Lawn Diseases

David S. McCall, Assistant School of Plant and Environmental Sciences, Virginia Tech

Overview

There are many diseases that occur on turfgrasses throughout the world. However, there are only a few diseases that consistently cause major concerns on lawns in Virginia. Diseases of lawn grasses are typically most common in the summertime for cool-season grasses, such as tall fescue or Kentucky bluegrass, or in the spring and fall for warm-season grasses, such as bermudagrass or zoysiagrass. This is largely due to the shift in growth habits of the grasses from active growth to survival, giving a competitive advantage to the pathogens responsible for diseases.

Tall fescue is the most common turfgrass species used in home lawns in Virginia. The most common and troublesome disease for tall fescue is brown patch. Brown patch occurs most frequently during warm and wet weather, but the lawn typically recovers in the fall when managed properly. However, heavy brown patch infestation in conjuction with drought or heat stress can cause total plant loss. Pythium blight and gray leaf spot can also be active at the same time as brown patch. Symptoms often overlap. Consult a professional, VCE Agent, or turf specialist if you are unsure which disease is developing as chemical control recommendations vary by disease.

Gray leaf spot has become increasingly problematic in late summer and early fall during prolonged periods of rainfall in association with warm temperatures. This disease can devastate a tall fescue lawn within a few days if conditions remain favorable for pathogen growth and reproduction. Curative applications for active gray leaf spot will only prevent infection of new plants while infected plants likely will not recover. The timing for severe gray leaf spot outbreaks has coincided with fall overseeding in recent years. This can cause additional problems as seedlings are more susceptible to the disease but are also watered more frequently during establishment.

Spring dead spot is the most common disease for bermudagrass and is most prevalent on intensively managed areas. Symptons include dead patches in the turf that appear in the spring as the turf emerges from winter dormancy. However, the pathogen responsible for this disease is most active in the root zone during the fall and winter. This disease is often unpredictable, but is usually found in high traffic or compacted areas and after severe winters.

General Cultural Controls

- **Fertility:** Turfgrass plants are healthier when steady supplies of nutrients are available, as opposed to spikes in nutrient levels that may result in rapid growth. The ideal time to fertilize is when conditions are optimal for root growth. Optimal conditions are usually in the fall for cool-season grasses and during the summer for warm-season grasses. A good fertilizer has nitrogen sources with around 30% water-insoluble nitrogen. Excessive readily-available nitrogen can increase the likelihood of brown patch, gray leaf spot, Pythium blight, and snow mold development. Conversely, insufficient nitrogen may cause diseases such as dollar spot, rusts, or general leaf spots to be more problematic. Have the soil tested and only apply other nutrients based on soil testing recommendations.
- **Irrigation:** It is impossible to control rainfall, but homeowners do have control over the frequency and duration of lawn irrigation. The ideal time to irrigate for minimizing disease is around sunrise. This decreases the leaf wetness period, which is critical for disease development, and rinses the leaves of dew and guttation water rich in sugars that attract fungi. Watering in the late morning or early evening prolongs leaf wetness and increases the likelihood of disease development. Lawns should not be irrigated excessively where water stands for prolonged periods of time in low-lying or poorly draining areas.
- **Mowing height:** In most cases, turfgrass that is cut too short is more susceptible to disease. Taller cut grasses can withstand more stress and recover faster after disease pressure subsides than turfgrass cut too short. Tall fescue lawns should be between three and four inches, especially during periods of heat and drought stress. Bermudagrass and zoysiagrass should be mowed around an inch and a half to two inches.
- **Air Movement:** Areas with poor air circulation have more turf diseases. Strategic pruning of trees and shrubs is a good way to improve air movement and allow additional sunlight into trouble areas.
- **Sanitation**: Wash mowing equipment to remove infested leaf clippings following each use. Many pathogens can survive on living and non-living plant debris and are later transported to new locations.

General Biological Controls

- **Disease resistant varieties:** Different varieties of turfgrass are susceptible to different kinds of diseases. Choose a variety of turfgrass that has performed well in the National Turfgrass Evaluation Program. Recent cultivar improvements have resulted in lower disease severity with many grasses. Specifically, there are new tall fescue varieties that are resistant to gray leaf spot and have reduced susceptibility to brown patch. Newer cold-tolerant bermudagrasses are less likely to be impacted by spring dead spot. Current varieties recommended in Virginia are available at the following link: http://www.pubs.ext.vt.edu/3008/3008-1456/3008-1456.html.

- **Friendly insects, animals, and organisms:** There are a number of commercially available biological fungicides that may reduce the severity of turfgrass diseases. The majority of these products contain beneficial bacteria or fungi. No biological fungicides tested in Virginia provide complete control of turfgrass diseases. However, several fungicides suppressed diseases, such as brown patch and dollar spot, and aided in turfgrass recovery. The use of biological fungicides in conjunction with other integrated management strategies may result in adequate disease suppression.

When to Call a Professional

It is difficult to determine when turfgrass diseases can be handled at home or if a professional consultation is needed. In most cases, lawns recover with limited damage from disease if the above-mentioned practices are followed. However, when conditions remain favorable for a disease for long periods of time, damage can be quite extensive. Any subsequent stress that prevents the turf from recovering makes the problems worse. For example, if weather conditions remain warm and wet for several days or longer, brown patch can become more severe. In many cases, the turf dies if drought and heat stress follow the warm, wet weather. It is impossible to predict the weather accurately over a long period of time, and it is hard to know, season by season, what weather conditions the turfgrass will endure. Calling a professional may be the right thing to do if weather conditions make turfgrass diseases worse, especially if losing the turf is unacceptable.

Additionally, there are many more fungicides available to control common lawn diseases than what are listed. However, many of these fungicides can only be used by a certified applicator, or are not packaged in small enough quantities for a single homeowner's lawn. If listed chemicals do not provide adequate control or are difficult to find, additional products may be used by turf professionals.

The following table shows the most common active ingredients that can be found by end users at landscape specialty retail centers. Efficacy of each chemical is highly dependent on product formulation, active ingredient use rate, reapplication interval, and environmental conditions.

Table 5.1 - Common Active Ingredients

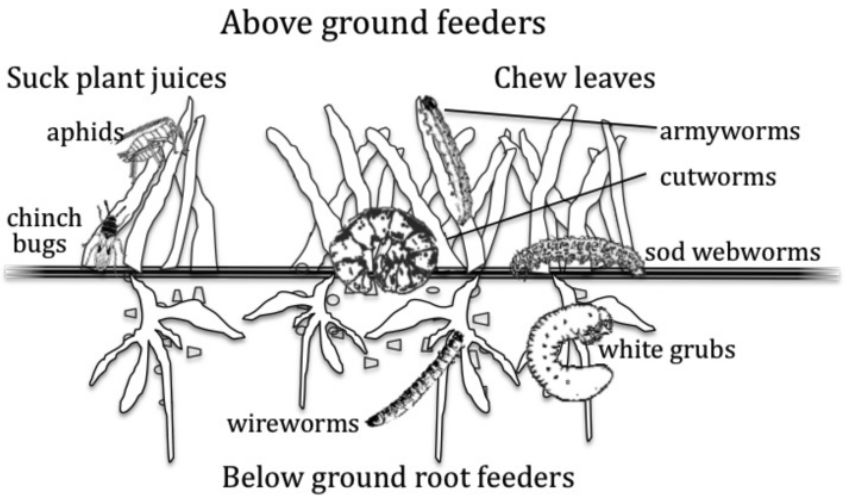
	azoxystrobin	fluoxastrobin	myclobutanil	propiconazole	pyraclostrobin + triticonazole	thiophanate-methyl
Brown patch	+	+	+	+	+	+
Dollar spot	-	+	+	+	+	+
Fairy ring	+	-	-	-	+	-
Gray leaf spot	+	+	-	+	+	+
Large patch	+	+	+	+	+	+
Melting-out/leaf spot	+	+	+	+	+	+
Microdochium patch (pink snow mold)	+	+	+	+	+	+
Pythium blight	+	+	-	-	+	-
Red thread	+	+	+	+	+	+
Rust	-	-	+	+	+	+
Spring dead spot	+	+	+	+	-	-
Summer patch	+	+	+	+	+	+

- *Active ingredient is (+) or is not (-) labeled for control of disease.*
- *If control level is not satisfactory, additonal products are available to certified professional applicators. Refer to PMG Horticulture and Forest Crops.*
- *Concentration of most fungicide active ingredients are much lower with consumer-packaged products than professional products. Application use rates may vary among consumer products. Always carefully read full label instructions before making any pesticide application.*

Timing of chemical applications: For optimal control, most fungicides should be applied preventatively when conditions become favorable for disease development. As noted above, most common diseases of cool-season lawns occur during the summer months; most common diseases of warm-season lawns occur during the spring and fall. When to reapply chemicals depends on active ingredients, product formulation, target pests, and environmental conditions. Systemic fungicides that move acropetally within the plant typically provide control for longer than contact fungicides.

Lawn Insects

Curt Laub, Research Associate, Entomology, Virginia Tech



Overview

The best way to minimize insect pests is to maintain a healthy, dense, stress-free lawn. The occurrence of insect pests usually is sporadic. The damage to turfgrass caused by insect pests is affected in two ways by weather conditions. First, the species of pests found in damaging numbers are dictated to some extent by weather; hot, dry summer conditions favor outbreaks of chinch bugs or sod webworm, while these same conditions during July may significantly reduce white grub populations. Second, the number of pests necessary to cause visible damage depends on the growth rate and general health of the turfgrass; a lawn in good health can tolerate higher numbers of insect pests than one that is water-stressed. Local weather conditions also influence the type of management practices that will be effective against turfgrass pests. For many biological control agents, exposure to hot temperatures or direct sunlight is detrimental, so special considerations must be met when using these methods.

Proper identification and monitoring of pest populations is the best way to avoid unnecessary or ineffective pest management practices. Keeping detailed records of materials and the level of satisfaction with their results can aid a homeowner in year to-year choices of pest management tactics. By following the steps outlined below, homeowners will be able to make informed decisions about pest management that will decrease pest populations and be safe, cost-effective, and environmentally sound:

1. Is the damage is caused by an arthropod pest and not drought, disease, poor soil fertility, or another cultural problem?

2. Identify the pest and learn its life cycle.

3. Monitor for pests to make sure that control measures are necessary. Often, a pest population will not be high enough to justify control measures.

   The drench test described here is for monitoring cutworms, sod webworms, and armyworms.

   In table 5.2, a flotation sample is described for monitoring chinch bugs, and a digging method is described for monitoring white grubs.

   Drench test for cutworms, sod webworms, and armyworms: Mix 3-4 tablespoons of dishwashing liquid in 2 gallons of water. Pour evenly over 1 square yard of turf. Watch the area for 10 minutes, counting the caterpillars as they rise to the surface.

4. Determine optimum timing of management practices. Make sure that a management tactic will suppress the pest population to an acceptable level, and that suppression is necessary to limit further damage.

