Crop Profile for Small Grains in North Carolina

Prepared: December, 2003

General Production Information

Production Facts:

- Small grains produced in North Carolina include winter wheat, sorghum, oats, barley, rye and triticale.
- Nationally, North Carolina ranked 16th in the production of winter wheat, 17th in sorghum, 18th in oats and 19th in barley in 2002.
- In 2002, North Carolina accounted for 1.8% of total U.S. winter wheat production, 0.1% of total U.S. sorghum production, 1.7% of total U.S. oat production, and 0.6% of total U.S. barley production.
- In 2002, North Carolina produced 20,160,000 million bushels of wheat for grain on 480,000 acres, 540,000 bushels of sorghum for grain on 12,000 acres, 1,995,000 bushels of oats for grain on 35,000 acres, and 1,380,000 bushels of barley for grain on 20,000 acres.
- Small grains are grown for flour, forage/feed, hay, and cover crops for tobacco, cotton and peanuts.

Production Regions:

- Small grains are grown primarily in the Coastal Plain and Piedmont of North Carolina and a lesser extent in the Mountains (Figures 1-4).Some regions of the state such as the northern Piedmont grow grains as an interim crop more than for grain production.

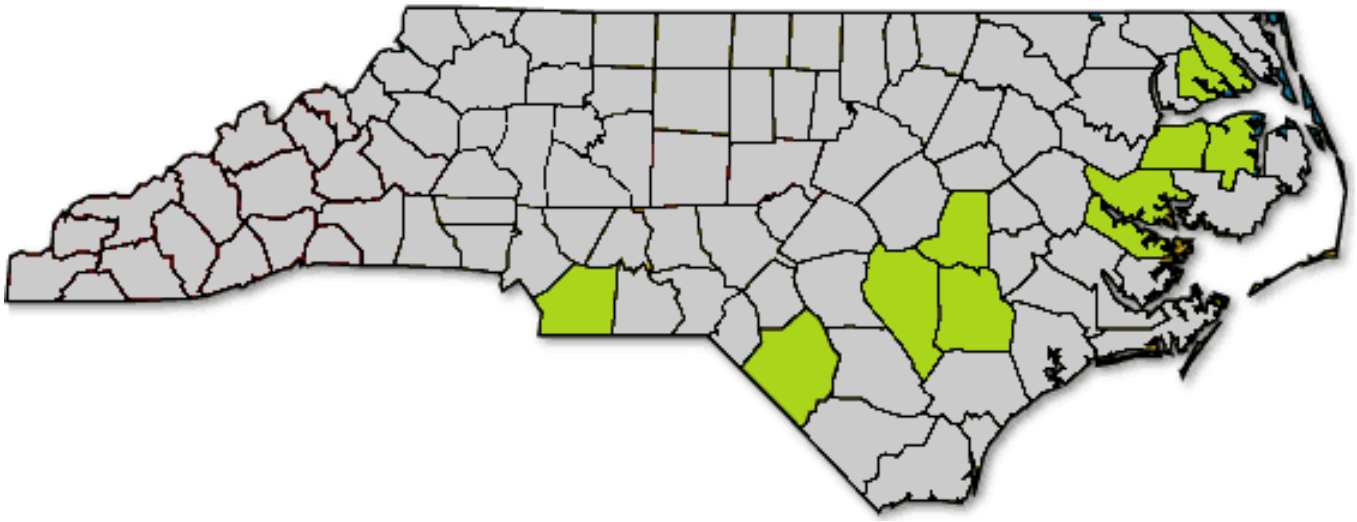
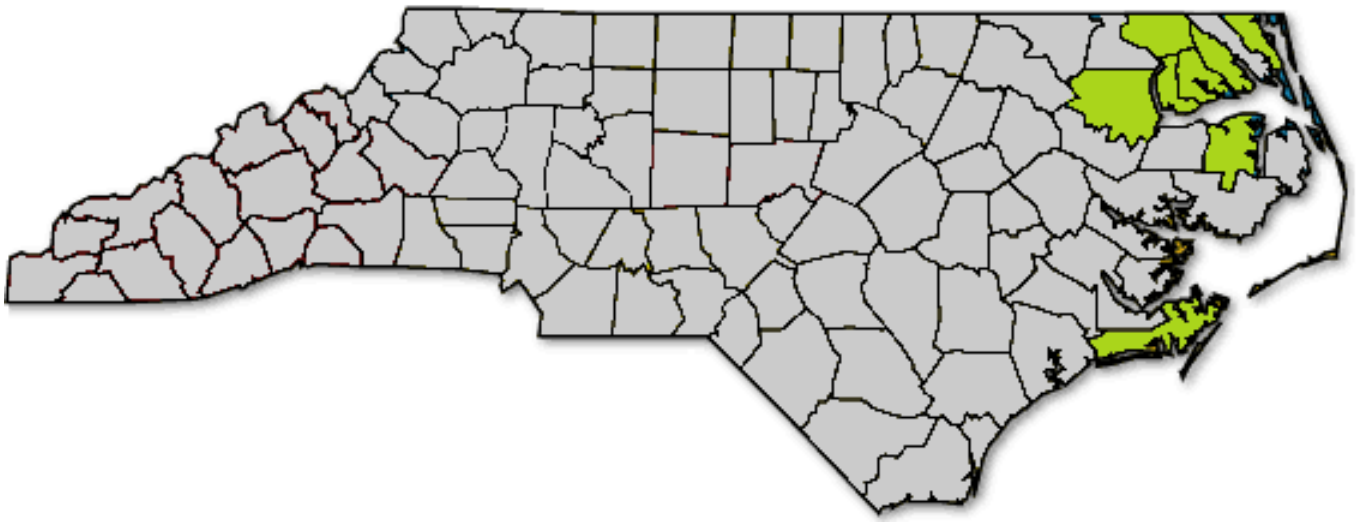
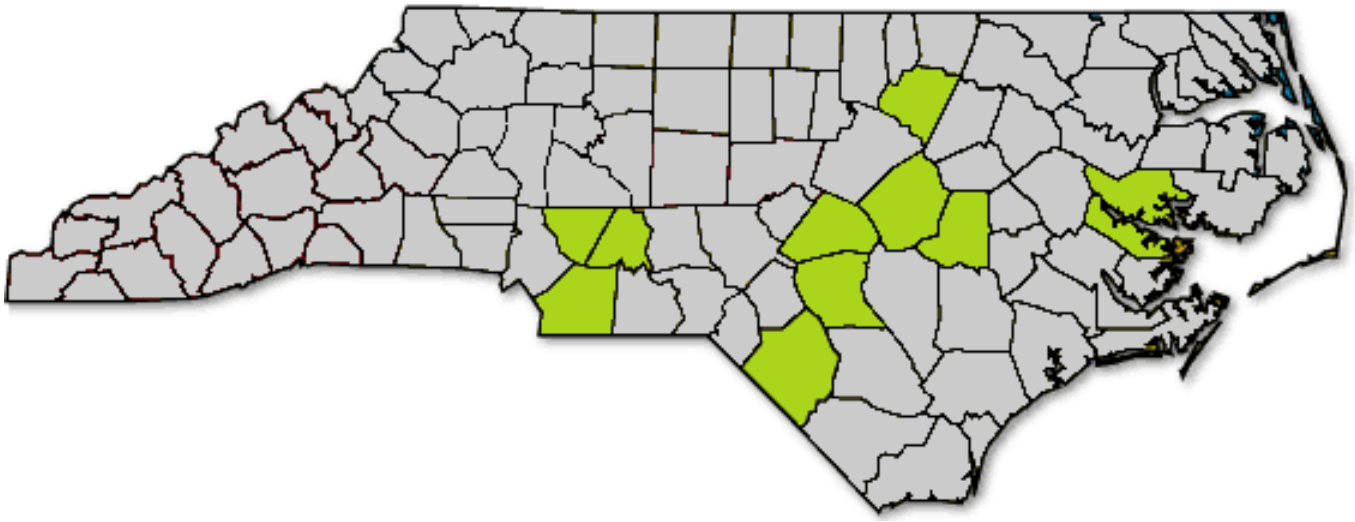


