Crop Profile for Wheat in Delaware

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General Production Information

Wheat: Acreage, Average Yield and Production. 2007 (1)

Location	Acres Planted	Acres Harvested	Yield Bushels/A	Production Bushels
New Castle Co.	8,700	8,200	72.2	592,000
Kent Co.	23,000	22,800	69.1	1,575,000
Sussex Co	25,300	24,000	65.5	1,573,000
TOTAL	57,000	55,000	68.0	3,740,000

Cultural Practices

Wheat production for Delaware (no-till) (2, 3)
A timely planted wheat crop germinates, emerges, and tillers before winter dormancy begins in December. Autumn dry matter production and nitrogen (N) requirements are low, but 20-30 lb N/ac is needed to establish the crop and promote root growth and tiller production. This reduces winter-kill and enhances nutrient and moisture use during spring growth. Excessive fall growth from over-fertilization with N can produce wheat susceptible to disease and winterkill. Over-fertilization with N also increases the potential for leaching losses during dormancy. Wheat uses little N during winter dormancy. Wheat breaks dormancy and resumes growth ("greenup") in late February or early March.

The no-till system has been employed successfully for wheat since 1980. In Delaware research trials, yield for no-till wheat was within 0.6 bu/A of the yield of conventionally planted wheat. In all cases, the key to a successful no-till small grain system is good management. Good management involves the selection and calibration of a no-till drill, proper lime and fertilizer planning, careful variety and seeding rate selection, and attention to weed, disease, and insect management.

No-till can substantially reduce the time interval between corn, sorghum, or soybean harvest and small grain planting. When planting date runs into November, any delay in planting results in reduced yield potential and possible crop failure. Labor and fuel savings also accrue by eliminating fall tillage.

Planting equipment

No-till drills require special attention to planting speed and depth settings based on soil conditions and the amount and type of residue/vegetation. No-till drill

planting accuracy improves when planting on level soil surfaces and when the crop residue has been spread uniformly during the previous crop harvest. The combine or mower should always be adjusted to spread the crop residue as uniformly as possible. In addition, certain types of no-till drills may require that grain sorghum or corn stalks be mowed before planting small grains. When situations are encountered where the no-till drill will not satisfactorily perform, conventionally planted small grain would be superior to no-till.

Liming

Soil pH is critical in small grain production. Wheat is sensitive to both high and low soil acidity levels. Soil pH must be adjusted based on soil type and manganese availability. Light sandy soils should be maintained at a pH from 5.8 to 6.0. Medium textured soils, such as a Sassafras sandy loam, should be maintained at a pH to 6.0 to 6.2. The heavier soils of northern Kent and New Castle counties can range from 6.2 to 6.5. Soil pH is especially important in the lighter soils since manganese deficiency can occur when the soil pH is over 6.0.

Fertility and top dressing

Small grain phosphorus (P) and potash (K) requirements are the same for both tillage systems. No differences in wheat yields have been shown between fall or spring applied P and K on a medium or higher fertility soil. Required P and K for double-cropped soybeans or grain sorghum can be applied on the small grains.

An important difference between no-till and conventionally tilled small grains relates to the nitrogen (N) response. Research indicates that on no-till wheat 20 to 30 lbs N/A is needed above spring N top dressing normally applied to conventionally-planted small grains. Up to 20 lbs N/A of fall applied N can be beneficial to a small grain crop planted following a high yielding corn crop since little soil N remains, especially on light soils. Fall N may also be beneficial if planting grain late in the season.

The most important fertilizer application is N top dressing in the spring. Research results indicate that on a yield basis ammonium nitrate is superior (3 to 5 bu/A yield advantage) to other N sources. No yield differences have been found between using 30 percent UAN (urea-ammonium nitrate solution) or ammonium sulfate (20-0-0-21.5) although UAN solution offers the advantage of applying N and herbicides (Harmony, 2,4-D, or Banvel) simultaneously. However, ammonium nitrate is generally more expensive and somewhat more difficult to acquire. If a 3 to 5 bu/A yield increase translates into added profits after subtracting the additional cost of using ammonium nitrate, then it is the preferred source. Otherwise, use UAN solution or ammonium sulfate. If a complete fertilizer is needed, the ammoniated phosphate sources can be used.

Urea should not be used to top-dress N on small grains unless rain or irrigation will follow within 24 hours after application. Urea N can readily be lost to the air when applied on a trash or vegetative surface or during warm, humid weather. If a complete analysis fertilizer is used and the material is a blended fertilizer, make sure that urea is not used as the N source. Unless urea N is incorporated by either tillage or watering (rain or irrigation), N loss as great as 40 percent can rapidly occur.

Worker Exposure

There are no worker hand activities in wheat that would cause pesticide exposure. As with any pesticide, applicators might be exposed during mixing, loading, and applying. Parathion, however, can be applied only by air using a closed system. The use of a closed system as well as other restrictions have significantly reduced any potential worker exposure. The Delaware Department of Agriculture reports that they have had no worker exposure violations or complaints related to pesticide use on wheat. Field crop extension agents in Delaware also report no incidents with worker exposure in wheat.

INSECT PESTS (4)

In Delaware, insects can attack wheat in the fall and spring. Soon after planting in the fall, Hessian fly and multiple aphid species are potential pest problems. Once spring growth resumes, aphids, cereal leaf beetle, true armyworm and grass sawfly can cause economic losses. In recent years, the cereal leaf beetle has become an important pest of wheat grown in the Mid-Atlantic region

Aphid Species

Biology and Life History

The most common aphid species found in Delaware wheat fields are the English grain aphid, oak-bird cherry aphid, corn leaf aphid, and the greenbug. These four species overwinter on small grains as eggs or as females that give rise to offspring in the spring. Wingless females will produce offspring without mating for a number of generations. As small grains mature in late spring to early summer, winged females move to other wild or cultivated grasses for the summer. In the fall, they return to newly-planted small grain fields to overwinter.