5. Consider several management strategies, including biological and cultural methods. Match the management strategy to the pest species. If the pest feeds on grass leaves (black cutworm, for example), any material should be applied to the above ground portion of the turf and not followed by watering. For white grubs that reside beneath the surface, any material used must be applied by injection or the application should be followed by watering.

General Cultural Controls

- When mowing, only cut one-third of the height of the lawn at a time.
- Turf more than 2.5 inches in height seldom requires treatment for cutworms or sod webworms. Also, when mowing remove clippings (adult cutworm moths lay eggs at the tip of grass blades.

General Biological Controls

- The seed of many cultivars of fescue and perennial ryegrass contains a beneficial fungus. This "endophyte enhanced" seed helps reduce the likelihood of attack by many insect and disease pests.
- Insect pathogenic bacteria, fungi and nematodes are available for some lawn pests. When using a biological control product, be aware of the conditions under which the product will work properly.
- There are a number of natural enemies, among them ground beetles, lady beetles, parasitic wasps and flies, spiders, and predatory mites that feed on lawn pests.

General Mechanical Controls

- Dethatch in spring or early fall if thatch (the brown layer between the grass blades and the soil surface) is greater than ½ inch deep.

General Chemical Controls

- Use narrow spectrum, less persistent pesticides whenever possible.
- Implement the management tactic as required by label instructions. For formulated insecticides, this is the law.
- Record pertinent information for future management decisions, including: date of application, material applied, pre-treatment pest population levels, weather conditions during and following application, pest population levels following treatment, level of satisfaction with results.

Precautions

- Read the label and follow all safety precautions, application rates, and pesticide disposal instructions.
- Keep pesticides in their original containers and store them out of reach of children and pets.
- Pesticides applied to your lawn can drift or leach and contaminate neighboring property and water sources. To avoid this, avoid applying pesticides when it is windy or if rain is forecast, and never let pesticide runoff flow into storm drains.

When to Call a Professional

- Hire a licensed pest control service if the problem is beyond your limitations. A pest control professional who practices integrated pest management can provide you with the safest and most effective management strategies.

Special Considerations

- **Fire Ant** has recently spread to Virginia. Refer to the Insects in Recreation Areas and Nursery Crops: Insects sections of the Pest Management Guide for current information on fire ant management. Virginia Cooperative Extension (VCE) Red Imported Fire Ant Factsheet: https://pubs.ext.vt.edu/444/444-284/444-284.html

Guidance on How to Find Specific Recommendations

- See Table 5.2 for specific recommendations

Links to Useful Sources of Information

- VCE Turf and Garden Tips: https://ext.vt.edu/lawn-garden/turfandgardentips/tips.html?content_list_start=0.
- VCE Spring and Summer Lawn Management Considerations for Cool-Season Turfgrasses (includes a section on common lawn insect pests): https://pubs.ext.vt.edu/430/430-532/430-532.html.
- VCE Japanese Beetle Factsheet: http://pubs.ext.vt.edu/2902/2902-1101/2902-1101.html.
- VCE Pest Monitoring Calendar for Home Lawns in Virginia (PDF file): https://pubs.ext.vt.edu/430/430-524/430-524.html.

Table 5.2 - Specific Insect Recommendations

Insect Pest	Labeled Pesticides	Recommendation
Ants	Beta-cyfluthrin Bifenthrin Carbaryl Clothianidin Cyfluthrin Cypermethrin Deltamethrin Esfenvalerate Imidacloprid Lambda-cyhalothrin Permethri	**Chemical Controls** Use as localized treatments to nesting area according to label directions. A general area application may not be necessary. Use of some other lawn insect controls will also control ants. Apply during daylight. **Related Fact Sheet** Imported Fire Ant Factsheet: https://pubs.ext.vt.edu/444/444-284/444-284.html
Chinch Bugs	Azadirachtin *Beauveria bassiana (insect pathogenic fungus)* Beta-cyfluthrin Bifenthrin Carbaryl Chlorantraniliprole Clothianidin Cyfluthrin Cypermethrin Dinotefuron Imidacloprid Lambda-cyhalothrin Permethrin Trichlorfon	Sample using flotation: A cylinder with open ends is driven into the turf, and about 1 inch of water is maintained in the cylinder for 5-10 minutes. Chinch bugs will float to the top of the water. Chinch bugs can cause significant damage to turf when found in densities of 15-20 immature bugs/ sq ft. Damage usually occurs to turf in sunny areas with a thick thatch layer. Two generations per year occur in Virginia. Insecticide treatment is often effective, but since the bugs are highly mobile, the area can be quickly recolonized. Therefore, an application in April-May, followed by 1 or 2 more applications at 2- to 3-week intervals is recommended for the first generation. Early treatment may provide season-long control. Do not mow or water turf for 2-3 days after treatment. **Cultural Controls** Reduce the use of fine (red) fescue in sunny areas, avoid spring fertilization with high nitrogen. **Biological Controls** If the insect-pathogenic fungus *Beauveria bassiana* is used as a control measure, do not apply fungicides immediately before or after application. **Related Fact Sheet** Chinch Bugs in Turfgrass: https://ohioline.osu.edu/factsheet/HYG-2503-11
Armyworms and Cutworms	Azadirachtin *Bacillus thuringiensis* var. kurstaki (Bt) Bifenthrin Carbaryl Chlorantraniliprole Clothianidin Cyfluthrin Deltamethrin Dinotefuron Entomopathogenic nematodes Halofenozide Imidacloprid Lambda-cyhalothrin Permethrin Spinosad Trichlorfon	Sample using drench test as described above. Cutworm populations of 3-8 worms per square yard may warrant treatment. Two generations can occur in Virginia. Armyworm populations above 9 per square yard may warrant treatment. **Biological Controls** Not all species of nematodes available commercially will provide adequate control. The species of nematode is provided on the product label under the “Active Ingredients” section. *Steinernema carpocapsae* is effective against black cutworms. **Chemical Controls** Apply materials in the early evening. Most insecticides used for armyworm and cutworm control are stomach poisons, and the larvae feed at night. Do not water the treatment in unless specified on the label and do not mow for several days after treatment. Armyworms and cutworms are highly mobile, so treated areas are likely to become reinfested from surrounding areas.

Table 5.2 - Specific Insect Recommendations (cont.)

Insect Pest	Labeled Pesticides	Recommendation
Mites (Clover mite)	Azadirachtin Diatomaceous earth Esfenvalerate Lambda-cyhalothrin	Clover mites are more nuisances than pests, though they may build up populations near building foundations that can cause silvering of turf. As their name suggests, they are not primarily feeding on grasses. The nuisance they cause occurs when they invade houses. When crushed they cause a red stain on the area. Populations high enough to warrant treatment occur in late winter or early spring, and occasionally in the fall. Control is usually only needed around the perimeter of structures – often only on the south side. **Mechanical Controls** Bare ground within 5 feet of the structure can be effective.
Sod Webworms	Azadirachtin *Bacillus thuringiensis* var. kurstaki (Bt) Bifenthrin Carbaryl Chlorantraniliprole Clothianidin Cyfluthrin Deltamethrin Dinotefuron Entomopathogenic nematodes Halofenozide Imidacloprid Lambda-cyhalothrin Permethrin Spinosad Trichlorfon	Sample using drench test as described above. Webworm densities of 15 per square yard warrant treatment. Sod webworm problems on turf are most noticeable in high maintenance conditions where grass is kept short. Two generations per year occur in Virginia. Young larvae, which are most susceptible to treatment, can be expected in turf about 2 weeks after adults are present, late June and again in early September. **Biological Controls** Unfortunately, by the time damage is noticeable, the larvae are not susceptible to Bt products because they are too old. Spring and early summer treatments may be effective against the larvae that have overwintered. Do not mow for 1-3 days after treatment. **Related Fact Sheet** *Sod Webworm Tips For Your Lawn (Michigan State University): http://www.canr.msu.edu/resources/sod_webworm_tips_for_your_lawn*

Table 5.2 - Specific Insect Recommendations (cont.)

Insect Pest	Labeled Pesticides	Recommendation
White Grubs (Japanese beetle, masked chafer, Asiatic garden beetle, etc.)	Azadirachtin *Bacillus popilliae* (Milky Spore disease) for Japanese beetle only; not effective on other grub species *Bacillus thuringiensis galleriae* *Beauveria bassiana* (insect pathogenic fungus) Carbaryl Chlorantraniliprole Clothianidin Dinotefuron Entomopathogenic nematodes: Products with *Steinernema riobrave* or *Heterorhabditis* as active ingredient. Halofenozide Imidacloprid Trichlorfon	Sample by digging: Use a shovel to cut several 1 ft x 1 ft squares, 2-3 inches deep. Peel up the turf and count the white grubs. Population high enough to warrant treatment is 6-10 grubs/sq ft. White grubs are actually several species of scarab beetle larvae. **Biological Controls** When using these products, be aware that control is not immediate. Milky spore is a slow-acting disease agent; grubs will take up to 30 days to die. However, when the disease is established, control can be effective for years without further application. After application, the disease perpetuates and spreads by infecting and being transported by grubs. If another insecticide is applied to an area treated with milky spore, this will slow the spread of the disease and is therefore not desirable. Be patient. If the insect-pathogenic fungus *Beauveria bassiana* is used as a control measure, do not apply fungicides immediately before or after application. White grubs can also be controlled by entomopathogenic nematodes. Not all species of nematodes available commercially will provide adequate control. The species of nematode is provided on the product label under the “Active Ingredients” section. Products with *Steinernema carpocapsae* in this section should not be used for grub control. These products should be applied only when the pest is present. Nematodes should be applied late in the day to avoid exposure to UV light damage, and soil temperature should be at least 60°. Early spring treatments are usually not effective because soil temperatures are too cold. Watering before and after application provides the best results. **Chemical Controls** These products should be applied at the labeled rate and watered in with 1/2 inch of water. Timing is important; make sure the grubs are present. Most insecticides provide the best control when used against young grubs. **Related Fact Sheet** Beetlemania—White Grub Control in Lawns (VCE) https://ext.vt.edu/lawn-garden/turfandgardentips/tips/beetlemania.html

This chapter was not reviewed in 2019.

Lawn Weeds

Shawn D. Askew, Associate Professor, School of Plant and Environmental Sciences, Virginia Tech

Overview

The first step in any lawn weed management program is to identify the problem. What is limiting the growth and density of the lawn's grass? What is competing for nutrients? High quality lawn grass kills seedling weeds and prevents large weed stands, which tend to decrease lawn aesthetics. Simply killing weeds is not enough. Without a healthy turf, weeds will return and invade the lawn. High quality lawns do not happen by accident. Quality turf depends on many factors, such as soil type, turfgrass variety, fertilization, irrigation, mowing, and pest management. The most important of these is good soil. As soil quality increases, the number of inputs required for a quality turf (fertilizers, water, and pesticides) decrease. Improving poor soils is among the most important factors to increase turf quality and achieve maximum weed prevention from the turfgrass. Although lawn grasses can be grown on almost any soil, everything is easier with quality topsoil. Any weed management program should start with a soil test. Retest the soil every three to four years to ensure that soil pH and nutrient levels are optimal for turfgrass growth.