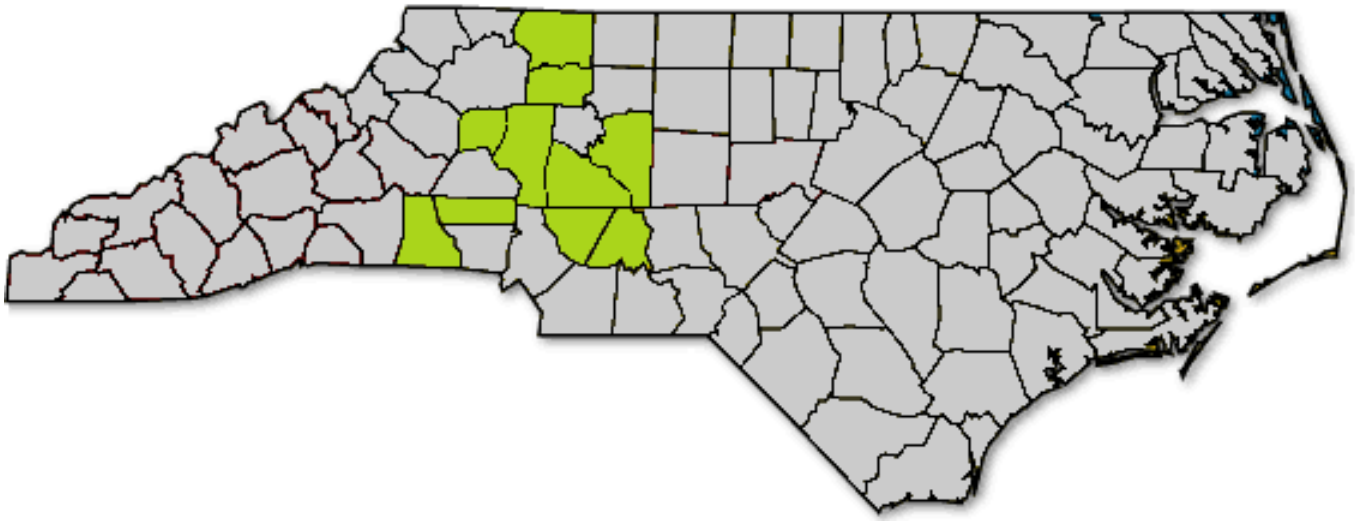
Figure 1.Leading wheat-producing counties in North Carolina in 2002 (shaded in green).



Leading sorghum-producing counties in North Carolina in 2002 (shaded in green).



Leading oat-producing counties in North Carolina in 2002 (shaded in green).



Leading barley-producing counties in North Carolina in 2002 (shaded in green).

Production Practices:

Most small grains are grown under conventional tillage with no-till acreage increasing slightly every year. Wheat planting dates vary from late September to early November depending upon region. Other planting dates expand this time frame by a week on each extreme.Frost and Hessian flies are factors in planting time.

Soil types vary greatly across the regions and irrigation is generally not used. At-plant nitrogen is usually needed with additional added as needed. Fifteen to 30 pounds of nitrogen per acre are needed.Liming is required based on soil testing.The target pH is 6.0 for mineral soils, 5.5 for mineral-organic soils, and 5.0 for organic soils. Animal waste is sometimes used in small grain fertilization. Regional differences include soil types, temperature and planting dates, Hessian fly pressure, fertilization, and liming requirements.Poorer soil type regions may utilize grains only for crop rotation purposes and on-farm livestock use. Production is much different from that in Midwestern states.