Damage

Although aphids can injure small grains by removing plant juices from the leaves, stems and grain heads, this direct feeding rarely causes economic damage. Generally, there are two exceptions to this rule:

(1) Greenbug aphid damage: The greenbug aphid secretes a toxic substance into the plants that kills plant tissue. Extensive feeding in the fall and early spring may result in circular yellow to brown spots with dead spots in the center. Infested plants appear stunted and discolored.

(2) Aphids feeding on grain heads**:** Significant damage can occur when large numbers of aphids feed on the grain head, causing shriveled or blasted heads.

This damage can result in reduced yield and test weight of the grain. This generally occurs when spring conditions are unusually cool, resulting in rapid aphid development but reduced natural enemy reproduction. The most important losses from aphids occur when aphids vector barley yellow dwarf virus. This occurs when aphids carrying the virus move back into fields in the fall from their wild or cultivated grass hosts.

Sampling grain aphids at tillering during fall and early spring

Grain aphids usually are held in check by their natural enemies, which include predators, parasites, and fungal diseases. When looking for aphids, it is important to recognize these natural enemies. Check grain fields each week starting in the fall or early spring if damage symptoms are evident. Infestations of aphids, particularly the greenbug and corn leaf aphid, occasionally build up in the fall. The first noticeable symptoms are often circular yellow to brown spots with dead plants in the center. These spots may increase in size if the infestation is allowed to persist. To determine aphid activity on tillering grain, examine 20 sites throughout the field. Each site should consist of at least 5 linear feet of a row. Look at areas in the field that are showing plant stress symptoms. Aphid damage may be confused with moisture stress or nitrogen deficiency. Count the number of aphids on small plants and, if aphids are numerous, estimate the numbers per linear foot of a row of larger plants. Make a tally of the proportion of each species, particularly if greenbugs are present.

Decisionmaking in grain aphids at tillering during fall and late winter

Treatment during the fall for aphid control is normally not necessary, except in the southernmost counties in intensively managed wheat where aphids have a history of transmitting virus diseases in fall. The potential for viral transmission is impossible to predict; however, consider treatment when infestations exceed 10 to 20 winged aphids per linear foot of row, especially if the greenbug aphid is the predominant species and plant damage is observed. Treatment during the early spring before heading is occasionally needed if localized infestations are causing stand reductions and late winter weather is unusually mild. Treatment is suggested if aphid counts exceed 150 per linear foot of row throughout the majority of the field and a low degree of beneficial insect activity is present. If greenbug is the predominate species, lower thresholds to 50 per linear foot of row.

Sampling grain aphids during the grain head stage

To determine aphid activity after the grain heads form, count the number of aphids on 100 heads throughout the field. Do not bias sampling by checking a few heads along the field margins where infestations usually are higher. Check for natural enemies at the same time that aphids are being counted. Aphids usually are clustered as colonies among bracts of the grain head and may move slightly when disturbed. Anything that actively moves when disturbed is probably

a predator. Make a note of the ratio of predators to aphids.

Decisionmaking in grain aphids during the grain head stage

The need for treatment depends primarily on the number of aphids, plant maturity, and the presence of natural enemies. Treatment during the grain head stage is generally considered when aphid numbers exceed more than 25 per head, especially if the crop is late, cool weather is forecasted, and the natural enemy complex is lacking. Control is not advised if the crop is approaching the hard-dough stage where there is good predator/parasite activity. Ratios of one or more predators to every 50 to 100 aphids are sufficient to achieve biological control.

Controls

Biological

Lady beetle adults and larvae, syrphid fly maggots, lacewing larvae, damsel bugs, and parasitic wasps often help to keep aphid populations in check. A ratio of one predator to every 50 to 100 aphids is sufficient to achieve biological control. One exception should be noted. During cool, spring weather conditions, the beneficial insect development often lags behind aphid development, resulting in aphid explosions and the need to apply an insecticide.

Cultural

Although varieties vary in their susceptibility to BYDV, there are no varieties that exhibit a high level of resistance to the virus. The avoidance of early planting, especially before the Hessian Fly Free date, can also help to reduce the potential for aphid-vectored BYDV problems.

Chemical

Insecticide and formulation	Rate of active ingredient per acre	Rate of formulation per acre	Time limits: Days before harvest	Remarks
Dimethoate (Dimethoate 4EC)	0.25-0.38 lb	0.50-0.75 pt	35	May not give acceptable control when temperatures are below 60 degrees F. Do not apply within 14 days of grazing. Labeled for use on wheat only. Do not make more than 2 applications per season.

Dimethoate (Dimethoate 2.67EC)	0.25-0.38 lb	0.75-1.0 pt	35	May not give acceptable control when temperatures are below 60 degrees F. Do not apply within 14 days of grazing. Labeled for use on wheat only. Do not make more than 2 applications per season.
Disulfoton (Di-Syston 8E)	0.25-0.75 lb	4.0-12.0 oz (wheat)	30	**Restricted Use:** When applying as a broadcast spray with water or liquid fertilizer to barley at planting, do not graze treated fields or cut for forage within 30 days of treatment. When applying to barley as a foliar spray in the spring or fall, do not graze treated fields or cut for forage after any application. Check label for specific application rates and other restrictions.
Disulfoton (foliar-fall or spring)	0.5-1.0 lb	0.5-1.0 pt (barley)	30	**Restricted Use:** When applying as a broadcast spray with water or liquid fertilizer to barley at planting, do not graze treated fields or cut for forage within 30 days of treatment. When

				applying to barley as a foliar spray in the spring or fall, do not graze treated fields or cut for forage after any application. Check label for specific application rates and other restrictions.
Imidacloprid (Gaucho 480)	0.03-0.09 lb per cwt of seed	1-3 oz per cwt of seed	Check the label for plant-back restrictions	Either a commercial seed treater or the producer at or immediately before planting may make applications. The former is recommended to ensure that seed is thoroughly coated to effectively control aphids transmitting barley yellow dwarf virus. Only for use in preventing disease transmission during fall. Note that most virus infections in Maryland and Delaware have occurred during spring; thus, gain in yield may not be enough to justify the cost of seed treatment. Gaucho XT contains metalaxyl fungicide (same as Allegiance FL seed treatment

