not “create” resistant plants; resistant plants are naturally present in very low numbers. Repeated use of the same herbicide, or those with the same mode of action, may select for resistant plants (in other words, allow the resistant plants to become the predominant type present). Resistant weed populations are allowed to flourish as competition from susceptible species is eliminated by the herbicide treatment.

Hoelon-resistant Italian ryegrass has become a problem in Georgia. These resistant populations are a response to repeated use of Hoelon for several years.

One effective way to avoid or delay buildup of herbicide-resistant weed populations is rotation of

herbicides with different modes of action. Additionally, integration of non-chemical controls, such as crop rotations and cultural control methods, can delay resistance evolution.

Early detection of herbicide-resistant weeds is important to limit their spread to other fields and farms currently not infested. Since most control failures are not due to weed resistance, growers should eliminate other possible causes of poor herbicide performance before assuming they have resistance. These causes include the following:

1) improper herbicide choice or rate
2) poor/improper application
3) POOR TIMING OF APPLICATION
4) unfavorable weather
5) later weed flushes
6) antagonism by other pesticides

After eliminating possible causes for control failure, then look for known indicators of resistance:

1) performance poor on one species, other species controlled well
2) product normally controls weed in question
3) poor control confined to spots in field, at least initially
4) some plants of species in question controlled well, others controlled poorly
5) field history of heavy use of herbicides with same mode of action

Liquid Nitrogen Tank Mixes

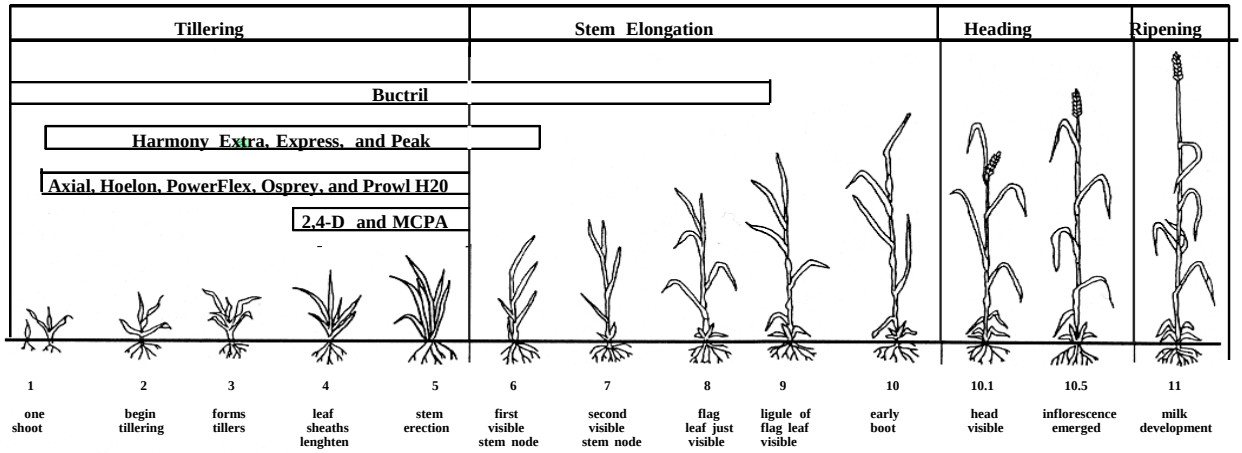
Although several herbicides used in wheat may be mixed with liquid nitrogen (see label of individual herbicides), herbicide and nitrogen timing for wheat applications may not coincide. For example, nitrogen should be applied at full tiller and prior to jointing, whereas herbicides should be applied when the weeds are small and the wheat will not be injured. Stretching the window for effective weed control to accommodate nitrogen fertilization may result in poor weed control and possibly greater wheat injury.

Additional Considerations for No-Till Wheat Production

In no-till production systems, weed control at planting is critical because many winter annual weeds such as chickweed, henbit, annual bluegrass, and Italian ryegrass are already established at planting time. Paraquat (Gramoxone, etc) or glyphosate may be applied after planting **but before wheat emerges** (Table 17) for control of emerged weeds.

A burndown herbicide is recommended in nearly every case of no-till wheat production. Without a burndown application, winter annuals can quickly get too large to control easily and can cause substantial yield reduction. Therefore, a burndown herbicide application at planting would most likely be of benefit. Higher rates of these herbicides may be needed for dense weed populations, under drought or cool or cold growing conditions, or for specific problem weeds.