Current North Carolina Cooperative Extension Service recommendations for pesticide use on small grains are provided in the following tables in the *North Carolina Agricultural Chemicals Manual*:

Table 5-3. Insect Control in Grain Sorghum (http://ipm.ncsu.edu/agchem/chptr5/503.pdf)

Table 5-4. Insect Control in Small Grains (http://ipm.ncsu.edu/agchem/chptr5/504.pdf)

Table 6-1. Foliar Fungicides for Wheat Leaf Disease Control (http://ipm.ncsu.edu/agchem/chptr6/601.pdf)

Table 6-2. Seed Treatment for Wheat Foliar Disease Control (http://ipm.ncsu.edu/agchem/chptr6/601.pdf)

Table 8-1. Chemical Weed Control in Wheat, Barley, Oats, Rye, and Triticale(http://ipm.ncsu.edu/agchem/chptr8/806.pdf)

Table 8-1. Chemical Weed Control in Sorghum (http://ipm.ncsu.edu/agchem/chptr8/807.pdf)

Table 8-21. Weed Response to Herbicides - Small Grains (http://ipm.ncsu.edu/agchem/chptr9/909.pdf)

Worker Activities

October: Worker on a tractor makes three passes over the field for tillage. In no-till wheat worker makes one pass over the field to bush-hog, and then a second pass over the field to spray a burn-down. In all tillage systems, one more pass is made to apply fertilizer.

October-November: Worker on a tractor makes one pass over the field to drill in seed.

November-December-January:Most wheat fields are ignored. With a small percentage (less than 10%) of fields, a worker may make a single pass to apply Hoelon for ryegrass control, or Warrior for Hessian fly control.

February-March: Worker on a tractor applies a broadleaf herbicide to all fields. Topdress N is applied to all fields. Sometimes this is done as a single pass using a tank mix. Sometimes it is done as two distinct passes.

April-May: About 30% of wheat fields are sprayed in a single pass with an insecticide for cereal leaf beetle. A small percentage of fields (less than 10%) get a single pass for a fungicide application.

June: A worker drives over the field once with a combine. Another worker drives a truck to haul away the grain.

Insect and Mite Pests

The two main insects that routinely create problems for growers are cereal leaf beetles and aphids. Cereal leaf beetles have spread into all areas of the state, making it the most serious insect pest of small grain statewide.Mild winters allow high aphid populations to develop, leading to increased yield loss due to plant infection by barley yellow

dwarf virus, an aphid-transmitted plant pathogen.Other insect pests of small grains include armyworms, fall armyworms, Hessian flies, and grasshoppers.

Cereal Leaf Beetle

The cereal leaf beetle (CLB) is North Carolina's most important insect pest of small grains. Because CLB is a pest early in the growing season when weather conditions can be quite variable, timing of control measures can be difficult. The key to managing this pest lies in understanding its biology in North Carolina and using this information along with field observations to determine when and where treatment may be necessary. New, but labor-intensive treatment thresholds, are available to growers.

Adult cereal leaf beetles overwinter in protected areas such as ground litter or debris along the edges of fields. They usually appear in small grain fields around mid-April but may appear earlier, particularly with mild winter temperatures.The appearance of adults indicates that egg laying will begin in 7 to 10 days. Adult feeding at this time has little impact on the plants. Peak egg laying usually occurs in late April to early May.The eggs hatch in a few days into slug-like yellow larvae that cover their bodies with a black globule of mucus and fecal matter as they grow. The major damage to small grains results from larval feeding on young leaves, especially the flag leaf, which is critical to proper grain head filling.As is the case with many insect pests, temperatures and weather greatly influence the insect's activity, which in turn affects our ability to manage it. Oats are slightly more susceptible to CLB than the other grains.

Insecticides:

- Organophosphates:
  - Azinphos-Methyl (Guthion, Sniper): Rarely recommended and generally not used.
  - Malathion: Effective. Other alternatives available. Light to moderate usage (5% of acreage).
- Carbamates:
  - Carbaryl (Sevin): Very useful for cereal leaf beetle. Slightly de-emphasized where mites and aphids are also a problem due to subsequent outbreaks. Essential for triticale.
  - Carbofuran (Furadan): Used in the Piedmont when long residual is needed (5% of acreage).
- Pyrethroids:
  - Lambda-cyhalothrin (Warrior T): New use for this insecticide (approximately 30% of acreage).
  - Meta-cypermethrin (Fury, Mustang Max): Available, but low usage (less than 1% of acreage).

Aphids

There are four species of aphid commonly found in grains in North Carolina.The corn leaf aphid is found on a variety of grains and grasses. With this aphid, injury seldom reaches economic levels.The greenbug is also found on a variety of grain hosts and can cause discoloration and stunting of plants due to injected toxins. Fortunately, it is not common in large numbers.

The two predominant species, bird cherry-oat aphid and English grain aphid do not inject toxins and plants appear to tolerate large infestations to foliage without economic loss. Heavy grain head feeding, especially by English grain aphid may reduce yields and populations should be monitored.

It is the spread of barley yellow dwarf virus (BYDV) by aphids, however, that concerns growers the most. Aphids infest grain in the fall and are active as long as temperatures remain above 50 degrees F, even when they are exposed to periodic freezing temperatures. All grains to some extent, but early-planted small grains in particular, are at risk of infection by BYDV if fall aphid populations are actively migrating into and within fields. Therefore, very early planting is discouraged, especially on farms where BYDV has been a problem. Thresholds for treating aphids in the fall are much lower than in spring. Early infection with BYDV (i.e., infection in the fall) may suppress yield significantly, whereas the spread of BYDV in the spring may produce relatively little yield loss.

In prior years, growers sometimes used Di-Syston at planting time on early-planted small grains or when spraying fall aphids if populations exceeded the threshold. This method may help to improve yield, however, tests have shown poor correlation between BYDV suppression and fall insecticide treatments. Gaucho (imidacloprid) and Cruiser (thiamethoxam) seed treatment have shown to reduce early aphid feeding and hence BYDV infection. Late planting seems to have a positive effect at reducing BYDV infection.

Insecticides:

Insecticides are not used for aphids in normal years. A few growers may treat for aphids in occasional years.

- Organophosphates:
    - Chlorpyrifos (Lorsban): Not registered in North Carolina.
        - Dimethoate: Not used.
        - Malathion: Useful. Less than 1% of acreage treated on rare years.
    - Methyl Parathion (Penncap-M): Effective, but generally not used.
    - Disulfoton (Di-Syston): Helpful against BYDV. Generally not used.
- Pyrethroids
    - Lamda-cyhalothrin (Warrior T). Generally not used.
- Chloro-nicotinyl
    - Imidacloprid (Gaucho), Seed treatment. Effective.Generally not used.
- Neonicotinoid
    - Thiamethoxam (Cruiser). Seed treatment. Generally not used.