				fungicide) and tebuconazole fungicide (same as Raxil fungicide).
Imidacloprid (Gaucho XT)	0.031 lb per cwt of seed	3.4 oz per cwt of seed	Check the label for plant-back restrictions	Either a commercial seed treater or the producer at or immediately before planting may make applications. The former is recommended to ensure that seed is thoroughly coated to effectively control aphids transmitting barley yellow dwarf virus. Only for use in preventing disease transmission during fall. Note that most virus infections in Maryland and Delaware have occurred during spring; thus, gain in yield may not be enough to justify the cost of seed treatment. Gaucho XT contains metalaxyl fungicide (same as Allegiance FL seed treatment fungicide) and tebuconazole fungicide (same as Raxil fungicide).
Thiamethoxam (Crusier 5FS)	0.03-0.05 lb per cwt of	0.75-1.33 oz per cwt of	45	See remarks for Gaucho-treated

	seed	seed		seed, which also apply to Crusier; however, observe a 120-day plant-back restriction for all crops not listed on the label.
Lambdacyhalothrin (Warrior)	0.02-0.03 lb	2.56-3.84 oz	30	**Restricted Use:** Wheat only. For fall treatment to prevent viral disease transmission by aphids, field tests in Virginia have shown an application of 2 oz of Warrior at one month after planting (2 - to 3-leaf stage through early tillering) provides the best control. Despite the convenience, do not apply Warrior with the fertilizer at planting time because the residual activity will not control aphids later when they colonize fields. For spring infestations, Warrior controls aphids when applied early for cereal leaf beetles in combination with fungicide treatments before flag-leaf stage.
Malathion (Malathion 8EC)	1.0-1.25 lb	1.0-1.25 pt	7	

Microencapsulated methyl parathion (Penncap-M 2F)		0.5-0.75 lb	2.0-3.0 pt	15	**Restricted Use:** Check label for other restrictions.
Zeta-cypermethrin (Mustang MAX)	0.02-0.025 lb	3.2-4.0 oz		14	**Restricted Use:** Wheat and triticalli only. Aids in control of aphids.
Gamma-cyhalothrin (Proaxis)	0.015 lb	3.84 oz		30	**Restricted Use:** NEW for 2006 - Wheat and triticale only. Do not apply within 30 days of harvest. Total product allowed per acre is 0.48 pt of formulation.
beta-cyfluthrin (Baythroid XL)	0.014-0.019 lb	1.8-2.4 oz			**Restricted Use:** Bird cherry oat and English only. Wheat only; PHI – 30 days Max allowed per 3-day interval: 2.4 fl oz/A; Max allowed per crop season: 4.8 fl oz/A; Max # applications: 2

Cereal Leaf Beetle

Biology and Life History

Overwintering adults emerge in late March and begin to lay eggs after 2 to 3 weeks of feeding. Since females prefer to lay eggs on young plants, spring-planted oats and late-planted wheat are the predominant hosts. In general, barley is more advanced in the spring and less attractive to egg -laying adults. Newly emerged larvae will feed voraciously for 10 days to 3 weeks. Larvae cover themselves with a brown or black coating of fecal material causing them to appear "slug-like". Summer adults emerge during late June and early July, feed on corn and wild grasses, then enter a summer dormancy. Only one generation occurs per year.

Damage

Both larvae and adults feed on the upper leaf surfaces of wheat and oats. Larvae feed on the outer surface of the leaves, giving the plants a silver or "frosted"

appearance. Adults feed between the leaf veins, resulting in longitudinal streaks on the leaves.

Sampling

Scouting should begin in early April as soon as adult beetles are observed. Use the adult abundance in each field as an indicator of potential egg pressure. Samples should be taken at a minimum of 10 random sites in the interior of each field (avoid the edges). At each site, 10 tillers (stems) should be examined to count the number of eggs and larvae. This will result in 100 tillers (stems) per field being examined. Eggs may be on the leaves near the ground. If the population consists mainly of eggs, then schedule field visits at a later date when greater than 50 percent of the immatures are larvae. Cereal leaf beetle is often unevenly distributed in the field, so it may be necessary to subdivide the field into two or more parts and sample each part as an individual field.

All fields that are not treated early should still be scouted for cereal leaf beetle larvae, as well as other insect pests. Later in April or early May, make detailed counts of larvae at 10 sites spread throughout the field. At each site, select a spot at random and carefully delineate the stems of a 6- to 8-inch section of a single row. Examine all the leaf blades, visually estimate the amount of defoliation, count the number of larvae, note the average larval size, and then count the number of stems in the delineated row section. Tally the total number of larvae and stems examined, and compute the average count of larvae per stem.

Decisionmaking

Damage can build up quickly, often in as little as 5 days, after larvae become large and high temperatures make the insects very active. Leaf feeding reduces the plant's ability to produce photosynthates and limits reproductive growth, particularly if the upper leaves are destroyed. Yields can be reduced by 45 percent when defoliation is 100 percent early in the heading period. Later damage, late in the grain-fill period, does not have a great impact. Keep in mind that the three stem leaves (flag leaf and two leaves below) all contribute to filling grain heads and achieving favorable grain test weight. In fact, the two lower stem leaves are about as important as the flag leaf.

An earlier-triggered threshold is now recommended to allow growers more lead time to take action and apply insecticides together with fungicides to share the application cost. The threshold is 25 or more eggs and/or small larvae per 100 tillers (or one per every four tillers). The orange-brown eggs are easy to find on the upper surface of the leaves. They are shaped like little cucumbers deposited singly or in chains of two or three close to the midrib. Treatment is suggested when the egg threshold is reached and more than 50 percent of the sample count consists of larvae—that is, after 50 percent egg hatch. This decision-making strategy works only if a good representative sample estimate of the egg density is obtained and growers wait until 50 percent of the eggs have hatched, at which time most eggs have been laid for the season. If the tendency is to focus on hot spots that exceed the threshold, then fields will be over-treated.