The second step to lawn weed management is to identify the suspect weed. The beauty of a lawn is in the eye of the beholder. Wild plants appreciated by one person are weeds to another. Some weeds are only visible above the turf canopy for a few weeks each year, while others persist and multiply. Learn the weed's life cycle—when it emerges, when it flowers and how long it will live. Now decide what steps to take to fix the problem in the short and long term.

Herbicides are just one of many options to treat weed problems in the lawn. In the following sections, general management options are discussed and these may be used in lieu of or in combination with herbicide treatments. In the later section, specific herbicide recommendations are given for the most common lawn weed problems.

General Cultural Controls

Healthy lawn grass is the most powerful weed prevention available. Practices that promote turfgrass health are required for successful weed management in the lawn. In fact, most weed problems in Virginia can be attributed to a single mistake made by most homeowners: mowing the lawn too short. No other cultural input for lawns exceeds the effort given to mowing, so mowing correctly is critical for optimal turfgrass health and performance. Most lawns in Virginia are tall fescue or other cool-season grasses like Kentucky bluegrass, perennial ryegrass, and fine-leaf fescues. Optimal mowing heights for these grasses vary somewhat depending on the species but a minimum of three inches is a good rule of thumb for most situations. When growing cool-season grasses in the warmer climates of Virginia, the single most important thing to promote a higher-quality lawn is to raise the cutting height to three to four inches in mid-to late spring, before the onset of summer stress periods. This promotes a deeper root system and provides more leaf canopy to conduct photosynthesis. Many consumer mowers are not adjustable or will not mow turf taller than approximately two inches. Owners of these mowers must accept the fact that their lawns require more water, pesticide, and fertilizer to stay healthy. In addition to mowing height, mowing frequency and efficiency, such as having a sharp mower blade, are key to turfgrass health. Mow often enough so that no more than one-third of the total turfgrass height is removed. When a lawn maintained at a three-inch height reaches four inches, it needs to be mowed. During spring and fall, mow the cool-season lawn every four to 5 days. In summer, mow every 7 to 10 days. During periods of drought, do not mow the lawn until rains return. Since most grass blades do not grow during drought, ignore the occasional tall leaf blade and do not mow the lawn for extended periods. In addition to mowing properly, there are several other cultural practices that reduce weeds in the lawn. The following table details the most important steps to create a healthy lawn that resists weeds.

Table 5.3 - Cultural practices that promote turfgrass ability to suppress weeds or prevent weed introduction and expansion in cool-season and warm-season lawns.

Cultural practice*	Cool-season lawns (tall fescue, Kentucky bluegrass, perennial ryegrass, fine-leaf fescues, etc)	Warm-season lawns (bermudagrass, zoysiagrass, centipedegrass, St. Augustinegrass)
Mow height	Mow tall fescue at three to four inches, others at two- to three-and-a-half inches.	Mow St. Augustine grass at three to four inches, others at one to two inches
Mow frequency	Follow the one-third rule, mow every four to five days in spring and fall and seven to ten days in summer.	Follow the one-third rule, mow every four to five days in summer and seven to ten days in spring and fall.
Mower	Keep blades sharp; sharpen blades every four to six weeks during the mowing season. Zoysiagrass and tall fescue turfs require more frequent sharpening than others.	
Soil	Conduct soil tests every three-four years and improve poor soils by adding compost, topsoil, core aeration or adjusting pH to between 6.3 and 6.8	
Fertility	Depending on the grass, apply two to three pounds nitrogen (N) per thousand square feet once per year, mostly in the fall. Do not apply more than one pound of water soluble nitrogen in a single application. Excessive spring nitrogen applications reduce summer stress tolerance and can increase weed and disease pressure. Apply phosphorus (P) and potassium (K) as indicated by soil test results. Avoid applying phosphorus and potassium when weeds are expected to germinate.	Depending on the grass, apply one to four pounds nitrogen (N) per thousand square feet each year, primarily in late spring thru mid-summer. Do not apply more than one pound of water soluble nitrogen in a single application. Apply phosphorus (P) and potassium (K) as indicated by soil test results.
Irrigation	If supplemental irrigation is available or desired, irrigate deeply and infrequently, providing at least one inch of water per week, including rainfall, during summer stress periods. Irrigate in early morning hours to minimize leaf wetness periods and reduce disease pressure. Avoid supplemental irrigation during periods when weeds are expected to germinate. If no irrigation is available, allow lawn to go dormant during drought	
Clipping management	Return clippings, as they essentially serve as ‘slow release fertilizer’ to the lawn and provide up to one-third of its annual nutrient needs. Do not worry about returning weed seed in clippings to the lawn, as indigenous seed in the soil far outnumber weed seeds deposited by mowing. If clippings are removed, use the higher range of recommended fertility programs. Compost collected clippings with other lawn and garden debris and return the compost to the lawn in order to improve soil tilth.	
Variety selection	Choose adapted varieties, refer to http://www.ext.vt.edu and search for the “recommended list” to find the latest turfgrass variety suggestions. Change turfgrass species or variety in different environments, such as shade.	
Aeration	Test soil one day after rain by inserting a knife or screwdriver into the ground. If difficult to insert, that area of lawn needs aeration. Aerate cool-season lawns in spring and/or fall. Aerate warm-season lawns in summer.	
Exclusion	Prevent weeds from entering new areas. Inspect soil, manure, or any organic additives for invasive weeds. Target creeping weeds outside the lawn or develop strategies that limit invasion into the lawn. Use only certified grass seed that is free of weed seed.	
Improve conditions	Fix drainage problems, trim low tree limbs, and try to increase light quantity and wind movement where turfgrass is growing.	
Choose sites	Don’t grow turfgrass in an area where it is not adapted. Deep shade or extremely poor soils are best suited to an inorganic mulch or plant species commonly used as ground covers that are better adapted to the environment.	

* There are numerous Virginia Cooperative Extension publications that provide much more extensive detail in overall best management practices in lawn care available at www.ext.vt.edu.

General Biological Controls

Although some biological organisms target weeds in turfgrass, none are available for home lawn use.

General Mechanical Controls

The primary means of mechanical weed control in lawns is hand weeding. Hand weeding is often overlooked as a viable option for lawn weed control. Tools are available to help remove weeds from the lawn without bending. A quick internet search will provide more information and vendors for these kinds of tools. Chemical sprays are often perceived as the easiest approach to weed control, but hundreds of weeds can be hand pulled in the time required to research and determine the appropriate chemical for the properly identified weed, purchase the chemical, mix the product in a calibrated applicator, and apply the product. Then it will take one to three weeks for the chemical spray to work. Hand pulling is arguably the easier choice. Plants like dandelion, plantain, ryegrass, annual bluegrass, crabgrass and goosegrass have few or no creeping stems, and are easier to pull than creeping plants like bermudagrass (wiregrass), nimblewill, and white clover. Although hand pulling creeping perennials like bermudagrass and nutsedge does not completely eradicate the population, such efforts are still beneficial to the turfgrass and limits population expansion of the weed. Always wait until after a rainfall or irrigation to hand pull weeds, as plants will then be easier to pull. Discard plants rather than leaving them to be mown into the lawn, as the pulled plants continue to grow and produce seed before they die, and stem fragments from some plants can take root in the lawn.

Remove mat-forming plants, like moss, by raking or vertical mowing. It is important to remove thick mats of biological material before seeding new turfgrass in the area. Some species of weeds may invade a lawn soon after establishment, but will not persist more than two to three years as they cannot compete in the presence of regular mowing. Thus, mowing acts as a mechanical control in a select few situations.

Solarization and shading are two other nonchemical approaches to control weeds. Unfortunately, these methods also kill desirable turfgrass. Solarization kills plants by covering them with a clear material and allowing solar radiation to heat the area to a temperature too high to support plant life. Shading removes the plants' ability to capture energy and eventually kills the plants. Both techniques take one to two months to kill plants. Then the area must be seeded or sodded back to desirable turfgrass.

In the natural life cycle of target weeds, many die with summer heat or winter frost. If these natural events kill the weed within a few weeks, costly chemicals are not needed. As mentioned earlier, large amounts of biological material left behind after these weeds die should be removed so turfgrass can grow.

General Chemical Controls

Both organic and synthetic chemicals can combat weeds. In both cases, safe handling procedures are important and these can be reviewed in Chapter 1. Granular and sprayable herbicides are available for use in home lawns. Granular products are strewn manually, scattered using specialized product containers, or applied using drop or rotary spreaders. There are two ways to calibrate the application of granular products. One is to measure the amount of product and apply all of that product uniformly to a given area of turf. The other is to calibrate the delivery rate of a machine and operate the machine until all desired area is covered. It is best to use the first method for home lawn application. Product bags often indicate the amount of area covered by one bag. For example, instructions may state that a bag of chemicals "covers 5000 square feet." The product in these bags is typically well blended, so use half the bag's contents to cover half the indicated area. The scientific way to partition product is by weight, but it is easier for homeowners to partition the product by volume. It is important that any measuring devices, such as cups, tin cans, etc. are filled the same way each time so volume measurements are accurate.

After measuring the product, determine the square footage of the area to be treated. Divide irregularly shaped areas into several rectangles or squares and determine the area of each. Simply multiply the length by the width of a given area to determine the area in square feet. For example, an area 15 feet by 25 feet contains 375 square feet. Repeat this process until the entire lawn has been measured and simply total the sum of all small areas into one number, which represents the square footage of the lawn. Let's say an area requires 75 percent of a bag of product. Place the product into the spreader, set the spreader on a low level, cover the entire lawn, then check the amount of product used. This is the easiest method to estimate how much product is needed to cover the lawn before the product is completely spread. If more than four times are needed, it is best to adjust the spreader to a slightly higher level and repeat the process. It is best to apply the product evenly to the lawn in two to four passes. By running the spreader over the entire lawn two to four times, the product application is spread uniformly across the lawn, and does not have any pattern associated with walking. Change walking patterns each time to improve product distribution.

To apply sprayable products, the primary equipment is the pump sprayer and the hose-end sprayer. Several products are sold in a container that serves as a hose-end sprayer. These are called "Ready-to-Spray" products. Regardless of the spray equipment,

application techniques are similar. First calculate square footage. Next, determine the amount of product needed. The Ready-to-Spray products are just that, "ready to spray." Simply attach a garden hose and apply the product uniformly to the target area. After-market, hose-end sprayers are cheap and can be used to apply many different concentrate products. Place the concentrate in the siphon container, set the dial to the desired dispense rate, and spray the product over the lawn. It is best to cover the entire area at least twice in different directions, so adjust calibration to apply only half the desired rate. By covering the entire area twice, the spray pattern is more uniform.