Armyworm

The armyworm (or true armyworm) occurs across the state, but economic infestations in small grains have usually been confined to the middle and northern tidewater regions. In recent years, as farmers continue to grow thicker stands of leafy grains, armyworms have become more difficult to control with insecticides because of coverage and weather problems.Consequently, farmers are advised to time insecticide applications to coincide with armyworm activity and to use higher application volumes (5 gallons per acre, by air) in thick grains.Armyworms are nocturnal and active in temperatures above 60 degrees F. Treating in the late afternoon on warmer days may be beneficial.

Insecticides:

Normally, insecticides are not used. Three to five percent of growers may use an insecticide for armyworms in occasional years.

- Organophosphates:

    - Malathion: Helpful. Used on 1 to 2% of acreage.
    - Methyl Parathion (Penncap-M): Effective. Used on 1 to 2% of acreage for occasional pests.
    - Ethyl Parathion (Parathion): No longer used.
- Carbamates:
    - Carbaryl (Sevin): Very useful. Used on 2 to 3% of acreage for occasional pests.
    - Methomyl (Lannate): Important. Used on 1% of acreage for occasional pests.
- Pyrethroids:
    - Lamda-cyhalothrin (Warrior T): Useful. Light usage on occasional pest.
    - Zeta-cypermethrin (Mustang Max, Fury): No known usage.
- Other:
    - Spinosad (Tracer): Recent registration for this pest. No usage.

Hessian Fly

Hessian fly is a sporadic pest and increasingly common.It is a larger problem in the southern and southeastern regions where late planting and use of fly-free dates is not practical.It is also a problem in the Piedmont when cultural practices support its development. Problem fields are often unrecognized.

For those with a persistent Hessian fly problem, high-risk situation, or susceptible variety, Gaucho (imidacloprid) seed treatment or Di-Syston (disulfuton), at planting are the best available tools. Current research indicates Warrior may be a viable rescue treatment and provide protection from additional oviposition if thresholds are low and timing is correct. Varietal research has provided some strains less desired by our Biotype-L fly.

Insecticides:

- Organophosphates:
    - Phorate (Thimet): Possible use at-plant.
    - Disulfoton (DiSyston) at-plant. Not used.
- Chloro-nicotinyls:
    - Imidacloprid (Gaucho).Seed treatment. Normally not used (on less than 1% of acreage in infrequent years).

Fall Armyworm and Grasshoppers

Fall armyworm and grasshoppers are occasional and sporadic pests of small grains in late summer and fall. When favorable environmental conditions occur, these pests may move from other crop ecosystems into small grains and require an insecticide treatment of the field border or the crop itself.

Insecticides:

- Carbamates:
    - Methomyl (Lannate): Used on less than 1% of acreage in occasional years.
    - Carbaryl (Sevin): Used on less than 1% of acreage in occasional years.
    - Carbofuran (Furadan): Not generally used.
- Organophosphates:
    - Malathion: Used on less than 1% of acreage in occasional years.

- Pyrethroids:
    - Lambda-Cyhalothrin (Warrior T) and others (Fury, Mustang Max): Used on less than 1% of acreage in occasional years.
- Others:
    - Spinosad (Tracer): New registration. Not used.

Cultural Control Practices:

Varietal testing and breeding for resistance to cereal leaf beetle are currently being conducted. Recent refinement of thresholds for cereal leaf beetle better define when pesticides are needed.

Biological Control:

The North Carolina Department of Agriculture and Consumer Services has been supporting efforts to establish larval and egg parasites of the cereal leaf beetle for the last fifteen years. While similar programs have been successful in other states, success in North Carolina has been limited and depends on a better understanding of the interactions between parasite biology and the diverse agronomic conditions and practices that are found across the state. Collaboration with the USDA and different parasite strains may lead to greater success.Also, insecticides that are currently used against CLB are incompatible with biological control since they also reduce parasite populations. Commercially available biological insecticides that might be effective against CLB and would not impact on parasites are not registered for use on small grains.

Biological control does not provide an immediate or complete solution to the problem with CLB. Time is required for parasites to become established in the field and to begin effective control of pest populations. North Carolina chemical control recommendations are available in the North Carolina Agricultural Chemicals Manual.

Other Issues:

Restrictions based on ability to give this commodity to people or animals as feed or hay, limit choices of chemicals for control of these pests.The chemicals available are not labeled across the board for all grains such as wheat, barley, rye, triticale, oats, sorghum, or for uses such as feed versus hay.

Diseases

Small grain diseases vary in intensity and severity each year depending on the weather, cultural practices, the variety of small grain grown, and the presence of a disease-causing agent. Efficient disease management requires that growers anticipate problems well in advance. For example, planting disease resistant varieties in the fall will minimize disease problems the following spring and summer. Proper crop rotations will also reduce the likelihood of disease occurrence in the future.

Small grain fields need to be monitored during the season to detect any developing problems. Growers need to familiarize themselves with weather conditions that favor diseases to aid in determining when to scout fields or apply crop protection chemicals. To apply disease control measures logically, growers must know which diseases are in their fields and their severity. County Cooperative Extension Service agents provide further information on small grain disease identification, scouting techniques, and a list of resistant varieties suited for each production area.

Common Diseases of Small Grains in North Carolina

Barley Yellow Dwarf Virus (BYDV)

This is the most important virus disease of wheat (also oats, barley and rye) in North Carolina. Barley yellow dwarf virus is most likely to occur after a warm fall and mild winter that favor grass (alternate host), cereal growth, and aphid multiplication. Symptoms are often overlooked or thought to be nutritional problems. Leaves are discolored in shades of yellow, red, or purple, especially from the tip to the base and from the margin to the midrib. Plants are stunted if infected early in the fall and are progressively less stunted if infections take place as the plant matures. Infected plants are normally found in small areas that are usually only a few feet in diameter. The virus is transmitted by aphids from grasses such as orchard grass, tall fescue, ryegrass, and others. It must survive in a living host and cannot live in plant debris or the soil. The oat-bird cherry aphid and English grain aphid are the most important in the fall and spring respectively. Aphids overwintering on corn are believed to be an important vector of the disease. The greenbug aphid is not a transmitter.