The concern about an early treatment strategy is that growers will automatically treat preventively and overuse insecticides. This can lead to an aphid problem by removing valuable predators, disrupt parasites of the cereal leaf beetle, and add unnecessary cost. If implemented properly, making the spray decision early can almost totally prevent defoliation, often allows the insecticide to be applied together with fungicides to share the application cost, and will not result in more fields treated than would ordinarily be treated later using a larval-based threshold. Use the egg/larval threshold with care and try to apply it to the high management fields only, that is, those that have a yield potential of greater than 60 bushels per acre. Also, avoid using insecticides at top-dress times because these applications are too early in relation to cereal leaf beetle movement into grain fields.

The cereal leaf beetle has a tendency to seek out the sparse wheat fields with the lowest yield potential. It may not be cost-efficient to apply early season controls in these fields, even though egg/larval densities exceed the threshold. In these situations, wait to see how well the crop responds to the nitrogen applications and then evaluate the larval infestation and the economics of treatment. Avoid spraying sparse plantings if possible because they serve as nurseries to increase populations of parasites that will help control the cereal leaf beetles next year.

If fields are not treated early using the egg/larval threshold, insecticidal control is suggested if larval density averages more than 50 per 100 tillers, defoliation is more than 10 percent, and most larvae are still young enough to cause additional injury. Once wheat reaches the hard dough stage, beetle damage has little effect on the yield and thus controls are no longer required.

Chemical Control

Insecticide and formulation	Rate of active ingredient per acre	Rate of formulation per acre	Time limits: Days before harvest	Remarks
Carbaryl (Sevin 80S)	1.0 lb	1.25 lb	21	**Restricted Use:** Wheat only. Do not make more than two applications after grain heads emerge. No time limits on use as pasture or forage.
Carbaryl (Sevin XLR Plus)	1.0 lb	2.0 pt	21	**Restricted Use:** Wheat only. Do not make more than two applications after

				grain heads emerge. No time limits on use as pasture or forage.
Lambdacyhalothrin (Warrior)	0.02-0.03 lb	2.56-3.84 fl oz	30	**Restricted Use:** Wheat only.
Methomyl (Lannate LV)	0.17-1.35 lb	0.75-1.5 pt	7	**Restricted Use:** Use a minimum of 3 gallons of diluted spray per acre by air. Do not graze or feed treated forage or hay to livestock within 10 days of last treatment.
Methomyl (Lannate 90SP)	0.17-1.35 lb	0.75-1.5 pt	7	**Restricted Use:** Use a minimum of 3 gallons of diluted spray per acre by air. Do not graze or feed treated forage or hay to livestock within 10 days of last treatment.
Zeta-cypermethrin (Mustang MAX)	0.011 - 0.025 lb	1.76 - 4.0 oz	14	**Restricted Use:** Wheat and triticalli only, not barley. Use sufficient water to obtain full coverage of foliage (minimum of 10 gallons by ground and 2 gallons by air). Maximum allowed amount per crop season is 0.125 lb ai per acre.
beta-cyfluthrin (Baythroid XL)	0.008-0.014 lb	1.0-1.8oz		**Restricted Use:** Wheat only; PHI – 30 days Max allowed per 3-day interval: 2.4 fl oz/A; Max allowed per crop season: 4.8 fl oz/A; Max # applications: 2

Biological and cultural control

A number of introduced parasites have been instrumental in keeping cereal leaf

beetle populations below economic damage levels. Also, favorable planting dates may help suppress populations. Wheat planted early in the fall immediately after the Hessian fly-free date will be more advanced in growth the next spring than late-planted small grains. These early plantings will be less attractive to and more tolerant of the beetles when they peak in the spring. Cereal leaf beetle infestations on spring-planted oats cannot be avoided by means of an early planting date. Generally, barley is more advanced in maturity and thus less attractive when beetles are active.

True Armyworm

Biology and Life History

Armyworms overwinter as partially grown larvae in the soil and in plant debris of crops and woodland. Moth emergence and egg laying begins in late April. Moth activity peaks by late April. Egg laying is often concentrated in weedy and lodged areas of a field. The first small larvae can be found on lower leaf tissue in early May. Larval development takes 20-28 days. In late May through June, larvae often move to other crops. Mature larvae burrow into the soil or under debris to pupate. Three to four generations occur each year, but only the first one attacks small grains.

Damage

Young larvae (less than 1/2 inch long) generally feed on the upper leaf surface. Larger larvae feed heavily on the leaf blades and weeds. The last instar(1.5 inches long and greater) will consume 80 percent of all the plant material eaten during their larval development. This stage lasts six to eight days before moving into the soil to pupate. Heavy defoliation of the flag level can result in significant economic loss. Unlike the sawfly, armyworms begin head clipping only when all vegetation is consumed and the last succulent part of the plant is the stem just below the grain head. Larvae can feed on the kernel tips of wheat, resulting in premature ripening and lower test weight.

Sampling

Armyworms should be detected while they are still small and easier to control. Check fields once each week starting the second week of May. Examine first the debris and undergrowth on the ground surface along field margins and lodged areas. Small worms usually are found curled in a C-shape around the base of the plants or under the debris and winter annual weeds. Armyworm frass or droppings also may be found on the soil surface. If small armyworms are present in these areas, obtain 10 to 20 worm counts at 50-pace intervals throughout the field. Note the average size of the worms and whether any defoliation of the flag leaf or head clipping has occurred.

Decisionmaking

As a general rule, barley should be treated if the number of armyworms exceeds one per linear foot between rows and most of the worms are greater than 0.75 inch long. In wheat, armyworms tend to nibble on the tips of kernels rather than

clip heads; thus, populations around two to three worms per linear foot between rows are required to justify control. In high-management wheat fields with 4-inch rows, treatment is recommended when armyworm levels exceed three to five per square foot of surface area.

Note that wheat fields with mixed infestations of armyworms and sawfly caterpillars may need treatment even if worm counts of each pest do not exceed threshold levels. Also, if the grain crop is close to harvest or the majority of armyworms are longer than 1.5 inches and no head clipping has occurred, control may not be needed.