To calibrate a pump sprayer, fill the sprayer with a known amount of clean water, mark off an area of 1000 square feet (such as 20 feet by 50 feet), and cover the area completely while spraying the clean water. Now check to see how much water was used in the test spray. This amount is the spray rate and should be near one to two gallons per thousand square feet. Once the spray rate is determined, it is easier to calculate the amount of concentrate product for each gallon of water and also know how much area it should treat.

Since most lawn herbicides are synthetic, they are covered under the specific recommendations later in this chapter. There are only a few organic weed control products available for use in lawns and those are summarized later in the chapter. Organic pesticides are chemicals that kill pests, just like synthetic pesticides. In many cases, organic pesticides share the same molecular structures as their synthetic counterparts. The difference is that organic pesticides are purified from naturally obtained material rather than being created synthetically. The public perception is that organic pesticides are safer than synthetic pesticides and a growing number of consumers desire organic, which are often labeled "nonchemical," alternatives. Unfortunately, only a few organic chemicals are available to fill this market niche for weed control in home lawns. Most organic weed control products also kill or severely injure desirable turf, and must be used for spot treatment of seedling weeds. Turf in the treated area quickly turns brown, but recovers in one to two weeks. Mature weeds also recover in about the same time period as turfgrass. These products are excellent for spot treating seedling weeds in gardens and ornamental beds but are of limited usefulness in lawns. Table 5.3 lists several organic weed control products on the market.

Corn gluten meal is one selective organic herbicide that exists for home lawns. Corn gluten meal contains alaninyl-alanine, a chemical that inhibits lateral root production in plants. When applied near the time of weed germination, survival of germinating weeds decreases due to a reduction in root vigor. Corn gluten meal also contains 9 percent nitrogen by weight and constitutes a nitrogen application rate of 1.8 pounds per thousand square feet of slow-release nitrogen, when the product is applied at the recommended 20 pounds per thousand square feet. This massive amount of fertilizer increases turfgrass competition in the short term and probably increases weed seedling mortality due to shading and other competitive effects of turfgrass. Alaninyl-alanine is short lived in soil, lasting on average about two or three weeks. If excess irrigation or rainfall occurs over extended periods, weeds may survive until alaninyl-alanine degrades in soil. For this and other reasons, corn gluten meal has performed inconsistently in Virginia's transition zone climate. More success has been seen with this herbicide in the northern US where cool-season lawn grasses are better adapted to the climate. In Virginia, applying 1.8 to 3.6 pounds of slow-release nitrogen from one to two treatments of corn gluten meal can spell disaster for lawn grasses when summer temperatures increase. Increased foliar growth from supraoptimal fertility in spring leaves turfgrass vulnerable to disease and drought later in summer. Thus, corn gluten meal has seldom been recommended in this Pest Management Guide. Current research at Virginia Tech is looking for more sustainable approaches to using corn gluten meal by reducing use rates to 10 pounds or less and adding synthetic herbicides at a fraction of their normal rates. These programs appear to maintain excellent turf quality, while exceeding weed control from corn gluten meal at full rates as well as drastically reducing pesticide use over conventional full rate pesticide treatments. When using corn gluten meal, reduce the rate to 10 pounds, and supplement the program by hand pulling escaped crabgrass and other weeds. This prevents turf harm from excess fertility and still avoids or reduces the use of synthetic herbicides.

Table 5.4 - Some organic weed control products marketed for use in lawns.

Active ingredient	Product(s)	Uses
Acetic acid (vinegar)	Weed/Grass Killer, Natural Weed Control, Erath Earth, Maestro-Gro Blackjack 21, Burnout Weed & Grass Killer	Nonselective, seedling weed control.
Ammoniated soap of fatty acid	Garden Safe Weed & Grass	Nonselective, seedling weed control.
Cinnamon Bark	AgraLawn Crabgrass Killer, Garden Weasel	Crabgrass control in warm-season lawns.
Cinnamon oil, rosemary oil	Organic Weed Killer	Nonselective, seedling weed control.
Citric acid	Burnout 2, Natural Weed Control	Nonselective, seedling weed control.

Table 5.4 - Some organic weed control products marketed for use in lawns. (cont.)

Active ingredient	Product(s)	Uses
Citrus oil (d-limonene)	Nature's Avenger, Worry Free Weed & Grass Killer	Nonselective, seedling weed control.
Clove oil	EcoSmart, Bioganic Weed & Grass Killer, Burnout 2	Nonselective, seedling weed control.
Corn gluten (Alaninyl-alanine)	Amaizeingly Green, Corn Weed Blocker, Espoma Green, Weed Man, WOW!, NaturO, Jonathan Green Organic Weed Control, Safe-T-Weed, Gard'n-Wise Organics, Dynaweed, Concern Weed Prevention Plus	Preemergence weed control in turfgrass. 9% slow-release nitrogen source by weight.
Ethanoic acid	Burnout Weed & Grass Killer	Nonselective, seedling weed control.
Thyme oil	Bioganic Weed & Grass Killer	Nonselective, seedling weed control.
Iron HEDTA	Weed Beater FE, Iron X, Fiesta Turf Weed Killer	Selective postemergence control or suppression of broadleaf weeds in turf

Precautions

When choosing lawn weed control products, know that most herbicides are relatively safe but still should be handled with respect and stored in a secure manner. Table 1.7 in Chapter 1 shows the relative toxicity of various pesticides. Most herbicides are far less toxic than insecticides or fungicides and have an LD_{50} value greater than 5,000 to 10,000 milligrams/kilograms. Those values are less than that of table salt (3,000). In fact, only a few herbicides are as toxic as caffeine (192) and aspirin (200) and these include paraquat (150) and diquat (231). Always follow label instructions on any pesticide product and use the product in a safe manner.

Although herbicides exhibit relatively little danger to humans, pets, and wildlife, they can cause serious injury to desirable ornamental plants. Herbicides should also be kept away from hardscapes, unless the herbicide is registered for such use, as they can move into streams and rivers through man-made drainage systems. Don't spray products when wind speeds are greater than five miles per hour, if possible, and use shields to protect spray from effects of wind. Similarly, many granular spreaders have deflector shields to minimize product delivery onto hardscapes. If granules are strewn onto sidewalks or pavement, sweep them up or blow them back onto the lawn. Never discard granules or liquids into any drain.

Don't apply any herbicide to areas saturated with water from frequent rains or irrigation. If soils are saturated and another rainfall occurs soon after herbicide application, the product will be highly prone to move in surface runoff water. This can injure plants away from the target site and the herbicide can move into storm water drains. Some herbicides can be tracked with shoes or tires to nontarget areas. Prevent traffic on treated areas until after rainfall or irrigation. Most herbicides are rain-fast within four to eight hours. Herbicides can also be irrigated to wash excess residue from leaves and prevent the product from being dislodged by foot or vehicle traffic.

Always read and follow the label instructions on the herbicide product. The information on the label is federal law, and to apply the product in any way other than what is specified on the label is a federal crime. These rules apply to handling, mixing, transporting, storing and applying the pesticide. For more information on safe use of pesticides, refer to Chapter 1 in this Pest Management Guide.

When to Call a Professional

Homeowners may waste more money and have fewer resources to draw from by trying to apply pesticides by themselves. Consumer pesticides have less active ingredient than products available to professionals. Consumer products are also more expensive per unit quantity, even if products are available in small quantities for a perceived low price. For example, a typical liquid broadleaf weed control product available to professionals is purchased in a minimum one gallon size for about $100. This container treats about two to four acres, or eight to 16 average sized lawns. To match the same amount of actual herbicide, the competitive consumer product requires 17 to 34 quart-sized containers at a cost of $260 to $520.

A general rule of thumb for hiring a professional is this: if you don't enjoy working in your lawn and landscape, hire a professional. Applying pesticides should only be attempted by one who is willing to take the time to learn basic pest management techniques. In the wrong hands, pesticides are a danger to the environment, people, and animals. They require secure storage, personal protection clothing, application equipment and other inputs that are best avoided if one does not intend to start a new hobby. Finally, many products are available only to professionals and work more effectively than consumer products.

Links to Useful Sources of Information

www.cdms.net Best source for pesticide labels and MSDS sheets
oak.ppws.vt.edu/~saskew/lawn_herbicides.xls Database of lawn herbicides registered in Virginia.

Specific Recommendations

Nearly 700 consumer herbicide products for lawns are registered for sale and use in Virginia. Consumer products may change in active ingredient composition or quantity at any time. There may be hundreds of specific products for a single active ingredient. Consumer products that are tested at universities and cooperative extension programs don't usually have recommendations that mention specific product names. Instead, active ingredients are recommended at rates representative of the scientific studies that evaluated their performance. The problem is that these rates are based on professional products that are not available to consumers. In addition, the common chemical names, such as "dicamba," are recommended in this section, while consumer products may not include these common chemical names anywhere on the package. Instead, consumer products list full chemical names, such as " Benzoic acid, 3,6-dichloro-2-methoxy," that may be expressed in several ways for each active ingredient. The use of active ingredients in these recommendations is inevitable, so this section tries to help consumers find the best products for their needs and choose them in a logical manner.

Many consumers believe that the subject of herbicide active ingredients is too complex and all references should be made to product names. However, it is impossible to reference several hundred product names in this section. Only 33 active ingredients are currently available in consumer products, and just 25 of those do not harm cool-season turfgrass. Just 11 active ingredients comprise the primary active ingredients in 85 percent of the products currently marketed in Virginia for consumer lawns. To find recommended active ingredients on consumer products, Table 5.5 contains the full chemical names for all active ingredients currently marketed for consumer lawn weed control in Virginia. Table 5.4 also lists the number of consumer products that contain each active ingredient and the most common use for these herbicides.

Recommendations in this section will be separated into eight categories based on the most common weed control problems in Virginia lawns. Within each category, herbicides are recommended based on active ingredient. Herbicide rate strongly influences product effectiveness, so a professional equivalency formula was created to reference the percentage active ingredient in various products to those in professional products tested at Virginia Tech. This formula allows consumers to select product from store shelves, find the active ingredients' percentage (A), total product weight or volume (B), and the area treated by the product in thousands of square feet (C). These three parameters are inserted into the formula (see Tables 5.6, 5.7, 5.8, and 5.9), which uses a professional equivalency constant to determine the fraction of the professional rate that would be applied when using the consumer product. For a step-by-step procedure for using this formula to calculate the professional equivalency of any consumer product, go to www.ppws.vt.edu/~saskew/PEC.ppt.