Controlling aphids with insecticides after infestation has not proven to be effective against BYDV. Use of Gaucho seed treatment has been shown to be a relatively effective preventive control for BYDV by reducing early aphid feeding. Growers in areas with a history of BYDV avoid planting varieties that are known to be susceptible to this disease. Oats are the most susceptible small grain. The little available information about wheat and barley resistance by variety is given in Table 1.

Table 1. Resistance to barley yellow dwarf virus by wheat and barley varieties.

Wheat Varieties	
Very Susceptible	FFR 555, AgriPro Marion, AgriPro Shelby, AgriPro Patton, Wakefield
Moderately Resistant	Madison, NK Coker 9835, AgriPro Hickory, NKC 9663, Roane
Resistant	NKC 9663
Barley Varieties	
Moderately Susceptible	Boone
Moderately Resistant	Callao, Nomini, Pennco, Starling, Wysor

Septoria Glume Blotch

Symptoms may occur at any time during the growth of the plant and on any portion of the plant. Lesions are round to lens shaped and are found on the oldest leaves first. Lesions begin with a water soaked appearance, later drying to have a yellow or red-brown color. Tissue death eventually extends beyond the lesion; sometimes the entire leaf is killed. A diagnostic feature in older lesions is small dark "pimplelike" spots known as pycnidia. The fungus is dispersed by windblown rain. Wet windy weather that favors spore dispersal increases the severity of this disease. Dry periods not only prevent infections, but halt disease development. Rotations away from small grains for at least three years and seed treatments, which control seedborne Septoria have been shown to be effective disease control measures.

Chemical Controls:

- Dithio-carbamate:

- Mancozeb fungicide; not used in normal years.

Loose Smut

Loose smut symptoms occur between heading and maturity. At first, diseased heads are blacked and clearly visible among newly emerged green, healthy heads. Infected heads emerge slightly earlier than normal and have their spikelets, except for a delicate membrane, entirely transformed into a dry olive-black spore mass. The membrane tears easily as heads emerge, and once the spores are dispersed by wind, all that remains is the stem or rachis (stem of the head). Infections occur only during flowering and are favored by wet weather and cool to moderate temperatures (61 to 72 degrees F). Within one week after flowering, the ovary and attachments become resistant. Infected seed do not appear abnormal. The fungus that is found inside the embryo of the seed will grow within the seedling when these seeds are planted and begin to germinate. Only after seed heads emerge from plants, which came from infected seed are the smutted grains seen. Therefore, infection that takes place in one year is not seen until plants from the infected seed mature in another year.

Powdery Mildew

Lesions are first noticeable as white, powdery spots on the lower leaves and stems. As the lesions mature they become darker, sometimes salmon colored with black spots (perithecia). If there is a heavy infestation, clouds of white spores can be seen as you walk through the wheat. Spores are dispersed by wind. High humidity (with or without rain) and cool temperatures (59 to 72 degrees F) favor disease development. The disease is markedly retarded above 77 degrees F.

Root Rots and Seedling Diseases

Some areas of a field may be sparsely populated with wheat. This may first be noticed as a weedy area. Seedlings will be rotted or will have lesions and be generally unthrifty. Root rots cause plants to be stunted, wilted, and/or discolored. The roots will have an unhealthy, darkened appearance. The fungi that cause these problems are rather common in most fields; therefore, dispersal is not as important as with other diseases. Exceedingly wet and cool weather favors root rot. Any conditions that retard seed germination can result in seedling disease.

Rust

Lesions are small, circular, and vivid orange-red in color. They may occur on stems, but are most common on the upper surface of the leaves. When heavily infected, the whole leaf will die. Winds can carry rust spores for great distances. Rapid development occurs between 59 to 72 degrees F when moisture is not limiting.

Scab or Head Blight

Scab is seen as prematurely bleached heads or spikelets. If the rachis is infected, everything above that point will be faded. Small dark spots (perithecia) and superficial pink or orange fungal growth (mycelium and spores) can be seen at the base of the spikelets. Only partly filled seed will be found in the infected spikelets. The fungus is spread by air currents. Moist, warm (77 to 86 degrees F) weather favors scab.

Table 2. Diseases and Management Methods

Disease	Management Methods
Scab (Fusarium blight)	1. Apply seed treatment. 2. Lengthen rotation (do not plant wheat after 3. Plow under infected residue to hasten decomposition 4. Do not spread manure that contains corn stalks.
Rust (leaf)	1. Plant resistant varieties 2. Plant Late 3. Use foliar fungicides 4. Apply resistant varieties
Scald	1. Rotate with crops other than barley 2. Destroy crop residue by plowing or burning 3. Plant resistant varieties
Helminthosporium leaf spot	1. Plow down residue before planting
Wheat soilborne mosaic virus	1. Rotate with crops other than wheat 2. Plant resistant varieties
Oat soilborne mosaic virus	1. Plant resistant variety (Coker 716 is resistant; Brooks is very susceptible; others susceptible)
Poor plant color	1. Good growing conditions or correction or fertility imbalances (not due to appearance)

Disease Control

Cultural Practices:

Cultural practices such as rotation, burying plant residue, and following soil pH and fertility recommendations aid in keeping plants healthy. However, growers who take the "maximum yield" or intensive management approach, which includes heavy seeding (greater than 2 bushels per acre), narrow row spacing (less than 7 inches), and high nitrogen rates (greater than 120 pounds per acre), are likely to have more disease problems than growers who do not use these practices. The benefit from this approach is higher yield. The drawbacks seen are higher production costs and, frequently, greater disease loss.

Resistant Varieties:

Resistant varieties are an important tool in small grain disease management. Breeding for resistance has been very

successful for control of some important small grain diseases. A list of resistant varieties for specific diseases is available in North Carolina Measured Crop Performance, Small Grains (also available from the Official Variety Testing, Department of Crop Science, Box 8604, North Carolina State University, Raleigh, North Carolina 27695-8604). Because of changes in the fungi that cause some small grain diseases, resistant varieties often become susceptible over a few years. Therefore, it is very important that growers remain knowledgeable about the disease resistance found in new varieties, as "old favorites" may become too diseased.