Chemcial control

Insecticide and formulation	Rate of active ingredient per acre	Rate of formulation per acre	Time limits: Days before harvest	Remarks
Carbaryl (Sevin XLR Plus (4 lb/ga))	1.0-1.5 lb	2.0-3.0 pt	21	Apply to wheat only. Do not make more than two applications after grain heads emerge. No time limits on use as pasture or forage.
Lambdacyhalothrin (Warrior)	0.02-0.03 lb	2.56-3.84 fl oz	30	**Restricted Use:** Wheat only.
Methomyl (Lannate LV 2.4EC)	0.23-0.45 lb	0.75-1.5 pt	7	**Restricted Use:** Use a minimum of 3 gallons diluted spray per acre by air. Do not graze or feed treated forage or hay to livestock within 10 days of last treatment.
Methomyl (Lannate 90SP)	0.23-0.45 lb	0.25-0.5 lb	7	**Restricted Use:** Use a minimum of 3 gallons diluted spray per acre by air. Do not graze or feed treated forage or hay to livestock within 10 days of last treatment.

Microencapsulated methyl parathion (Penncap-M 2F)	0.5-0.75 lb	2.0-3.0 pt	15	**Restricted Use:** Check label for restrictions.
Zeta-cypermethrin (Mustang MAX)	0.011-0.025 lb	1.76-4.0 oz	14	**Restricted Use:** Wheat and triticalli only, not barley. Use sufficient water to obtain full coverage of foliage (minimum of 10 gallons by ground and 2 gallons by air). Maximum allowed amount per crop season is 0.125 lb ai per acre.
beta-cyfluthrin (Baythroid XL)	0.014-0.019 lb	1.8-2.4 oz		**Restricted Use:** Bird cherry oat and English only. Wheat only; PHI – 30 days Max allowed per 3-day interval: 2.4 fl oz/A; Max allowed per crop season: 4.8 fl oz/A; Max # applications: 2

Biological and cultural control

Parasites, diseases, insect predators, and birds usually keep armyworms under control in small grains. However, the effectiveness of these natural control agents is reduced during cool, wet springs and during growing seasons that follow years of drought.

Grass Sawfly

Biology and Life History

Adult sawflies emerge in early April, mate, and begin to lay eggs in the leaf margins of small grains. Most egg laying is complete by early May. The first larvae can be found by early May feeding on the lower leaf blades. Mature larvae can be distinguished by their solid green color, amber head with a brown band and many legs. Larval development takes approximately 21-30 days. By mid-June, larvae burrow into the ground and begin a period of summer diapause (hibernation) in the prepupal stage

Damage

Sawfly larvae prefer to feed on the stems and are potentially more damaging than armyworms. Larvae begin to climb and feed on stems when the larvae are half grown and the grain is in the tiller to head stage. Stem clipping often occurs

before leaf feeding is complete and/or the grain reaches physiological maturity. Head clipping often peaks by May 10, ten days before peak armyworm damage.

Sampling

The sawfly caterpillar is a sporadic pest of wheat and barley, primarily on the Eastern Shore. It is easily distinguished from armyworms and other caterpillars by its solid-green body, its prominent amber head and its many legs (three pairs of jointed legs, each ending with a claw and eight pairs of short, fleshy prolegs without claws). Young caterpillars are lighter green and somewhat translucent. Mature worms are about 1.25 inches long and assume a curled position when disturbed.

Like armyworms, sawfly caterpillars must be detected when they are still young before head clipping occurs. Grain fields should be checked once each week starting the first week in May. This pest normally appears about a week earlier than armyworms, although mixed populations are frequently found in the same areas. First examine the crop for clipped heads and partially consumed leaf blades in rank growing areas and along field margins adjacent to woods. Shake the plants before counting the larvae on the ground. Unlike armyworms, this insect feeds during the day. If caterpillars are present, then sample as recommended for armyworms.

Decisionmaking

One sawfly caterpillar clips an average of five to eight grain heads during its larval development. The general rule is to treat when most caterpillars are greater than 0.75 inch long and worm counts exceed 0.4 per linear foot of row or 0.7 every square foot. The best time to treat is between May 15 and May 25. It is too late if the number of clipped heads per unit area is 3 to 4 times the average worm count and most caterpillars are greater than 1 inch long.

Fields with mixed infestations of armyworms and sawfly caterpillars may need treatment even if worm counts of each pest do not exceed threshold levels. Usually one foliar application of insecticide controls both insect pests. It is not wise to delay treatment in case armyworms appear later. If an armyworm problem is going to develop, the young worms are normally present when treatment is applied for sawfly caterpillars.

Chemical control

Insecticide and formulation	Rate of active ingredient per acre	Rate of formulation per acre	Time limits: Days before harvest	Remarks
Zeta-cypermethrin (Mustang MAX)	0.02-0.025 lb	3.2-4.0 oz	14	**Restricted Use:** Wheat and triticalli only. Use sufficient water to obtain full coverage of

				foliage (minimum of 10 gallons by ground and 2 gallons by air). Methomyl (Lannate LV 2.4EC) and microencapsulated methyl parathion (Penncap-M) are effective if used at the rates recommended for armyworms. Lannate and Penncap-M are also labeled on barley.
Lambdacyhalothrin (Warrior)	0.02-0.03 lb	2.56-3.84 oz	30	**Restricted Use:** Wheat only.
beta-cyfluthrin (Baythroid XL)	0.014-0.019 lb	1.8-2.4 oz		**Restricted Use:** Wheat only; PHI – 30 days Max allowed per 3-day interval: 2.4 fl oz/A; Max allowed per crop season: 4.8 fl oz/A; Max # applications: 2

Biological control
None Available

Cultural control
None Available

Hessian Fly

Biology and Life History
The Hessian fly has traditionally been an insect pest of wheat grown in the Midwestern states. In recent years, populations have been increasing in the Mid-Atlantic region and economic losses are starting to occur as a result of changes in wheat production practices. In the Mid-Atlantic region, there are generally two generations per year. Adults emerge in September from the "flax seeds" (puparium) that survive on wheat stubble throughout the summer.