Table 5.5 - A list of the more common active ingredients found in consumer herbicides

Common Name	Number of Consumer Products	Most Common Use	Synonyms Often Found on Product Labels
2,4-D	173	Postemergence broadleaf control (bittercress, buttercup, wild carrot, chickweed, dandelion, mustards, plantain, thistles, wild garlic, and others).	2,4-D, dimethylamine salt
			2,4-Dichlorophenoxyacetic acid compd. with N-methylmethanamine
			2,4-Dichlorophenoxyacetic acid, dimethylamine salt
			Acetic acid, (2,4-dichlorophenoxy)
			Dimethylamine 2,4-dichlorophenoxyacetate
			Acetic acid, (2,4-dichlorophenoxy)-, 2-ethylhexyl ester
			2,4-D, 2-ethylhexyl ester
			2,4-Dichlorophenoxyacetic acid, 2-ethylhexyl ester
			2-Ethylhexyl (2,4-dichlorophenoxy)acetate
			Triisopropanolamine 2,4-dichlorophenoxyacetate
			2,4-D, triisopropanolamine salt
			2,4-Dichlorophenoxyacetic acid, triisopropanolamine salt

Table 5.5 - A list of the more common active ingredients found in consumer herbicides (cont.)

Common Name	Number of Consumer Products	Most Common Use	Synonyms Often Found on Product Labels
2,4-DP	30	Postemergence broadleaf control (bittercress, buttercup, wild carrot, chickweed, dandelion, mustards, plantain, thistles, wild garlic, and others).	Dichlorprop-P (R)-2-(2,4-Dichlorophenoxy)propanoic acid, dimethylamine salt (+)-2,4-DP, dimethylamine salt 2,4-DP-p, DMA salt Dimethylamine salt of (+)-R-2-(2,4-dichlorophenoxy) propanoic acid Methanamine, N-methyl-,(R)-2-(2,4-dichlorophenoxy) propanoate N,N-Dimethylammonium (R)-2-(2,4-Dichlorophenoxy) propanoate Propanoic acid, 2-(2,4-dichlorophenoxy)-, (R)-,
Atrazine	17	For use in warm-season turf only and restricted use. Postemergence and preemergence control of grass and broadleaf weeds.	2-Chloro-4-(ethylamino)-6-(isopropylamino)-s-triazine 1,3,5-Triazine-2,4-diamine, 6-chloro-N-ethyl-N'-(1-methylethyl)- 1-Chloro-3-ethylamino-5-isopropylamino-2,4,6-triazine 2-Chloro-4-(propylamino)-6-ethylamino-s-triazine 3-(N-Butyl-N-acetyl)aminopropionic acid S-Triazine, 2-chloro-4-(ethylamino)-6-(isopropylamino)-
Benefin	21	Preemergence control of crabgrass, annual bluegrass, and other annual grasses.	Benfluralin Benzenamine, N-butyl-N-ethyl-2,6-dinitro-4-(trifluoromethyl)- N-Butyl-2,6-dinitro-N-ethyl-4-(trifluoromethyl)aniline N-Butyl-N-ethyl-2,6-dinitro-4-(trifluoromethyl)benzenamine N-Butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-p-toluidine P-Toluidine, N-butyl-N-ethyl-a,a,a-trifluoro-2,6-dinitro-
Bentazon	5	Postemergence sedge control and seedling broadleaf control.	Sodium bentazon 1H-2,1,3-Benzothiadiazin-4(3H)-one-2,2-dioxide, 3-isopropyl-, sodium salt 3-Isopropyl-1H-2,1,3-benzothiadiazin-4(3H)-one-2,2-dioxide, sodium salt
Carfentrazone	15	Kills seedling broadleaf weeds during turf seeding. Also adds fast symptoms when added to other products.	Benzenepropanoic acid, .alpha.-2-dichloro-5-{4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl}-4-fluoro-, ethyl ester Ethyl 2-chloro-3-{2-chloro-4-fluoro-5-{4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl}phenyl} propanoate Carfentrazone-ethyl
Dicamba	144	Postemergence broadleaf control (Knotweed, smartweed, curly dock, chickweed, ground ivy, spurge, clover, and others).	3,6-Dichloro-o-anisic acid, dimethylamine salt Dicamba, dimethylamine salt Benzoic acid, 3,6-dichloro-2-methoxy- Dimethylamine 3,6-dichloro-o-anisate 2,5-Dichloro-6-methoxybenzoic acid 2-Methoxy-3,6-dichlorobenzoic acid 3,6-Dichloro-2-methoxybenzoic acid MDBA O-Anisic acid, 3,6-dichloro-

Table 5.5 - A list of the more common active ingredients found in consumer herbicides (cont.)

Common Name	Number of Consumer Products	Most Common Use	Synonyms Often Found on Product Labels
Diquat	13	Nonselective. Fast acting, contact type herbicide. Less effective on mature perennial weeds.	6,7-Dihydrodipyrido(1,2-a:2',1'-c)pyrazinediium dibromide
			1,1'-Ethylene-2,2'-dipyridylium dibromide
			9,10-Dihydro-8a,10a-diazoniaphenanthrene dibromide
			Dipyrido(1,2-a:2',1'-c)pyrazinediium, 6,7-dihydro-, dibromide
			Diquat bromide
			Ethylene dipyridylium dibromide
Dithiopyr	101	Preemergence control of crabgrass, annual bluegrass, and other annual grasses.	3,5-Pyridinedicarbothioic acid, 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-, S,S-dimethyl ester
			S,S-Dimethyl 2-(difluoromethyl)-4-(2-methylpropyl)-6-(trifluoromethyl)-3,5-pyridinedicarbothioate
Fenoxaprop	2	Postemergence control of many grass weeds.	Propanoic acid, 2-{4-{(6-chloro-2-benzoxazolyl)oxy}phenoxy}-, ethyl ester, (R)-
			(+)-Ethyl 2-(4-((6-chloro-2-benzoxazolyl)oxy)phenoxy) propanoate
			Fenoxaprop-p ethyl ester
Fluazifop	12	Postemergence control of many grass weeds.	Butyl (R)-2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy) propanoate
			Fluazifop-P-butyl
			Propanoic acid, 2-(4-((5-(trifluoromethyl)-2-pyridinyl)oxy)phenoxy)-, butyl ester, (R)-
Glyphosate	103	Nonselective. For spot treating or weed control on driveways, patios, etc.	Glyphosate, isopropylamine salt
			Glycine, N-(phosphonomethyl)-, compd. with 2-propanamine (1:1)
			Glyphosate-isopropylammonium
			Isopropylamine glyphosate (N-(phosphonomethyl)glycine)
			N-(Phosphonomethyl)glycine, isopropylamine salt
Halosulfuron	1	Postemergence sedge control.	3-Chloro-5-(((((4,6-dimethoxy-2-pyrimidinyl)amino)carbonyl) amino)sulfonyl)-1-methyl-1H-pyrazole-4-carboxylic acid, methyl ester
			1H-Pyrazole-4-carboxylic acid, 3-chloro-5-(((((4,6-dimethoxy-2-pyrimidinyl)amino)carbonyl)amino)sulfonyl)-1-methyl-, methyl ester
			Methyl 3-chloro-5-(4,6-dimethoxypyrimidin-2-yl carbamoylsulfamoyl)-1-methyl pyrazole-4-carboxylate
			Halosulfuron-methyl
Imazapic	3	Nonselective. Used to extend residual control.	imazapic-ammonium
			3-Pyridinecarboxylic acid, 2-(4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl)-5-methyl-, monoammonium salt, (.+-.)-
Imazapyr	5	Nonselective. Used to extend residual control.	2-(4,5-Dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl)-3-pyridinecarboxylic acid with 2-propanamine (1:1)
			2-(4-Isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl)nicotinic acid with isopropylamine (1:1)
			Imazapyr, isopropylamine salt

Table 5.5 - A list of the more common active ingredients found in consumer herbicides (cont.)

Common Name	Number of Consumer Products	Most Common Use	Synonyms Often Found on Product Labels
Imazaquin	2	For warm-season turf only. Also used to extend residual control of nonselective products.	3-Quinolinecarboxylic acid, 2-(4,5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl)-, monoammonium salt Ammonium salt of imazaquin Imazaquin, monoammonium salt
Isoxaben	8	Preemergence control of broadleaf weeds.	N-(3-(1-Ethyl-1-methylpropyl)-5-isoxazolyl)-2,6-dimethoxybenzamide Benzamide, N-(3-(1-ethyl-1-methylpropyl)-5-isoxazolyl)-2,6-dimethoxy- Benzamizole N-3-(1-Ethyl-1-methylpropyl)-5-isoxazolyl-2,6-dimethoxybenzamide
MCPA	7	Postemergence broadleaf control (clovers, chickweed, lespedeza, and others).	2-Ethylhexyl 2-methyl-4-chlorophenoxyacetate ((4-Chloro-o-tolyl)oxy)acetic acid, 2-ethylhexyl ester 2-Methyl-4-chlorophenoxyacetic acid, 2-ethylhexyl ester Acetic acid, (4-chloro-2-methylphenoxy)-, 2-ethylhexyl ester MCPA, 2-ethylhexyl ester (4-Chloro-2-methy(phenoxy)acetic acid with N-methylmethanamine 2-Methyl-4-chlorophenoxyacetic acid, dimethylamine salt Acetic acid, (4-chloro-2-methylphenoxy)-, compd. with N-methylmethanamine Dimethyl amine salt of 2-methyl-4-chlorophenoxyacetic acid Dimethylamine 2-methyl-4-chlorophenoxyacetate
MCPP	152	Postemergence broadleaf control (clovers, chickweed, lespedeza, and others).	Mecoprop-P MCPP-p DMAS MCPP-p, DMA salt Propanoic acid, 2-(4-chloro-2-methylphenoxy)-, (R) (+)-(R)-2-(4-Chloro-2-methylphenoxy)propanoic acid
Mesotrione	13	Postemergence control of grass weeds (crabgrass, foxtail, seedling goosegrass, nimblewill, others) and suppression of bermudagrass, sedges, and some broadleaf weeds	2-{4-(methylsulfonyl)-2-nitrobenzoyl}- 1,3-cyclohexanedione
Oryzalin	5	For warm-season turf or mature tall fescue only. Preemergence control of annual grasses and some broadleaves.	3,5-Dinitro-N4,N4-dipropylsulfanilamide 3,5-Dinitro-N',N'-dipropylsulfanilamide 4-(Dipropylamino)-3,5-dinitrobenzenesulfonamide Benzenesulfonamide, 4-(dipropylamino)-3,5-dinitro- N(sup4),N(sup4)-Dipropyl-3,5-dinitrosulfanilamide Sulfanilamide, 3,5-dinitro-N4,N4-dipropyl-
Oxadiazon	27	Preemergence control of crabgrass, goosegrass, and other annual grasses.	2-tert-Butyl-4-(2,4-dichloro-5-isopropoxyphenyl-delta2-1,3,4-oxadiazoline-5-one 1,3,4-Oxadiazol-2(3H)-one, 3-?2,4-dichloro-5-(1-methylethoxy)phenyl-5-(1,1-dimethylethyl)-

Table 5.5 - A list of the more common active ingredients found in consumer herbicides (cont.)