Figure 1. Ideal Postemergence Timing of Herbicides Relative to Wheat Development in Georgia.



Feekes Scale of Wheat Development

Table 15. Key Characteristics of Common Weeds Infesting Georgia Wheat.	
Common Name	**Description**
annual bluegrass	Small tufted to clumped winter annual. Leaf blade, smooth on both surfaces, with two distinct, clear lines, one on each side of the mid-rib.
annual ryegrass	Bunch or clump grass, often has shiny green leaves, deep green in color. Auricles, or clasping structures, are present at the point of leaf attachment to the stem. Leaves rolled in the bud. Ligule is membranous.
Carolina geranium	Long leaf petioles, densely hairy. Leaves roundish and deeply dissected into segments.
cheat	Summer or winter annual, 5 to 25 inches in height, clump-forming and erect to spreading. Leaves rolled in the bud, young leaf blades are twisted and appear to be spiraling upward. Blade with short dense hairs.
curly dock	Perennial, forming a rosette of leaves often exceeding 12" in diameter. Leaf margins often curly or wavy, tapering at the base.
cutleaf evening-primrose	Leaves formed in rosette with notched/lobed margins. Distinctive white mid rib of leaves.
henbit	Stems 4-sided with a purplish cast. Leaves opposite with long internodes. Small purple flowers are formed in whorls arising from the base of the leaves.
little barley	Bunch or clump grass, light green leaves. Membranous ligule present at base of leaf near connection to the stem. Seedheads similar in appearance to barley or wheat only much smaller with short, stiff awns.
swinecress	Leaves highly serrated, formed in a rosette. Strong odor present when the leaves are crushed.
vetch	Winter legume with compound leaves containing 3-9 pairs of leaflets. Climbing plant with tendrils present at the ends of stems.
wild garlic	Onion-like leaves, hollow and tube-like.
wild mustard	Dark yellow flowers, leaves slightly segmented and not attached to the stem by clasping leaf stems. Cotyledons are heart-shaped but first true leaves are almost rectangular in shape and only slightly pubescent. Hypocotyl is generally green.
wild onion	Onion-like leaves, flat and not hollow.
wild radish	Light yellow flowers, highly segmented leaves giving the appearance of long slender stems. Lower portion of the stem with stiff, downward pointing hairs. Cotyledons heart-shaped with a purple hypocotyl. Young true leaves are densely hairy.
wild turnip	Dark yellow flowers, uppermost leaves clasp or wrap-around the stem.

Table 16. Weed Responses to Broadleaf Herbicides Used in Wheat.

Weeds	2,4-D[1]	MCPA[1]	Express[1]	Express +MCPA[1]	Buctril[1]	Harmony Extra[1]	Peak[1]	Finesse[2]
Annual bluegrass	N	N	N	N	N	N	N	N
Annual ryegrass	N	N	N	N	N	N	N	F
buttercup	G					G		
common chickweed	P	P	G	G	PF	G		G
common ragweed	G	F			E	PF	E	
cornflower	G				GE	P		
cudweed	GE	GE			G	E		
curly dock	P	P			PF	E		
dandelion	E	E			E			
dogfennel	G	F			GE	E		
evening primrose	E	E			F-G	G	G	
field pennycress	G				G	G		
goldenrod	F	G			F			
hairy vetch	FG	FG			F	P		
henbit	P	P	F	FG	F	G	FG	G
horsenettle	F	F			F			
horseweed	F	F			F	FG		
knawel	P				P	G		
Lambs-quarters	G	G			E	E	G	
plantains	E	E			E	E		
shepherd's-purse	GE	GE			G	E	G	
swinecress	G	G			GE	E		
thistles	G	G			G	FG	FG	
VA pepper-weed	E				FG	G		
wild garlic	F	P			P	GE	E	
wild mustard	E	G-E	F	E	G	F-G	G	G
wild radish	E	G-E	F	E	FG	F-G	G	G

[1] Timely postemergence application.
[2] Applied preemergence.