Damage
If fall damage is extensive, plants will appear weakened and stunted. Spring infestations generally result in lodged plants as a result of maggots feeding on the first or second joint. During the last three years, Hessian fly has caused varying levels of yield loss. Fields planted in continuous wheat and/or no-till situations where volunteer small grains are present at the time of planting suffer the

greatest yield loss. Entire fields can be severely stunted due to fall infestations. Spring infestations often result in lodging ranging from 5 to 25%.

Monitoring and Decision Making
Currently, no methods are available for effectively monitoring Hessian Fly populations. Yellow sticky traps have been used to monitor for presence of adult flies.

Biological control
None available

Cultural control
Since chemical controls have still not proven to be an economic alternative, a combination of the following cultural practices still provide the best control: complete plowing of infested wheat stubble soon after harvest, crop rotation (do not plant wheat in the same field 2 years in a row), elimination of volunteer wheat before planting to prevent early egg laying, avoiding the use wheat as a fall cover crop near fields with infestations the previous season, planting after the fly free date (Oct 3 – New Castle County; Oct 8 – Kent County; Oct 10 – Sussex County) and the use of resistant varieties.

The use of avoidance, i.e. using the Hessian Fly Free Date, should still be used as a part of a total management program. However, changes in current management practices and warmer fall weather have made this tool less effective in recent years. The recent development of varieties with resistance to Biotype L, the predominant Hessian fly biotype in Delaware, may provide effective Hessian Fly management. However, these varieties have just been released and are currently being evaluated under commercial conditions.

WEEDS (4)

Annual and Perennial Broadleaves and Grasses

Frequency of Occurrence
Annually.

Damage Caused
Reduced yields from weed competition, and loss due to interference with harvesting equipment. Crops can become contaminated with weed plant parts (e.g. wild garlic, Canada thistle buds) during harvesting that can result in reduced selling price or in severe cases, rejection of the crop.

% Acres Affected
100%

Pest Life Cycles

A wide range of winter and summer annual and perennial weed species may be present in winter wheat fields in DE. Some of the more common ones include mustard species, common vetch, field pansy, henbit (deadnettle), horseweed, chickweed, common lambsquarters, and common ragweed, wild garlic, annual bluegrass, brome species, ryegrass, and Canada thistle.

Timing of Control
Preplant, at planting, and postemergence.

Yield Losses
Can be as high as 100% in severely infested fields. Fields with infestations of weeds posing contaminant problems (Canada thistles, wild garlic) can be passed over for harvesting.

Regional Differences
Weeds are a common problem throughout the state.

Cultural Control Practices
Cultivation is not a viable option after the wheat has been planted.

Biological Control Practices
None

Post-Harvest Control Practices
Application of herbicides after harvest can control perennial weeds and aid in long-term control.

Chemical Control

Weed Problem	Chemical rate per acre	Product per acre	Treatment Time	Remarks
Contact kill of most annual weeds for no-till plantings	Paraquat 0.5-1.0 lb + surfactant	Gramoxone Inteon 2.0-4.0 pt + surfactant as labeled	No-till establishment	Use 2.0-2.5 pints per acre for weeds 1 to 3 inches, use 2.5-3.0 pints per acre for weeds 3 to 6 inches, and use 3.0-4.0 pints per acre for weeds over 6 inches. Weeds 6 inches or taller may

				not be controlled. Apply after planting but before emergence of the small grain. Use 20 to 60 gallons of diluted spray per acre. As the density of the crop residue increases, the spray gallonage should increase to ensure complete coverage and kill. Use the higher rate if existing vegetation is dense, cool temperatures exist, or drought conditions are prevalent.
Kill of most annual weeds for no-till plantings	Glyphosate 0.5-5.0 lb	Roundup Weather Max 0.5-3.1 qt or Touchdown Total 0.35-3.5 qt or other labeled glyphosate formulation	No-till establishment	See label for specific use instructions. The low rate can be used when small winter annuals are present and less than 2 inches high. Increase rate on larger weeds. Application with fan-type nozzles is

			preferred. The lower rate is more effective in 3 to 10 gallons per acre. The higher rates can be used in controlling certain perennials if their stage of growth and condition match glyphosate's labeling. Touchdown Total is available in a non-surfactant formulation called Touchdown HiTech.
Bedstraw, bittercress, black nightshade, common mallow, fixweed, kochia, lambsquarters, pennycress, pigweed sp., sheperdspurse, sowthistle, wild buckwheat, and others. Local research indicates suppression of speedwell sp. and star-of-bethlehen.	Carfentrazone 0.0078 - 0.0313 lb	Aim 2EC 0.5 - 2.0 oz	May be applied to barley, grain and forage millet, oats, rye, triticale, and wheat. Make applications to actively growing weeds up to 4 inches tall and to rosettes less thatn 3 inches in diameter. Apply with a non-ionic surfactant at 0.25% by volume. A sprayable liquid nitrogen fertilizer at 2 - 4% by volume

				or ammonium sulfate at 2 - 4 pounds per acre may be addes to the non-ionic surfactant. Aim may be tank-mixed with other registered herbicides to expand the spectrum of control. Do not harvest treated small grains for forage within 7 days of application. ALTERNATIVE USE - HARVEST AID: Aim may be applied at 1 - 2 oz per acre to any of the small grain crops listed above to defoliate or dessicate troublesome broadleaf weeds such as morningglories, pigweed, and velvetleaf that may be present at harvest. Aim may be used alone or as a tank mixture with other harvest aids. Applications should be made when the crop is mature and grain has begun to dry

				down. Applications shold be made in a minimum of 10 gallons per acre with the addition of eithe non-ionic surfactant, crop oil concentrate, or methylated seed oil. A sprayable liquid nitrogen fertilizer at 2 - 4% by volume or ammonium sulfate at 2 - 4 lb per acre may be added to the non-ionic surfactant, crop oil, or methylated seed oil.
Corn chamomile, corn gromwell, cowcockle, knawel or German moss, mayweed, mustard (wild), pennycress (field), pepperweed, radish (wild), shepherdspurse, yellowrocket. Weak in control of chickweed and henbit	Bromoxynil 0.375-0.5 lb	Buctril 1.5-2.0 pt	Postemergence fall or spring	Destroy all weed seedlings before seeding small grains. Look for weeds as soon as small grains start to germinate. Apply after small grain is beyond 2-leaf stage and weed seedlings have no more than three to four leaves or rosettes 1.5 inches across. Best results can be expected with flat fan nozzles using a minimum of 30