Seed Treatments:

There are many different seed treatments available for wheat. Most seed treatment ingredients are fungicides, but some are insecticides. Each ingredient has certain strengths and weaknesses that may determine the particular rates used. These treatments can be very beneficial in certain cases. Specific information is available in the Seed Treatments chapter in the 2004 Small Grains Production Guide.

Chemical Controls:

- Dithio-carbamate:
  - Thiram fungicide
- Other:
  - Dividend (Difenoconazole + mefenoxam), Raxil (Tebuconazole), and Raxil-Thiram are commonly used.Gaucho-Raxil is becoming more widely used.Three to five percent of the seed is treated with a fungicide.

Foliar Fungicides:

Fungicides are applied to protect the flag leaf and head from disease damage. This may require applications as early as Feekes Growth Stage 6 (first node) or as late as stage 10.1 or head emergence. Although fungicides are sometimes sprayed on small grains to help control foliar diseases, net profit is increased only if the amount of disease controlled produces more income than the treatment costs. Some of the considerations that North Carolina growers use in determining whether to spray fungicides are:

1. Yield potential: Fields should have a high-yield potential (50 bushels of wheat per acre or more) for sprays to be profitable.
2. Fertility level: 100 to 120 pounds of nitrogen or more increases the chance for disease loss.
3. Susceptibility: Resistant varieties are much less likely to need fungicide application than susceptible ones.
4. Weather: Review the environmental conditions that favor disease, and compare these to the short and long-term weather forecasts to predict the likelihood of continued disease development.
5. Field location: Some fields cannot be sprayed by air, and tractors cause yield loss when traveling over jointing grain. Therefore, susceptible varieties should not be grown in these areas because of the difficulty in spraying them.
6. Seed treatment: The use of Baytan seed treatment will reduce the amount of powdery mildew during the fall and winter, resulting in less disease the following spring. Baytan also controls smut disease. Baytan must be applied by a certified seed conditioner. It is not currently labeled for on-farm or hopperbox use.
7. Thresholds: Scouting information is used to help time foliar fungicide applications. Scouting procedures are discussed below.

Table 3. Fungicide thresholds for diseases of small grains in North Carolina.

Disease	Comments
Leaf Rust*	Apply fungicide only when rust covers 1 to 3% of area of upper leaves.
Powdery Mildew*	Apply fungicide only when rust covers 5 to 10% of area of upper leaves.
Septoria	If 25% of the indicator leaves have one or more lesions, then a fungicide application is indicated. Indicator leaves are: Feekes Growth Stage 6-8: Flag 4, and Flag 5. Feekes Growth Stage 8-10: Flag 3. Feekes Growth Stage 10-10.51: Flag 2. Feekes Growth Stage 10. 52-11: Flag 1.

* When spraying for Powdery Mildew or Rust **always** apply a fungicide that is efficacious against Septoria.

Scouting Procedures:

Beginning in mid-March, fields are scouted on a weekly basis to check for disease occurrence. Care is taken to correctly identify the disease. The following steps are used as a guide in developing the scouting procedure.

1. Review field history with grower. Record fields that have had chronic disease problems. Make sure to check for these diseases when scouting.
2. Scout weekly starting in mid-March. Check the most disease-prone locations first. Foliar diseases tend to be worse in thick growth. Often row ends where seeding and fertilizer rates are inadvertently high have the heaviest disease pressure. Soilborne viruses often occur in low, wet areas.
3. Identify all diseases present as soon as possible. Some diseases increase quickly (e.g., rust) and must be dealt with in a prompt manner. Multiple diseases sometimes require different control measures.
4. Map the affected areas to help determine where treatments should be carried out, to accurately monitor disease increase, and to plan for the future.

Disease Summary:

Successful disease management requires skillful planning and foresight since few postplanting practices are useful. Disease management is inseparable from plant production practices such as soil fertilization management, seedbed preparation, and rotation. Resistant varieties and other cultural control practices are the best means of controlling diseases. Awareness of varieties that are currently resistant is an important part of preplant planning. Intensive management increases the likelihood that foliar fungicides will be beneficial. However, the use of foliar fungicides will not normally pay in North Carolina under the prevailing economic conditions. Triadiminol (Baytan) seed treatment is a practical way to achieve fall and early spring chemical protection from smut and powdery mildew, as it is relatively inexpensive and effective. The majority of growers use resistant varieties and a few growers use some type of seed treatment.

Chemical Control:

- Carbamates:
  - Benomyl (Benlate): No longer recommended

- Dithio-carbamates:
  - Maneb: Not used in North Carolina.
  - Thiram: Fungicide and seed protectant. The standard for seed protection in North Carolina. Used on 30% of all treated seed.

Table 4. Foliar fungicides for wheat leaf disease control in North Carolina.

Disease	Chemical (Chemical Class)	Comment
Septoria leaf blotch	Mancozeb (dithio-carbamate)	Minor use. Propiconazole is possible alternative.
Septoria glume bloth	Mancozeb (dithio-carbamate)	Minor use. Propiconazole is possible alternative.
Tan spot	Mancozeb (dithio-carbamate)	Minor use. Propiconazole is possible alternative.
Helminthosporium	Mancozeb (dithio-carbamate)	Minor use. Propiconazole is possible alternative.

Weeds

Weeds reduce yield and quality in small grain. Effective weed management programs involve planting grain that is free of weed seed and garlic bulblets, using good seedbed preparation and proper fertilizations, seeding at the proper time and rate, planting in narrow rows, and applying herbicides when needed.

In North Carolina, weeds that most often interfere with small grains are winter annuals, which germinate in the fall or early winter, and perennials such as wild garlic and curly dock. Winter annuals include broadleaf weeds and annual (Italian) ryegrass. One of the best tools for suppressing weeds in small grains is a healthy, vigorous crop. A shallow tillage before seeding will often kill germinating weed seeds and existing plants. For no-till, a burndown herbicide is recommended if weeds are present in the field at planting. If weeds germinate later, a postemergence herbicide is sometimes used.Good management practices are used to minimize the effects of weeds in small grain production.