Key: E = excellent control, 90% or better; G = good control, 80% to 90%; F = fair control, 70% to 80%; P = poor control, 25 to 50%; N = no control, less than 25%

Table 16. Weed Responses to Grass and Broadleaf Herbicides Used in Wheat.

Weeds	Axiom[2]	Hoelon[1]	Axial[1]	Osprey[1]	PowerFlex[1]
Annual bluegrass		N		G	
Annual ryegrass	P-G[3]	E[4,5]	G-E[5]	G-E	G-E
buttercup		N	N		
common chickweed		N	N	F-G[6]	
common ragweed		N	N		
cornflower		N	N	P	
cudweed		N	N		
curly dock		N	N	P	
dandelion		N	N		
dogfennel		N	N		
evening primrose		N	N	P	
field pennycress		N	N		
goldenrod		N	N		
hairy vetch		N	N		
henbit	G-E	N	N	G[6]	
horsenettle		N	N		
horseweed		N	N		
knawel		N	N		
Lambs-quarters		N	N		
plantains		N	N		
shepherd's-purse		N	N		
swinecress		N	N	E	
thistles		N	N		
VA pepper-weed		N	N		
wild garlic		N	N	P	
wild mustard		N	N	G	G-E
wild radish	G-E	N	N	G	G-E

[1] Timely postemergence application.
[2] Applied spike to wheat but PRE to weeds.
[3] Provides good control if herbicide is activated prior to ryegrass germination, poor control if ryegrass emerges prior to Axiom activation.
[4] Will not control Hoelon-resistant ryegrass.
[5] Axial and Hoelon have similar mode of action. Axial may not control Hoelon-resistant ryegrass.

Key: E = excellent control, 90% or better; G = good control, 80% to 90%; F = fair control, 70% to 80%; P = poor control, 25 to 50%; N = no control, less than 25%

Table 17. Chemical Weed Control in Wheat.

Weeds Controlled	Herbicide, Formulation, and Mode of Action Categlory[1]	Amount of Formulation (broadcast rate/acre)	Pounds Active Ingredient (broadcast rate/acre)	REMARKS AND PRECAUTIONS (read all labels)
		PREPLANT NO-TILL		
Emerged annual broadleaf and grass weeds	paraquat: (Gramoxone Inteon) 2 SL (Firestorm, Parazone) 3 SL MOA 22	 2 to 4 pt 1.33 to 2.7 pt	0.5 to 1.0	Apply before crop emerges. Rate depends on weed size; see label. Add nonionic surfactant at 1 pt per 100 gal of spray or crop oil concentrate at 1 gal per 100 gal of spray. See label for application directions.
Emerged annual broadleaf and grass weeds, control or suppression of perennial weeds	glyphosate 3.57 SL (3 lb a.e.) 4 SL (3 lb a.e.) 5 SL (3.7 lb a.e) 5.5 SL (4.5 lb a.e.) 6 SL (5 lb a.e.) MOA 9	 1 to 3 pt 1 to 3 pt 0.8 to 2.4 pt 11 to 32 fl oz 10 to 28 fl oz	0.38 to 1.13	Apply before crop emerges. Rate depends upon weed size; see label. Numerous other brands of glyphosate are available. Adjuvant recommendation varies by glyphosate brand.
		PREEMERGENCE		
Annual ryegrass and annual broadleaf weeds	chlorsulfuron + metsulfuron-methyl (Finesse) 75 WDG MOA 2 + 2	 0.5 oz	0.0195 + 0.0039	Ryegrass control is variable; expect only suppression. May stunt wheat on sandy soils. Use suggested primarily in areas where Hoelon-resistant ryegrass is suspected. **Plant only STS soybeans following wheat harvest.** See precautionary statements on label concerning late-planted wheat and cold conditions. Crop injury may result if organophosphate is used. SEE ROTATIONAL RESTRICTIONS.
		SPIKE		
Wild radish, henbit, annual ryegrass	flufenacet + metribuzin (Axiom) 68 WDG MOA 15 + 5	 4 to 10 oz	0.136 to 0.034 + 0.34 to 0.085	Apply to wheat in the spike stage (up until the 3 leaf stage). Check label for use on cultivar planted. Preemergence applications can cause severe injury. For most Georgia soils, 6 to 8 oz/A of product is ideal. If Axiom is activated prior to ryegrass emergence then control will be good but if ryegrass emerges prior to Axiom activation then control will be poor. Controls wild radish and henbit.
		POSTEMERGENCE		
Annual ryegrass	diclofop-methyl (Hoelon) 3 EC MOA 1	 1.33 to 2.67 pt	0.5 to 1.0	Apply when ryegrass is in the one- to four-leaf stage and prior to first wheat node (joint) developing. See label for specific rates depending on weed size and environmental conditions. Do not make more than one application per season. Do not tank mix with broadleaf herbicides or use liquid nitrogen as the carrier. May add 1 to 2 pt per acre of crop oil concentrate when conditions are dry or when ryegrass is large. In most cases, crop oil is not necessary. Crop injury may result if organophosphate is used. **Warning:** Will not control Hoelon-resistant ryegrass. **To minimize resistance:** Rotate Axial or Hoelon with Osprey or PowerFlex. Avoid rotating PowerFlex and Osprey. Avoid rotating Hoelon and Axial. Adding Axiom or Prowl H_20 to a program would be beneficial.