				pounds per square inch and 10 gallons per acre. With flood nozzles, use a minimum of 20 gallons of water per acre and 30 gallons per square inch. Use higher rate for cowcockle, henbit, chickweed, and wild mustard control. Poor control has resulted when applied to larger weeds. Thorough weed coverage is necessary for effective control. Do not apply if small grains form a canopy, during or after boot stage, or when crop is under stress from lack of moisture. Do not graze treated fields for 30 days after application. May be applied with fluid fertilizer.
Weed Problem	Chemical rate per acre	Product per acre	Treatment Time	Remarks
Burdock, buttercup (bulbous), chicory, cornflower or bachelor's	2,4-D amine 0.25-0.75 lb	2,4-D amine 0.5-1.5 pt (various brands 4.0 lb/gal)	Postemergence spring	Spray 2,4-D when grain is 4 to 8 inches high or after tillering but before jointing.

buttons, dandelion, dock (curly) seedlings, fanweed, fleabane, goatsbeard, henbit, lettuce (prickly), meadow campion or ragged robin, mustard (black, wild), pennycress, plantain, poppy (corn), primrose, radish (wild), rock cress, shepherdspurse, smartweed, thistle (blessed), turnip (wild), vetch (hairy), and suppression of garlic, onions (wild), and thistles				Spraying small grain too early or after jointing can result in reduced yields and uneven ripening. The higher rates of 2,4-D increase the risk of grain injury. Use production practices favorable to maximum crop competition. Do not graze dairy animals or feed forage within 14 days of treatment. Always premix 2,4-D amine with water before mixing with liquid fertilizer.
Bluegrass (annual), bromegrass (some species - see label), chickweed (common - suppression), chickweed (mouseear), henbit, ryegrass (Italian - suppression)	Flufenacet + metribuzin 0.17-0.425 lb	Axiom 68DF 4.0-10.0 oz		Apply by ground application only. Apply from spike to 3-leaf growth stage of wheat. Use 4.0 to 6.0 oz/acre on coarse soils and 6.0 to 10.0 on medium and fine soils. Axiom may be tank-mixed with and/or applied sequentially with any other herbicides which are registered for

				use in winter wheat unless prohibited on the label of the tank-mix or sequentially applied product. Do not apply in tank-mixtures with crop oil concentrates, vegetable and/or petroleum oils as crop injury may result.
Corn chamomile, corncockle, cowcockle, dandelion, dogfennel, goatsbeard, knawel or German moss, mayweed, and smartweed, weak on chickweed	Dicamba 0.125 lb	Banvel 0.25 pt or Clarity 0.125-0.25 pt	Postemergence spring	See label for grazing restrictions. Apply after grain is fully tillered but before jointing.
Above weeds listed for dicamba and 2,4-D	Dicamba 0.06-0.125 lb + 2,4-D amine or ester 0.25-0.375 lb	Banvel 0.13-0.25 pt or Clarity 0.13-0.25 pt + 2,4-D amine or ester 0.5-0.75 pt (various brands 4.0 lb/gal)	Postemergence spring	Good general treatment for broadleaf control. Controls wider spectrum of weeds than either herbicide alone. Apply after grain is fully tillered but before jointing.

Many winter annual broadleaf weeds	Dicamba 0.06-0.125 lb + bromoxynil 0.25-0.375 lb	Banvel 0.13-0.25 or Clarity 0.13-0.25 pt + Buctril 1.0-1.5 pt	Postemergence spring	Apply after grain is fully tillered but before jointing. Observe label precautions.
Previous weeds listed for 2,4-D and dicamba and for improved performance against the following difficult-to-control weeds: fiddleneck, garlic (wild), gromwell, henbit, and onion (wild)	Dicamba 0.125 lb + 2,4-D amine 0.5-1.0 lb or Dicamba 0.125 lb + 2,4-D ester 0.5-0.75 lb	Banvel 0.25 pt or Clarity 0.25 pt + 2,4-D amine 1.0-2.0 pt (various brands 4.0 lb/gal) or Banvel 0.25 pt or Clarity 0.13-0.25 pt + 2,4-D ester 1.0-1.5 pt (various brands 4.0 lb/gal)	Postemergence spring	Apply after grain is fully tillered but before jointing. This combination gives better control of more weeds than either chemical alone. This is only labeled on fall-seeded wheat, not barley, oats, or rye. Do not use unless possible crop injury will be tolerated.

Annual ryegrass	Diclofop-methyl 0.5-1.0 lb	Hoelon 1.33-2.66 pt	Postemergence	Hoelon will not control broadleaf weeds. It is slow acting in controlling ryegrass. Hoelon can be applied preemergence at 2.0 to 2.66 pints per acre in Delaware, Maryland, Virginia, and West Virginia. For

				postemergence control, apply Hoelon to wheat before the first node (jointing) develops. **Do not apply to ryegrass past the 5-leaf/2-tiller stage.** Post applications are permitted in Delaware, Maryland, Virginia, and West Virginia. The use of 1.0 pint to 1.0 quart of crop oil concentrate per acre may be helpful, but do not use when conditions are cool and wet. Do not tank-mix Hoelon with any broadleaf herbicides in Delaware, Maryland, or Virginia as reduced annual ryegrass may occur. Broadleaf herbicides can be applied 5 days after Hoelon is applied. Hoelon is labeled for use with numerous fungicides. Hoelon is labeled to be

				tank-mixed with liquid nitrogen (28 to 32 percent), but do not use less than 2.0 pints of Hoelon per acre. Hoelon-resistant annual ryegrass has been confirmed in Delaware, Maryland, New Jersey, and Virginia.
Annual ryegrass and some winter annual weeds, but not chickweed	Diclofop-methyl 0.75-1.0 lb + bromoxynil 0.25-0.375 lb	Hoelon 2.0-2.66 pt + Buctril 1.0-1.5 pt	Postemergence	See previous remarks concerning Hoelon. Do not apply other broadleaf herbicides within 1 week of a Hoelon application.