Common Name	Number of Consumer Products	Most Common Use	Synonyms Often Found on Product Labels
Oxyfluorfen	6	Nonselective weed control. Used for spot treating on driveways, patios, etc where residual control is needed.	2-Chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl) benzene 2-Chloro-.alpha.,.alpha.,.alpha.-trifluoro-p-tolyl 3-ethoxy-4-nitrophenyl ether 2-Chloro-4-trifluoromethyl-3'-ethoxy-4'-nitrodiphenyl ether Benzene, 2-chloro-1-(3-ethoxy-4-nitrophenoxy)-4-(trifluoromethyl)-
Pelargonic acid	2	Nonselective.	Nonanoic acid
Pendimethalin	36	Preemergence control of crabgrass, annual bluegrass, and other annual grasses.	N-(1-Ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine 3,4-Xylidine, 2,6-dinitro-N-(1-ethylpropyl)- Aniline, 3,4-dimethyl-2,6-dinitro-N-(1-ethylpropyl)- Benzenamine, 3,4-dimethyl-2,6-dinitro-N-(1-ethylpropyl)- N-(1-Ethylpropyl)-3,4-dimethyl-2,6-dinitroanaline
Penoxsulam	5	Postemergence control of hard-to-kill broadleaf weeds.	Benzenesulfonamide, 2-(2,2-difluoroethoxy)-N-(5,8-dimethoxy[1,2,4]triazolo[1,5-c]pyrimidin-2-yl)-6-(trifluoromethyl)-
Prodiamine	135	Preemergence control of crabgrass, annual bluegrass, and other annual grasses.	2,4-Dinitro-N3,N3-dipropyl-6-(trifluoromethyl)-1,3-benzenediamine 1,3-Benzenediamine, 2,6-dinitro-N1,N1-dipropyl-4-(trifluoromethyl)- N3,N3-Dipropyl-2,4-dinitro-6-(trifluoromethyl)-1.3--phenylenediamine Toluene-2,4-diamine, alpha,alpha,alpha-trifluoro-3,5-dinitro-N4,N4-dipropyl-
Quinclorac	21	Postemergence crabgrass control.	3,7-Dichloro-8-quinolinecarboxylic acid 8-Quinolinecarboxylic acid, 3,7-dichloro-
Sethoxydim	7	Not registered in all turfgrasses. Kills weedy grasses.	2-(1-(Ethoxyimino)butyl)-5-(2-(ethylthio) propyl)-3-hydroxy-2-cyclohexen-1-one 2-Cyclohexen-1-one, 2-(1-(ethoxyimino)butyl-5-(2-(ethylthio) propyl)-3-hydroxy-
Siduron	13	Preemergence crabgrass control while seeding turf.	1-(2-Methylcyclohexyl)-3-phenylurea Urea, N-(2-methylcyclohexyl)-N'-phenyl-
Simazine	5	Warm-season turf only for post- and preemergence control of annual bluegrass and other weeds.	2-Chloro-4,6-bis(ethylamino)-s-triazine 1,3,5-Triazine-2,4-diamine, 6-chloro-N,N'-diethyl- S-Triazine, 2-chloro-4,6-bis(ethylamino)-
Sulfentrazone	29	Postemergence sedge control. Excessive rates may injure turfgrass.	Methanesulfonamide, N-(2,4-dichloro-5-(4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl)phenyl)- 1-(2,4-Dichloro-5-(Nsub2-methylsulfonylamino)phenyl)-3-methyl-4-difluoromethyl-deltasupr2-1,2,4-triazolin-5-one 1-(2,4-Dichloro-5-methylsulfonylamidophenyl)-4-difluoromethyl-4,5-dihydro-3-methyl-1H-1,2,4-triazol-5-one 2-(2,4-Dichloro-5-methylsulfonylamidophenyl)-4-difluoromethyl-2,4-dihydro-5-methyl-3H-1,2,4-triazol-3-one

Table 5.5 - A list of the more common active ingredients found in consumer herbicides (cont.)

Common Name	Number of Consumer Products	Most Common Use	Synonyms Often Found on Product Labels
Triclopyr	34	Postemergence control of hard-to-kill broadleaf weeds.	Triethylamine triclopyr 3,5,6-Trichloro-2-pyridinyloxyacetic acid, TEA salt Acetic acid, ((3,5,6-trichloro-2-pyridinyl)oxy)- Triclopyr, triethylamine salt Triethylammonium triclopyr
Trifluralin	18	Preemergence control of crabgrass, annual bluegrass, and other annual grasses.	a,a,a-trifluro-2,6-dinitro-N,N-dipropyl-p-toluidine Benzenamine, 2,6-dinitro-N,N-dipropyl-4-(trifluoromethyl)-

I. Preemergence Control of Crabgrass, Goosegrass, and Other Summer Annual Grass Weeds

There are eight active ingredients that comprise 345 consumer products for preemergence control of annual grasses (Table 5.6). All of these herbicides work by creating a barrier of herbicide on the soil surface through which seedling weeds must grow when they germinate. Germinating seedlings have shallow roots and are sensitive to effects of these herbicides, while emerged plants are generally not susceptible. The following are important factors that determine effectiveness of these herbicides.

- *RATE* - Product rate is always important when using herbicides. As rate of preemergence herbicides decrease, the duration of effective weed prevention decreases. At full professional rates, most products prevent weed emergence for about two months. Only in special environmental conditions do these products exceed two months of activity. If excessive rates are applied, desirable turf may be injured or the herbicide persists for several months and may prevent turfgrass seedling establishment for renovation. Many consumer products are equivalent to one-half to three-quarters times that of the professional product rates. In a quality, dense lawn grass with minimal history of crabgrass problems, these rates are fine. In a lawn with persistent crabgrass problems, two to three applications may be needed to extend crabgrass control throughout the season. Don't exceed label rates or annual use limitations as stated on product labels.

- *TIMING* - Much debate has been waged related to timing of preemergence crabgrass herbicides. Most extension recommendations suggest applying the products just before crabgrass emergence. Crabgrass emerges when soil temperatures are above 55 F for several days or growing degree days at base 55˚ F reach a cumulative 70 to 100 units. Biological indicators of crabgrass emergence include forsythia bush and daffodil. Crabgrass emerges when approximately half of forsythia blooms have fallen and after most daffodil blooms have faded. So herbicides should be applied during full forsythia and daffodil bloom. While not as effective as spring application, fall application is also an acceptable approach to spring crabgrass control. Herbicides do still degrade in winter, but at a much slower rate than in summer. In a warmer, wet winter, over half of the herbicide will be lost between fall application and spring. In a cold dry winter, less than half of the herbicide may be lost in the same time period. Field dissipation studies show that half of applied pendimethalin degrades in about 44 days during summer temperatures. The time required to lose half of applied pendimethalin in winter (average 50˚ F) is 101 days. It is not unreasonable to expect half of applied pendimethalin to be lost over the 150 to 180 days of fall and winter if the herbicide is applied in October and crabgrass emerges in March or April. Applying herbicides in the fall may also help control of some winter weeds, but the disadvantage is that crabgrass control will not last as long into the summer when compared to spring application.

- *'WATER- IN' THE PRODUCT* - Preemergence herbicides must be incorporated onto the soil surface through irrigation or rainfall before the products can affect target weeds. A light rain or irrigation is sufficient. Crabgrass herbicides are highly susceptible to photodegredation, which means they can be destroyed by light between application and incorporation. It is important to water them within a few days of treatment.

- *UNIFORM APPLICATION* - These products work by creating a barrier, and are only as effective as the uniformity of that barrier. Sprayable products allow for more uniform application than granules, but both types can be applied uniformly by setting the applicator to half or quarter rates and covering the entire area two or four times.

Table 5.6 - Herbicides that prevent emergence of crabgrass and other annual grasses. A professional equivalency formula is provided to allow comparison of active ingredients and rates of consumer products to the rates proven to work at Virginia Tech and used by professionals.

Active Ingredient(s)	No. of Consumer Products in VA	Average Percent Active Ingredient in Consumer Products[1]	Professional Equivalency Constant (use formula)[2]	Special Notes
Benefin + Trifluralin	34	1.03 + 0.52	6.9	
Benefin + Oryzalin	1	1.0 + 1.0	6.9	Only apply to mature tall fescue or warm-season grasses. Excessive rates injure turf.
Dithiopyr	94	0.16	0.57	Controls emerged crabgrass up to the tillering growth stage.
Dithiopyr + Oxadiazon	2	0.125 + 1.0	N/A[3]	Excessive rates injure turf.
Oryzalin	4	0.92	4.6	Only apply to mature tall fescue or warm-season grasses. Excessive rates injure turf.
Oxadiazon	22	1.07	6.9	Among the most effective on goosegrass. Excessive rates injure turf.
Pendimethalin	33	1.04	4.6	
Pendimethalin + Oxadiazon	2	1.25 + 2.0	N/A	Excessive rates injure turf. Improved goosegrass control.
Prodiamine	116	0.34	3.4	
Prodiamine + Oxadiazon	1	0.2 + 1.0	5.5	Excessive rates injure turf. Improved goosegrass control.
Prodiamine + Sulfentrazone	13	0.18 + 0.1	1.7	Also controls sedges if applied as a second treatment after May 15. Excessive rates injure turf.

How to use professional equivalency constants:

(Go to www.ppws.vt.edu/~saskew/PEC.ppt for more information)

What is needed:

A = the sum of all active ingredients found under the “Active Ingredients” section of the product label (if the product contains 0.2% prodiamine and 1.0% oxadiazon, enter “1.2”)

B = total product weight in pounds (for example, for a 16 pound bag, enter “16”)

C = the area treated by the product expressed in thousands of square feet (i.e., if the bag treats 5800 square feet, enter 5.8)

Place these parameters into the following formula: Fraction of Professional rate = $\frac{\left(\frac{A \times B}{C}\right)}{\text{Equivalency Constant}}$

[1] These numbers represent the average percentage of active ingredient when combining all consumer products in Virginia that contain the same active ingredients. When selecting a product, examine the percentage active ingredient and compare to these averages. A larger number means more herbicide per unit weight but the actual amount applied to the lawn depends on the recommended rate expressed on the product label.

[2] The result of these constants when used in the formula represents the fraction of the professional rate tested at Virginia Tech and found to work. For example, a product that contains 0.77% benefin plus 0.38% trifluralin and covers 4000 square feet with a 16 pound bag will be found to be 0.67 times the professional rate using the formula. It is against the law to increase the consumer product rate above that recommended on the product label. To combat this problem, one can either apply the product more frequently (if the label allows) or buy another product to make up the difference. Just because the product exhibits a lower rate than that tested by Virginia Tech does not necessarily mean it will not work. By using the professional equivalency formula, however, one can make intelligent decisions regarding product choice. Choose the product that is closest to the professional rate (gives a value in the formula closest to 1.0).

[3] This active ingredient combination is only available in consumer products so comparison to professional products is not applicable.