Weeds Controlled	Herbicide, Formulation, and Mode of Action Categlory[1]	Amount of Formulation (broadcast rate/acre)	Pounds Active Ingredient (broadcast rate/acre)	REMARKS AND PRECAUTIONS (read all labels)
POSTEMERGENCE (continued)				
Annual ryegrass, small wild radish, and other broadleaf weeds	mesosulfuron-methyl (Osprey) 4.5 WDG MOA 2	4.75 oz	0.013	Apply to ryegrass between one-leaf and two-tiller while wheat is emerged but before jointing. Add a non-ionic surfactant (at least 80% active) at 2 qts per 100 gal. spray solution with ammonium nitrogen fertilizer (28-0-0, 30-0-0, 32-0-0) at 1 to 2 qt per acre. DO NOT topdress within 14 days of Osprey application. Do not use liquid nitrogen as the carrier. May mix Osprey with Harmony Extra. Do not mix with 2,4-D. ***Ryegrass resistant to Osprey is present*** and becoming more common in Georgia. **To minimize resistance:** Rotate Axial or Hoelon with Osprey or PowerFlex. Avoid rotating PowerFlex and Osprey. Avoid rotating Hoelon and Axial. Adding Axiom or Prowl H_20 to a program would be beneficial.
Annual ryegrass	pinoxaden (Axial) 0.83 EC (Axial XL) 0.42 EC MOA 1	 8.2 fl oz 16.4 fl oz	0.053	Apply to wheat with two leaves up to pre-boot when ryegrass has one leaf to two tillers. If using Axial, add Adigor Adjuvant at 9.6 fl oz per acre. If using Axial XL, no adjuvant needed. Mixtures with Harmony will improve broadleaf control. May be applied in water/nitrogen mixtures containing up to 50% liquid nitrogen by volume. Add water to tank, then add Axial, and then the adjuvant (if needed); mix thoroughly and add the nitrogen. Axial and Hoelon have the same mode of action; therefore, Axial may not control Hoelon-resistant ryegrass. Research in Georgia has shown Axial to kill about 50% of the Holeon-resistant populations that have been studied. **To minimize resistance:** Rotate Axial or Hoelon with Osprey or PowerFlex. Avoid rotating PowerFlex and Osprey. Avoid rotating Hoelon and Axial. Adding Axiom or Prowl H_20 to a program would be beneficial.
Annual ryegrass, wild radish, and other broadleaf weeds	pyroxsulam (PowerFlex) 7.5 WDG MOA 2	 3.5 oz	0.0164	Apply from three leaf wheat through jointing. Apply after majority of ryegrass is emerged but before it exceeds the two-tiller stage. Add crop oil concentrate at 1% v/v (1 gal per 100 gal spray solution). May tank mix with Harmony Extra. Do not mix with dicamba, 2,4-D, or MCPA. Can be applied in water-nitrogen mixture containing up to 50% liquid nitrogen by volume, or a maximum of 30 lb/A. If applying in liquid nitrogen, use a non-ionic surfactant at 0.25% v/v, instead of crop oil concentrate. An independent liquid ammonium nitrogen fertilizer application should not be made within 7 days of application. Current labeling is 9 month rotation to soybean and 12 months for cotton. UGA research has shown no problems double cropping cotton or soybeans behind PowerFlex-treated wheat thus far. ***Ryegrass resistant to Osprey is present*** and becoming more common in Georgia. Rygegrass resistant to Osprey is almost certainly resistant to PowerFlex. **To minimize resistance:** Rotate Axial or Hoelon with Osprey or PowerFlex. Avoid rotating PowerFlex and Osprey. Avoid rotating Hoelon and Axial. Adding Axiom or Prowl H_20 to a program would be beneficial.