Chemical Herbicides for Small Grains

2,4-D

Low rates can injure some plants, so caution is used to prevent drift to nearby crops. The herbicide 2,4-D has been used many years and is marketed in a variety of chemistry types (acid, esters, amines, and salts) and formulations. One problem is that, although it appears two companies market identical 2,4-D types, they contain varying amounts of surfactants, compatibility agents, and emulsifiers. There are not any good guidelines. Without personal experience, the grower must assume the lower cost formulations contain smaller percentages of these additives. If formulations do not contain surfactants, it is recommended to add them to the spray mixture for improved control.

Different formulations of 2,4-D are labeled for use in wheat and other winter crops. The esters are somewhat more effective in controlling weeds than are the amine salt or acid formulations. Since esters tend to be more soluble in

oily or organic substances, they are able to penetrate waxy leaf surfaces more quickly and are not as easily washed from plant surfaces by rainfall. Their ability to evaporate a little faster aids entry into leaf pores. Common ester forms include butoxyethanol, 2-butoxyethyl, butoxypropyl, butyl, ethyl, isoctyl, and isopropyl esters. The various esters are about equal in providing control, but the volatile forms (ethyl, butyl, and isopropyl) are more likely to evaporate under hot temperatures and move from the sprayed area, causing injury to nearby susceptible plants.

At least 15 different salts are available in formulations. At least one formulation is available as an oil soluble amine and provides somewhat better plant entry and control than do the regular amine formulations. Rates vary between 0.25 and 1.0 pounds active per acre. Higher rates are used only for difficult perennial weed problems or resistant annual weeds.

Dicamba

Low rates of dicamba can injure some plants, so caution is used to prevent drift to nearby crops. Dicamba is sold under the trade name Banvel and contains 4 pounds per gallon dicamba. It is applied alone or as a tank mix with either 2,4-D amine or ester to provide wider spectrum weed control. Tank mixtures with high rates of 2,4-D sometimes cause some crop injury.

Diclofop

Diclofop is sold under the trade name Hoelon. It is applied pre- or postemergence to wheat, but only postemergence to barley. Hoelon is used for ryegrass control and control of a few other winter grasses especially when applied at higher rates as a preemergence treatment. Hoelon cannot be applied to oats because it causes severe injury. Thorough and uniform spray coverage of ryegrass is necessary for good control. Rainfall is needed within seven days of application for best preemergence control.

Symptoms on ryegrass are slow to develop and depend on how fast growth is occurring. It is not uncommon for 10-14 days to elapse before symptoms begin developing. Strains of ryegrass that are resistant to Hoelon are found in many parts of the southeast. If resistant strains are observed in a field, Hoelon is discontinued.

Prosulfuron

Prosulfuron is marketed as Peak herbicide. It is rated good to excellent for control of wild garlic, wild mustard, wild radish, field pennycress, shepherdspurse and cutleaf eveningprimrose. Peak is not very effective on henbit or chickweed. It is sometimes tank-mixed with 2,4-D or dicamba to provide broader spectrum control. It is also mixed with nitrogen solution for application. Peak performs best when applied on days when temperatures are expected to reach 50 degrees F or higher. Peak has a 10-month rotation restriction for soybeans, cotton, peanut, and tobacco.

Thifensulfuron-methyl + Tribenuron-methyl

Thifensulfuron-methyl + tribenuron-methyl is marketed under the trade name Harmony Extra. Harmony Extra is used for control of wild radish and wild garlic. It is also used for many broadleaf weeds such as dock, thistle, chickweed, buttercup, and wild turnip. It is applied after harsh winter temperatures have ended and wild garlic plants are less than 12 inches tall and new crop growth is 4 to 6 inches. Several hours of dry weather are needed after application. When liquid nitrogen is used as the carrier, early temporary yellowing or stunting of the small grain sometimes occurs, especially if the temperature is high. It is recommended to reduce the rate of surfactant as instructed on the label when liquid nitrogen is used as the carrier, to avoid small grain damage. Visual effects on

weeds from Harmony Extra are not be evident for three to five weeks after application, but weed competition is reduced quickly after spraying.

Special Considerations for No-Till Small Grains:

In a no-till system, weed control at planting is critical. In a conventionally planted small grain crop, newly germinated weeds are destroyed during land preparation. In no-till, winter annual weeds (chickweed, henbit, and knawel) are up and growing at planting time. Unless controlled, they will be very competitive with the emerging small grain for nutrients, sunlight, and moisture during fall and early winter.

Emerged weeds are controlled by applying 1.5 pint per acre of Gramoxone Extra after planting but before small grain emergence. A higher chemical rate is sometimes needed for a dense weed population, cool or cold growing conditions, or drought.

Roundup Ultra or other glyphosate formulation are also used at the rate of 0.5 to 2.0 quart per acre. The low rate is effective on winter annuals less than 2 inches tall. For taller annuals, a higher rate is recommended.Both Gramoxone and glyphosate are used with a spray adjuvant to be effective. Adjuvant concentration is dependent on several factors such as weed growth stage.Fan-type nozzles are recommended with 10 to 40 gallons of water per acre. Low glyphosate rates are more effective when applied in 3 to 10 gallons of water per acre.

When few or no weeds are present at planting, weed control measures are postponed until after the small grain reaches the two-leaf stage. For postemergence control of small winter annuals and wild garlic, Harmony Extra is recommended at 0.3 to 0.4 ounces per acre. Good timing is stressed for fall weed control. Winter annuals quickly get too large to control easily and cause substantial yield reductions.

Early spring weed control is the same for no-till systems as for conventional-till small grain systems. Fields are inspected to determine what weeds are present and if a chemical weed control treatment is necessary.

Special Considerations about Herbicide Resistance:

Herbicide-resistant weeds survive and grow normally at dosages that usually control the weed effectively. Resistance results from a change or genetic shift within a population that impairs control in the field. An herbicide-resistant weed may be present initially in a field in very small numbers within the weed population (perhaps one in a billion or less). As selection pressure, from the continued use of the same herbicide or herbicides with similar modes of action (same herbicide group), acts on the weed population, there will be a shift in the overall weed population from susceptible weeds to resistant weeds. This occurs because the resistant weed population is allowed to set seed and flourish under conditions of reduced competition due to the continued control of the susceptible weed population.