II. Postemergence Control of Crabgrass, Goosegrass, and Other Summer Annual Grass Weeds

There are only four active ingredients that can selectively control emerged crabgrass and other annual grass weeds found in consumer lawn products (Table 5.7). These include fenoxaprop, fluazifop, quinclorac, and sethoxydim. Apply these products to actively growing crabgrass. Younger plants are easier to control than older plants. It is important to accurately identify the grass weed being targeted. For example, quinclorac is the most common active ingredient for postemergence crabgrass control and it does not control goosegrass or bermudagrass. The following are the most important rules to follow when targeting annual grass weeds with postemergence herbicides:

- *IDENTIFY THE LAWN GRASS* - Some herbicides are safe to use on one species of turfgrass but will severely injure or kill another species of turfgrass. These differences often occur between warm-season and cool-season turfgrasses, but are not limited to this trend. Identify all species of turfgrass in the lawn and confirm that the product used is safe on these species.

- *IDENTIFY THE GRASSY WEED* - Many grass weeds look alike and herbicides are often specific to the ones they control.

- *AVOID STRESS* - Drought, heat, frost, or any other stressful situation that reduces the growth rate of target grass weeds severely reduces the effectiveness of selective grass weed killers.

- *USE ADJUVANT* - Most consumer products are prepackaged with appropriate adjuvants, but some selective grass herbicides may need other additives, such as surfactants, to make them work. Read and follow the herbicide label.

- *MIX CAUTIOUSLY* - All selective grass herbicides, except quinclorac, have serious problems when mixed with other herbicides. Don't mix these with broadleaf herbicides, insecticides, or other products unless the mixture is known to be effective.

- *REPEAT TREATMENT* - Typically products need to be applied at two to four week intervals for complete control.

- *WATCH THE RATE* - Selective grass herbicides have a high possibility of injuring desirable turfgrass. Accurately calibrate sprayers and do not apply excess product, or the turfgrass will be injured severely.

- *AVOID "OLD" RTU PRODUCT* - Concentrate products are designed to have a shelf life of five to 10 years but "ready-to-use, RTU" products have a shorter shelf life, as they are already mixed with water. Avoid buying any RTU product that has been sitting on a shelf for over six months and expect product performance to decline over time when stored at home.

Table 5.7 - Herbicides that control emerged crabgrass and other annual grasses in the lawn. A professional equivalency formula is provided to allow comparison of active ingredients and rates of consumer products to the rates proven to work at Virginia Tech and used by professionals.

Active Ingredient(s)	No. of Consumer Products in VA	Average Percent Active Ingredient in Consumer Products[1]	Professional Equivalency Constant (use formula)[2]	Special Notes
Fenoxaprop	2	0.41	4.24	Only kills grasses. Expect some turfgrass injury. Also controls Japanese stiltgrass.
Fluazifop	12	0.48	2.81	Only kills grasses. Expect some turfgrass injury. Also controls Japanese stiltgrass.
Mesotrione	13	40	7.3	Controls many annual and perennial grassy weeds. Suppresses sedges and several broadleaf weeds.
Quinclorac + 2,4-D + Dicamba + Sulfentrazone	3	5.3 + 9.19 + 1.1 + 0.53	24.77	Controls crabgrass, sedges, and broadleaf weeds.
Quinclorac + 2,4-D + dicamba	21	2.5 + 5.6 + 0.58	24.77	Kills broadleaf weeds and crabgrass.
Sethoxydim	4	15.8	N/A[3]	Only kills grasses. Expect some turfgrass injury. Also controls Japanese stiltgrass.

How to use professional equivalency constants:

(Go to www.ppws.vt.edu/~saskew/PEC.ppt for more information)

What is needed:

A = the percentage of fenoxaprop, fluazifop, mesotrione, quinclorac, or sethoxydim found under the “Active Ingredients” section of the product label; ignore other ingredients (if the product contains 0.029% dicamba, 0.313% 2,4-D, and 0.104% quinclorac, enter “0.104”)

B = total product volume in fluid ounces (for a 1 quart bottle, enter “32”)

C = the area treated by the product expressed in thousand square feet (for example, if the bottle treats 5800 square feet, enter 5.8; for “ready-to-use” products assume a 24 ounce bottle treats 200 square feet, and enter 0.2)

Place these parameters into the following formula: Fraction of Professional rate = $\frac{\left(\frac{A \times B}{C}\right)}{\text{Equivalency Constant}}$

[1] These numbers represent the average percentage of active ingredient when combining all consumer products in Virginia that contain the same active ingredients. When selecting a product, examine the percentage active ingredient and compare to these averages. A larger number means more herbicide per unit weight but the actual amount applied to the lawn depends on the recommended rate expressed on the product label.

[2] The result of these constants when used in the formula represents the fraction of the professional rate tested at Virginia Tech and found to work. For example, two products are chosen that each treat 5000 square feet with 32 fluid ounce bottles. One product contains 0.41% fenoxaprop and the other contains 1.79% quinclorac. Using the formula, we find that the maximum rate of the fenoxaprop product is 0.62 times the professional rate and that of the quinclorac product is 0.46 times the professional rate. It is against the law to increase the consumer product rate above that recommended on the product label. To combat this problem, one can either apply the product more frequently (if the label allows) or buy another product to make up the difference. Just because the product exhibits a lower rate than that tested by Virginia Tech does not necessarily mean it will not work. By using the professional equivalency formula, however, one can make intelligent decisions regarding product choice. Choose the product that is closest to the professional rate (gives a value in the formula closest to 1.0).

[3] This active ingredient combination is only available in consumer products for use on lawns so comparison to professional products is not applicable.

III. Preemergence Control of Annual Bluegrass and Winter Broadleaf Weeds

Annual bluegrass and other winter weeds germinate when air temperatures fall below 75 F for extended periods as autumn approaches. Controlling these weeds with preemergence herbicides is similar to controlling crabgrass with preemergence herbicides, except products are applied in late summer or early fall instead of early spring. Refer to the section on "Preemergence Control of Crabgrass, Goosegrass and Other Summer Annual Grass Weeds" for specific products. Annual bluegrass germinates around the same time desirable cool-season turfgrass is seeded for lawn renovation or establishment. Avoid applying preemergence herbicides for annual bluegrass control before any lawn seeding. Seeding must be delayed for two to four months following herbicide application. Herbicides may typically be applied after the second mowing on new turfgrass, with some exceptions. Read and follow herbicide label. Also, avoid fertilizing the lawn with phosphorus fertilizer in early fall, as it promotes survival of germinating annual bluegrass seedlings.

IV. Postemergence Control of Annual and Roughstalk Bluegrass

Few selective herbicides exist to control annual bluegrass (*Poa annua*) and roughstalk bluegrass (*Poa trivialis*) in cool-season lawns and none are available to homeowners. Annual bluegrass should be targeted with preemergence herbicides and hand weeded or spot treated with nonselective herbicides. Roughstalk bluegrass should be spot treated and hand weeded. Postemergence herbicides for annual bluegrass control are available to professionals but none exist for postemergence control of roughstalk bluegrass.

V. Postemergence Control of Broadleaf Weeds

There are over 200 consumer broadleaf herbicides available for lawn weed control in Virginia. These are represented by 16 unique combinations of active ingredients (Table 5.8). Broadleaf weeds can be controlled anytime weeds are actively growing. Annual broadleaf weeds are best controlled when weeds are young. Perennial broadleaf weeds are best treated in the fall when weeds are moving energy reserves to roots in preparation for winter dormancy. The following points are important when controlling broadleaf weeds in the lawn:

- *IDENTIFY THE LAWN GRASS* - Some herbicides are safe to use on one species of turfgrass, but will severely injure or kill another species of turfgrass. These differences often occur between warm-season and cool-season turfgrasses but are not limited to this trend. Identify all species of turfgrass in the lawn and confirm that the product used is safe on these species.

- *IDENTIFY THE WEEDS* - Some broadleaf weeds die in summer or winter and may not need treatment. Others may require special active ingredients to insure complete control.

- *ACTIVELY GROWING WEEDS* - Avoid stressful periods, like drought, heat, and cold, so that weeds are growing when treated.

- *GET THE HERBICIDE IN* - Most broadleaf herbicides enter through foliage and require good coverage with foliar sprays, or the presence of dew on foliage, to dissolve granules and allow herbicide to enter the plant.

- *REDUCE DRIFT* - Broadleaf herbicides harm desirable ornamental shrubs and flowers, so don't apply them in windy conditions. Take steps to make sure the herbicide does not drift onto nontarget sites.

- *HARD-TO-KILL* - Some perennial broadleaves, like ground ivy, wild violet, common lespedeza, wood sorrel, and Virginia buttonweed, are difficult to kill. Use products that contain triclopyr or penoxsulam and expect to treat these weeds repeatedly, regardless of the product used.

- *AVOID "OLD" RTU PRODUCT* - Concentrate products are designed to have a shelf life of five to 10 years but "ready-to-use (RTU)" products have a shorter shelf life, as they are already mixed with water. Avoid buying any RTU product that has been on store shelves for over six months, and expect product performance to decline over time when stored at home.

Table 5.8 - Herbicides that selectively control broadleaf weeds in lawn grasses. A professional equivalency formula is provided to allow comparison of active ingredients and rates of consumer products to the rates proven to work at Virginia Tech and used by professionals.

Active Ingredient(s)	No. of Consumer Products in VA	Average Percent Active Ingredient in Consumer Products[1]	Professional Equivalency Constant (use formula)[2]	Special Notes
2,4-D + MCPP	11	1.1 + 0.54	$2.8_{Granular}$ 42.2_{Liquid}	Both granular and spray products available. Must have dew on turf for granular application.
2,4-D + Dicamba + MCPP	74	5.0 + 0.65 + 1.9	$2.4_{Granular}$ 52.3_{Liquid}	Both granular and spray products available. Must have dew on turf for granular application.
2,4-D + Dicamba + MCPP + Carfentrazone	10	19.1 + 1.1 + 3.6 + 0.36	52.3	Spray products only. Provides symptoms within 48 hours.
2,4-D + Dicamba + MCPP + Sulfentrazone	9	3.0 + 0.27 + 1.0 + 0.07	$3.5_{Granular}$ 53.7_{Liquid}	Both granular and spray products available. Also controls sedges.
2,4-D + Dicamba + MCPP + Dithiopyr	4	0.64 + 0.06 + 0.14 + 0.16	2.4	Granular products only. Also provides residual control of crabgrass and annual bluegrass.
2,4-D + Dicamba + MCPP + Isoxaben	4	4.73 + 0.52 + 1.1 + 2.63	52.3	Spray products only. Also provides residual broadleaf control.
2,4-D + Dicamba + Quinclorac	17	4.76 + 0.45 + 1.64	67.2	Spray products only. Also controls crabgrass.
2,4-D + Dicamba + Quinclorac + Sulfentrazone	3	9.19 + 1.1 + 5.3 + 0.53	65.9	Spray products only. Also controls sedges.
2,4-DP + 2, 4-D + MCPP	30	0.62 + 1.44 + 0.63	$4.8_{Granular}$ 73.9_{Liquid}	Both granular and spray products available. Must have dew on turf for granular application.
Dicamba + MCPP + MCPA + Carfentrazone	3	0.02 + 0.07 + 0.34 + 0.002	92.8	Spray products only. Provides symptoms within 48 hours.
Triclopyr	23	4.05	45.3	Spray products only. Kills brush, aids in control of perennial weedy grasses.
Triclopyr + 2.4-D + Dicamba	2	0.084 + 0.74 + 0.072	N/A[3]	Spray products only. Improved control of hard-to-kill broadleaf weeds.
Triclopyr + dicamba + MCPA	3	1.56 + 1.35 + 13.72	83.2	Spray products only. Improved control of hard-to-kill broadleaf weeds.
Penoxsulam	2	0.04	N/A[3]	Granular products only. Aids in control of hard-to-kill broadleaf weeds; use in conjunction with other broadleaf herbicide for broad-spectrum control.
Penoxsulam + Dicamba	1	0.03 + 0.07	N/A[3]	Granular products only. Improved control of hard-to-kill broadleaf weeds.
Penoxsulam + 2.4-D + Dicamba	2	0.01 + 1.04 + 0.08	N/A[3]	Granular products only. Improved control of hard-to-kill broadleaf weeds.