Weeds Controlled	Herbicide, Formulation, and Mode of Action Categlory[1]	Amount of Formulation (broadcast rate/acre)	Pounds Active Ingredient (broadcast rate/acre)	REMARKS AND PRECAUTIONS (read all labels)
POSTEMERGENCE (continued)				
Fair to good residual control of annual ryegrass	pendimethalin (Prowl H20) 3.8 AS MOA 3	1.5 to 2.5 pt	0.71 to 1.18	Apply from 1st leaf stage of wheat up to flag leaf. Prowl will only provide residual weed control. May tank mix with any postemergence herbicide labeled for use in wheat. Current supplemental label expires Dec 31, 2009. Check most recent label for expiration date.
Wild radish, wild mustard, wild garlic, curly dock, and most winter annual broadleaf weeds	thifensulfuron-methyl + tribenuron-methyl (Harmony Extra SG with TotalSol) 50 SG (Harmony Extra) 75 WDG MOA 2 + 2	 0.45 to 0.9 oz 0.3 to 0.6 oz	0.0094 to 0.0188 + 0.0047 to 0.0094	Apply after two-leaf stage of wheat but prior to flag leaf. Most winter annuals can be controlled with 0.6 to 0.75 oz/A of Harmonsy Extra 50 SG; however, 0.75 to 0.9 oz/A is recommended for controlling wild garlic or wild radish. Add 1 qt of nonionic surfactant per 100 gal of spray solution. For best results, apply when weeds are in the two- to four-leaf stage, temperatures are above 50 F, and not drought stressed. Garlic should be less than 12 inches tall and should have 2 to 4 inches of new growth. Liquid nitrogen may be used as the carrier. May tank mix with 0.25 to 0.375 lb active ingredient of 2,4-D or MCPA for improved control of wild radish. Follow instructions on labels when mixing 2,4-D, MCPA, or using nitrogen as carrier. Reduce surfactant rate according to label when using nitrogen as the carrier or when mixing with 2,4-D.
Wild mustard, chickweed, field pennycress	tribenuron-methyl (Express SG with TotalSol) 50 SG (Express) 75 WDG MOA 2	 0.25 to 0.5 oz 0.167 to 0.33 oz	0.008 to 0.0155	Apply after two-leaf stage of wheat but prior to flag leaf. Add 1 qt of nonionic surfactant per 100 gal of spray solution. Only partial control of wild garlic, henbit, shepherdspurse, and wild radish. Apply when weeds are small and not drought stressed. May be applied in mixture with some liquid fertilizers; however, some discoloration and stunting may occur when tank mixed with liquid nitrogen; see label. May tank mix with 0.25 lb a.i. of MCPA for improved control of wild radish when wheat has at least 2 tillers but before jointing. Add 1 pt/A of surfactant with this Express plus MCPA mixture. May also mix with 2,4-D and apply to fully tillered wheat.
Most winter annual broadleaf weeds except chickweed, henbit, and knawl	2,4-D amine (various brands) 3.8 L 2,4-D ester (various brands) 3.8 L 2,4-D ester (various brands) 5.7 L 2,4-D acid/ester (Weedone 638) 2.8 L MOA 4	 1.0 to 1.25 pt 1.0 to 1.25 pt 0.67 to 0.84 pt 1.0 to 1.25 pt	 0.48 to 0.6 0.48 to 0.6 0.48 to 0.6 0.35 to 0.43	Apply after wheat is fully tillered (stages 4 and 5 on Feekes scale) but before jointing. Spraying wheat too young or after jointing may reduce yields. Better results obtained when day-time temperatures are above 50 F. Increase rate by 50% to control corn cockle. For wild onion or wild garlic, increase rate according to respective labels for better control. Georgia research has shown greater injury by 2,4-D when using liquid nitrogen as the carrier. Ester formulations can be added directly into nitrogen. If using amine formulation, premix in water (1 part 2,4-D to 4 parts water) and add mixture to nitrogen with strong agitation. Amine formulations give less burn than ester formulations in nitrogen. Ester formulations may be more effective on weeds in cold conditions. May be tank mixed with several other herbicides; see labels.
	MCPA (various brands) 4.0 L (various brands) 3.7 L MOA 4	 0.5 to 1.0 pt 0.5 to 1.0 pt	 0.25 to 0.5 0.23 to 0.46	Apply to wheat after tillering (preferably 2+ tillers) but before jointing. Apply before weeds are in the four-leaf stage or two inches in height. Rosette weeds should be treated when less than one inch in diameter. Rates may be increased according to labels. Wheat should be fully tillered before high rates are applied. No spray additive required. May be tank mixed with several other herbicides; see labels. Suggest mixtures with Express or Harmony Extra.