Recommendations to avoid or delay the build up of herbicide resistance include a rotation of herbicides with different modes of action. The use of a good crop rotation helps make alternative herbicide selection easier. Cultural control methods such as the use of weed-free seed and tillage are utilized to combat herbicide resistance. Herbicides are recommended only when needed. Weeds are tolerated in a crop if they are below levels that cause economic damage. Growers are encouraged to keep good records of herbicide applications on a per field basis in order to help in rotating herbicides.

If weed resistance to an herbicide is suspected, growers first check that the problem is not a result of adverse environmental conditions, spray timing, rates, application procedures, or a late flush of weeds. Herbicide resistance

is suspected when:

* Weed escapes occur in irregular shaped patches.

* Weeds previously controlled by a herbicide escape treatment, while other labeled weeds are controlled.

* Grower records show repeated use of the same herbicide or group of herbicides.

* Grower can't attribute escapes to environmental conditions or (with postemergence products) weed emergence after application.

* The same herbicide or herbicide group failed in the same area of the field in the previous year.

Special Considerations for Wild Garlic Control:

Wheat infested with garlic lowers producers' returns. Aerial bulblets of wild garlic harvested with the grain give flour products a garlicky flavor. “Garlicky” wheat fed to dairy cows can cause off flavor milk and milk products. Even when the bulblets are removed, an odor of garlic often remains. A combination of adequate nitrogen fertilization and herbicide application is needed for garlic control.

For many years, infested wheat fields at the fully tillered stage have been treated with 2 pints of 2,4-D per acre. Low volatile esters of 2,4-D are more effective in controlling garlic. These, however, are not recommended for use near susceptible crops or plants. This amount of 2,4-D does not effectively kill wild garlic, though the production of aerial bulblets is reduced. Also, the tops of garlic plants are sometimes bent down so that a grain combine is set high enough to pass over them without picking up garlic bulblets. Banvel, at a rate of 0.25 pint per acre, is sometimes added to the 2,4-D. Control has been variable from year to year. Weather conditions and size of the wild garlic influences the degree of control. Spraying wild garlic when 6 to 8 inches tall seems preferable for control.

Harmony Extra provides more effective wild garlic control when wild garlic is less than 12 inches tall with 2 to 4 inches of new growth. Harmony Extra is applied at 0.5 ounce per acre with a non-ionic surfactant of at least 80 percent active ingredient at 2 pints per 100 gallons of spray solution. Typical symptoms of dying wild garlic plants (discoloration and collapse) may not be noticeable for three to five weeks. The above rate will also control a number of common winter annual broadleaf weeds. However, if the goal is to control only winter annual broadleaf weeds, the rate is reduced.

Peak is also very effective against wild garlic at rates of 0.25 to 0.5 ounces per acre. Non-ionic surfactant is added to the spray solution at 1 quart per 100 gallons of water or liquid nitrogen.

Special Considerations for Ryegrass Control:

Ryegrass is extremely competitive with wheat and barley and can greatly reduce yields. Hoelon selectively controls annual (Italian) ryegrass. Hoelon is applied preemergence in wheat only.

For postemergence control in wheat and certain barley varieties, Hoelon is applied when the ryegrass is in the two to five-leaf stage. Hoelon is less effective on ryegrass beyond the five-leaf stage and does not control broadleaf weeds. When spraying wheat, crop oil concentrate is sometimes added to the water carrier at 1 to 2 pints per acre. For postemergence applications in barley, only a water carrier with no crop oil concentrate is used. Hoelon is not readily

translocated, so thorough spray coverage is recommended. Hoelon and liquid nitrogen are not tank mixed. Hoelon may be tank mixed with Buctril (a restricted use pesticide) for broadleaf control. However, Buctril is not effective on several of the most common winter annual broadleaf weeds found in North Carolina small grain fields. It is suggested that Hoelon and Harmony Extra should not be tank mixed for application in North Carolina. Hoelon is also never tank mixed with 2,4-D or Banvel. 2,4-D or Banvel are not used within five days of applying Hoelon because it would reduce ryegrass control. Hoelon acts slowly. Ryegrass appears reddish or brown and withered within two to three weeks.

Chemical Controls:

- Organophosphates:
  - Bensulide (Betasan): Not used in North Carolina.
  - 2,4-D: Generally not used (less than 1% of the acreage).
- Benzoic acids:
  - Dicamba (Banvel): Generally not used.
- Aryloxyphenoxypropionics:
  - Diclofop (Hoelon): Generally not used.
- Triazinylsulfonylureas:
  - Prosulfuron (Peak): Generally not used.
  - Thifensulfuron-methyl + tribenuron-methyl (Harmony Extra): Used on 95% of acreage (spring).
- Amine salts:
  - Glyphosate (Roundup Ultra): Used on 20% of acreage.
- Bipyridylium:
  - Paraquat (Gramoxone Extra): Generally not used.

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On-Line Resources

1. Small Grain Production Guide (http://www.smallgrains.ncsu.edu/Guides/Guides.html)
2. Small Grain Acreage, Yield and Production Report (http://www.agr.state.nc.us/stats/crop_fld/fldsgryr.htm)
3. Ranking of Major North Carolina Farm Commodities (http://www.agr.state.nc.us/stats/cashrcpt/commrank.htm)
4. Managing Cereal Leaf Beetle in Small Grains and Corn (http://www.ces.ncsu.edu/depts/ent/notes/Grain/smg_3.html)
5. The Hessian Fly: A Pest of Wheat In North Carolina (http://www.ces.ncsu.edu/depts/ent/notes/Grain/Hessian/HflyAG-368.html)
6. Scab Management Recommendations (http://www.smallgrains.ncsu.edu/Alerts/ScabAlert.html)
7. North Carolina Wheat Variety Characteristics (http://www.smallgrains.ncsu.edu/Varieties/Varieties.html)
8. Scouting Small Grains in North Carolina (http://ipm.ncsu.edu/grain/smgrain521.html)
9. North Carolina Agricultural Chemicals Manual (http://ipm.ncsu.edu/agchem/agchem.html)
10. Pesticides and Wildlife- Small Grains (http://ipm.ncsu.edu/wildlife/small_grains_wildlife.html)

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