Annual grasses, ryegrass (Italian - suppression), pigweed sp., lambsquarters (common)	Pendimethalin 0.71-1.43 lb	Prowl H2O 1.5-3.0 pt	Prowl H2O can be applied postemergence in winter wheat from the first leaf stage until before the flag leaf is visible/emerged. Prowl H2O should be applied prior to weed emergence. Emerged weeds will not be controlled by this treatmemnt. For control of established weeds, Prowl H2O may be tank-mixed with any postemergence herbicide registereed for use in wheat. Consult label for rotational restrictions and rainfall requirements.

Use in IPM Programs

Use of these herbicides is consistent with IPM recommendations. Postemergence herbicides support the use of scouting and as-needed applications.

Resistance Management

Most growers are using Harmony Extra exclusively for weed control in fields planted to small grains. They are being encouraged to tankmix Harmony Extra with 2,4-D whenever possible to minimize the risk of resistance.

Efficacy Issues
The listed herbicides have different but often overlapping spectra of species control. Currently there are no labeled herbicides for control of Hoelon-resistant ryegrass, annual bluegrass, or brome species. Some of the herbicides being used in the mid-west and western portions of the U.S. are not appropriate for the Mid-Atlantic region.

Alternatives
Other new herbicides under research AEF130060, AEF 107892, metolachlor, clodinofop, and chlorsulfuron.

DISEASES (4)

Diseases of wheat are: seed decay, seedling blights, powdery mildew, loose smut, leaf rust, septonia leaf, tan spot, glume blotch, and scab. No Organo-phosphate or Carbamate pesticides are used to treat these diseases. Mancozeb, a potential carcinogen, is applied as a foliar fungicide to treat septoria leaf, glume blotch and tan spot.

When no-tilling wheat into corn stubble, there is an increased risk of head scab. Scab-causing spores produced on corn stubble move in air currents up to wheat plants. Head infection occurs when moist, warm weather occurs during flowering. Depending on time of infection, one or more spikelets or the entire head is bleached. Infected grain may contain mycotoxins that are harmful to non-ruminant livestock.

When wheat follows wheat for several years in the same field, a disease known as take-all can develop. The disease usually affects small areas in a field, but unless the field is rotated out of wheat, these areas can enlarge and result in substantial yield losses. Symptoms include a black lesion near the base of each stem, poor root growth causing the plant to be easily pulled out of the ground, shortened plants, and sterile, whitened seed heads.

Crop	Active Ingredient	Fungicide trade name	Application rate per acre	PHI (days)	Remarks
Wheat	Azoxystrobin	Quadris	6.2-10.8 fl oz	14 for hay Beginning of flowering for grain	See efficacy chart for target diseases. Do not apply before jointing [stage 6 on Feekes' or 31 on Zadoks' scale (Fig. 1)]. Applications can be made through heading (Stage 10.5 on Feekes' or 59 on Zadoks' scale). Do not apply once flowering begins. Do not apply more than 0.77 quarts per acre per season. Do not harvest treated wheat for forage. Minimum rate for powdery mildew control is 7.7 fl oz per acre. Do not make more than 2 applications per season of this or other strobilurin (QoI) fungicide (pyraclostrobin or trifloxystrobin) to reduce development of resistance to this class of fungicides.
Wheat	Pyraclostrobin	Headline	6.0-9.0 fl oz	14 for hay Beginning of flowering for grain	See efficacy chart for target diseases. Applications can be made through heading (Stage 10.5 on Feekes' or 59 on Zadoks' scale). Do not apply once flowering begins. Do not apply more than 18 fl oz per season. To reduce development of resistance to this class of fungicides, do not make more than 2 applications per season of this or other strobilurin (QoI) fungicide (pyraclostrobin or trifloxystrobin).

Wheat	Propiconazole	Tilt	2.0-4.0 fl oz	Beginning of flowering	See efficacy chart for target diseases.

					Applications can be made through heading (Stage 10.5 on Feekes' or 59 on Zadoks' scale). Do not apply once flowering begins. Do not apply more than 4.0 fl oz per acre per season. Do not graze or feed livestock treated forage or cut green crop for hay or silage. After harvest, the straw may be used for bedding or feed. Soybeans may be double-cropped, but do not use hay, forage, or fodder from soybeans for feed or bedding. Do not plant rotational crop within 105 days unless it is on label.
Wheat	Propiconazole + trifloxystrobin	Stratego	10 fl oz	Beginning of flowering	See efficacy chart for target diseases. Applications allowed through heading (Stage 10.5 on Feekes' or 59 on Zadoks' scale). Do not apply more than 10 fl oz per acre per season. Do not graze or feed livestock treated wheat straw, forage or hay. Do not cut green crop for hay or silage. After harvest straw may be used for bedding. Double-crop soybeans are allowed, but do not use hay, forage, or fodder from the soybean crop as feed or bedding.

Wheat	Mancozeb	Dithane M45	2.0 lb	26	Make

		Penncozeb 80WP	1.0-2.0 lb		application up through heading (Stage 10.5 on Feekes' or 59 on Zadoks' scale). Do not apply once flowering begins. Do not apply more than 3 times per season (6 lb of product). Do not graze livestock in treated areas prior to harvest.
Wheat, barley and triticale	Propiconazole + azoxystrobin	Quilt	10.5 - 14.0 fl oz	45	See efficacy chart for target diseases. Applications can be made through heading (Stage 10.5 Feeke's or 59 on Zadok's scale) for wheat only. Applications to barley and triticale can be made through flag leaf development (Stage 9 Feeke's or 39 on Zadok's scale). Do not apply more than 2 applications per season. Do not harvest for

				forage. Under certain conditions crop injury may occur when tank mixed with herbicides or fertlizer.

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