Weeds Controlled	Herbicide, Formulation, and Mode of Action Categlory[1]	Amount of Formulation (broadcast rate/acre)	Pounds Active Ingredient (broadcast rate/acre)	REMARKS AND PRECAUTIONS (read all labels)
PRE-HARVEST				
Annual broadleaf and grass weeds, suppression of perennial weeds	glyphosate 3.57 SL (3 lb a.e.) 4 SL (3 lb a.e.) 5 SL (3.7 lb a.e) 5.5 SL (4.5 lb a.e.) 6 SL (5 lb a.e.) MOA 9	 1 to 2 pt 1 to 2 pt 0.8 to 1.6 pt 11 to 22 fl oz 10 to 20 fl oz	0.38 to 0.75	Apply after hard dough stage of grain (30% or less grain moisture) but at least 7 days before harvest. Do not apply to wheat grown for seed.
Annual broadleaf weeds	2,4-D amine (various brands) 3.8 SL 2,4-D ester (various brands) 3.8 SL 2,4-D ester (various brands) 5.7 SL 2,4-D acid/ester (Weedone 638) 2.8 SL MOA 4	 1 to 2 pt 1 to 2 pt 0.67 to 1.3 pt 1 to 2 pt	 0.48 to 0.95 0.48 to 0.95 0.48 to 0.95 0.35 to 0.7	Apply when grain is in the hard dough stage (30% or less grain moisture) or later. Do not allow drift to sensitive crops. Amine formulations STRONGLY ENCOURAGED.

[1]Mode of Action (MOA) code developed by the Weed Science Society of America. MOA codes can be used to increase herbicide diversity in a weed management program to delay the development of resistant weeds.

Important Note: Observations in Georgia wheat fields indicate crop damage when 2,4-D is tank mixed with liquid nitrogen. This also may be evident with other herbicide-nitrogen mixtures. To avoid possible damage and obtain better weed control, herbicides and nitrogen should be applied separately.

Table 18. Forage, Feed, and Grazing Restrictions for Wheat Herbicides.	
Trade Name	**Restrictions**
Axial	Do not graze livestock or harvest forage for hay from treated areas for at least 30 days after application. Must wait 60 days to fed straw to livestock.
Axiom	Do not graze within 30 days of application.
Express	Do not graze livestock in treated areas. Do not feed forage or hay from treated areas to livestock. Harvested straw may be used for bedding and/or feed.
Harmony Extra	Do not graze livestock in treated areas. Do not feed forage or hay from treated areas to livestock. Harvested straw may be used for bedding and/or feed.
Hoelon	Do not allow livestock to graze treated fields for 28 days after treatment. Do not harvest forage, hay, or straw from treated fields prior to grain harvest.
Finesse	No grazing restrictions.
MCPA	Do not forage or graze meat animals or dairy cattle within 7 days of slaughter.
Osprey	Do not apply within 30 days of harvesting wheat forage, and 60 days for hay, grain, and straw.
PowerFlex	Do not graze treated crop within 7 days following application. Do not cut the treated crop for hay within 28 days after application.
Prowl H20	Do not apply within 28 days of harvest of wheat had and within 11 days of harvest of wheat forage.
Roundup WeatherMax	Stubble may be grazed immediately after harvest.
2,4-D	Do not graze dairy cattle within 7 days of application. Do not apply within 30 days of cutting for hay. Remove meat animals from treated areas 3 day prior to slaughter.