How to use professional equivalency constants:

(Go to www.ppws.vt.edu/~saskew/PEC.ppt for more information)

What is needed:

A = the sum of all active ingredients found under the "Active Ingredients" section of the product label (if the product contains 1.37% 2,4-D, 0.13% dicamba and 0.31% MCPP, enter "1.81")

B = total product weight in pounds for granules or volume in fluid ounces for liquids (for a 16 pound bag, enter "16" and for a 32 ounce bottle, enter "32")

C = the area treated by the product expressed in thousand square feet (i.e., if the bag treats 5800 square feet, enter 5.8)

Place these parameters into the following formula: Fraction of Professional rate = $\frac{\left(\frac{A \times B}{C}\right)}{\text{Equivalency Constant}}$

[1] These numbers represent the average percentage of active ingredient when combining all consumer products in Virginia that contain the same active ingredients. When selecting a product, examine the percentage active ingredient and compare to these averages. A larger number means more herbicide per unit weight but the actual amount applied to the lawn depends on the recommended rate expressed on the product label.

[2] The result of these constants when used in the formula represents the fraction of the professional rate tested at Virginia Tech and found to work. For example, a concentrate product that contains 7.59% 2,4-D plus 0.84% dicamba plus 1.83% MCPP and covers 8000 square feet with a 32 fluid ounce bottle will be found to be 0.78 times the professional rate using the formula. It is against the law to increase the consumer product rate above that recommended on the product label. To combat this problem, one can either apply the product more frequently (if the label allows) or buy another product to make up the difference. Just because the product exhibits a lower rate than that tested by Virginia Tech does not necessarily mean it will not work. By using the professional equivalency formula, however, one can make intelligent decisions regarding product choice. Choose the product that is closest to the professional rate (gives a value in the formula closest to 1.0).

[3] This active ingredient combination is only available in consumer products so comparison to professional products is not applicable.

Table 5.9 Broadleaf Weed Control in Bluegrass, Tall Fescue, Perennial Ryegrass, and Common Bermudagrass.

		Response to Herbicides					
Weed	**Classification**	**2,4-D + dicamba**	**2,4-D + MCPP**	**2,4-D + Dicamba+ MCPP**	**2,4-D + Dicamba+ Triclopyr**	**2,4-D + Dicamba + Penoxsulam**	**Preferred Time to Treat**
Bedstraw	[1]A	[2]S	I	R-I	S	I-S	Spring
Bindweed - Field	P	S	I-S	S	S	S	Spring
Hedge	P	S	I-S	S	S	S	Spring
Bittercress	WA	S	S	S	S	S	Fall
Black Medic	SA & P	S	I	S	S	S	Spring & Fall
Buttercup	WA & P	S	S	S	S	S	Spring & Fall
Buttonweed - Virginia	P	R-I	R	R-I	I-S	I-S	Spring Sequentially
Carpetweed	SA	S	S	S	S	S	Spring
Carrot - Wild	B	S	S	S	S	S	Fall
Catsear Dandelion	P	S	S	S	S	S	Fall
Chickweed - Common	WA	S	S	S	S	S	Spring & Fall
Mouseear	WA & P	S	I-S	S	S	S	Spring & Fall
Chicory	P	S	S	S	S	S	Fall
Cinquefoil - Common	A	S	S	S	S	S	Spring
Clover - Crimson	SA	S	S	S	S	S	Spring
Hop	SA	S	S	S	S	S	Spring
White	P	S	S	S	S	S	Spring & Fall
Daisy - Oxeye	P	I	I	I	I-S	S	Spring & Fall
Dandelion	P	S	S	S	S	S	Spring & Fall
Dichondra	P	I-S	I-S	I-S	I-S	I-S	Spring & Fall
Dock	P	I-S	I	I-S	I-S	I-S	Spring
Dogfennel	P	I	R-I	I	I-S	I-S	Spring & Fall
Garlic - Wild	P	I	I	I	I	I	Fall
Geranium - Carolina	WA	S	S	S	S	S	Spring & Fall
Ground ivy	P	I	I	I	I-S	I-S	Spring
Hawkweed	P	I	I	I	I-S	I-S	Fall
Healall	P	S	I-S	S	S	S	Fall
Henbit	WA	I-S	I	S	S	S	Fall
Honeysuckle	P	S	I-S	S	S	S	Spring & Summer
Horsenettle	P	I	R-I	I	I	I	Spring
Horseweed	WA & SA	I-S	I-S	I-S	S	I-S	Spring & Fall
Knapweed	B	I	I	I	I-S	I-S	Fall
Knawel	WA	I	I	I	I-S	I-S	Fall
Knotweed	SA	I	I	I	I-S	I-S	Spring & Summer
Lambsquarters	SA	S	S	S	S	S	Spring & Summer
Lespedeza	SA	I	I	I	I-S	I	Spring

Table 5.9 Broadleaf Weed Control in Bluegrass, Tall Fescue, Perennial Ryegrass, and Common Bermudagrass. (cont.)

Weed	Classification	Response to Herbicides					Preferred Time to Treat
		2,4-D + dicamba	2,4-D + MCPP	2,4-D + Dicamba+ MCPP	2,4-D + Dicamba+ Triclopyr	2,4-D + Dicamba + Penoxsulam	
Mallow	SA	I-S	I	I-S	I-S	I-S	Spring & Summer
Mugwort	P	R-I	R-I	R-I	I	I	Spring
Mustards	WA & B	I-S	I	S	S	S	Fall
Onion - Wild	P	I	I	I	I	I	Fall
Pennycress	A	S	S	S	S	S	Fall
Pepperweed	WA	S	S	S	S	S	Fall
Pigweed	SA	S	S	S	S	S	Spring & Summer
Plantains	P	S	S	S	S	S	Spring & Fall
Poison ivy	P	I-S	I	I-S	I-S	I-S	Summer & Fall
Poorjoe	A	I	I	I	I-S	I-S	Spring & Summer
Spurge - Prostrate	SA	R-I	R-I	R-I	R-I	I-S	Summer
Spotted	SA	R-I	R-I	R-I	R-I	I-S	Summer
Purslane	SA	S	I-S	S	S	S	Spring & Summer
Red Sorrel	P	I	I	I	I-S	I-S	Fall
Shepherd's Purse	WA	S	S	S	S	S	Fall
Smartweed	SA	I-S	I	I-S	I-S	I-S	Spring & Summer
Sowthistle	WA	S	S	S	S	S	Fall
Speedwell - Corn	WA	R	R	R	I	--	Spring
Persian	WA	R	R	R	I	--	Spring
Star-of-Bethlehem	P	R	R	R	R	--	Spring
Strawberry - Wild	P	I	R-I	I	I	I	Fall
Teasel - Common	B	I-S	I-S	I-S	S	I-S	Spring
Cutleaf	B	I-S	I-S	I-S	S	I-S	Spring
Thistle - Bull	B	I-S	I-S	I-S	I-S	R-I	Fall
Canada	P	I	R-I	I	I	R-I	Fall
Musk	B	S	S	S	S	S	Spring
Plumless	B &P	S	S	S	S	I-S	Spring
Violet	P	R-I	R	R-I	I-S	I-S	Spring Sequentially
Wood sorrel - Creeping	WA & P	R-I	R-I	R-I	I-S	--	Spring
Yellow	A	I	I	I	I-S	--	Spring
Yarrow	P	I	I	I	S	--	Fall
Yellow Rocket	B & P	S	I-S	S	S	I-S	Fall

[1]A = annual (summer or winter); B = biennial; P = perennial; SA = summer annual; WA = winter annual.
[2]R = resistant in most instances, poor control usually less than 50%; I = intermediate tolerance, good control at times with high rates, may require multiple treatments; S = weed susceptibility, often good control 70% or higher.

VI. Postemergence Control of Perennial Grass Weeds

The most common perennial grass weeds in Virginia are bermudagrass (wiregrass), dallisgrass, nimblewill, orchardgrass, and quackgrass. In most cases, the only control is to hand weed the grass or spot treat with a nonselective herbicide that contains glyphosate. In recent years, research studies have led to selective control measures for bermudagrass in cool-season lawns. Consumer products that contain fenoxaprop, fluazifop, mesotrione, and topramezone can be used as recommended to control bermudagrass. More effective control can be achieved by mixing triclopyr (Turflon Ester contains 61.6% triclopyr and is mixed to apply 0.73 fluid ounce per gallon to treat 1000 square feet). Triclopyr should not be applied during summer on Kentucky bluegrass or hard fescue. Selective bermudagrass control requires four to eight treatments per year depending on rate. Start treating when targeted bermudagrass starts to produce shoots and leaves in late spring and treat at three to four week intervals until frost. If the product label does not allow this many treatments, supplement with another product and apply in sequence or hand weed bermudagrass during mid-summer and limit treatments to spring and fall. Lawn grasses will be temporarily injured when targeting bermudagrass with these herbicides. Delay treatment if lawn grass has not completely recovered prior to the next normally-scheduled treatment. If turfgrass injury is a concern, treat only in spring and fall and discontinue treatments during mid-summer. Do not exceed maximum use rates or number of applications specified on product labels.

VII. Postemergence Control of Sedges

Yellow nutsedge is the most common sedge problem in Virginia. Sedges emerge in early summer and are present from June until frost. Most sedges are perennials and enter dormancy during winter. Sedges are not controlled by selective grass killers or preemergence herbicides that are used to prevent crabgrass. Sedges thrive in wet or hot summers and often require more than one herbicide treatment for season-long control. Yellow nutsedge produces small nutlets underground that sprout at some time in the future. It is important to hand pull small populations of sedge plants to reduce production of these nutlets. Hand pulling does not remove nutlets that are already produced, but helps reduce population expansion by preventing mature plants from making more nutlets. Herbicides kill some, but not all, nutlets attached to parent plants. Sedge problems won't be solved in one or two seasons, and require constant vigilance.

Table 5.10 - Herbicides that selectively control sedges in lawn grasses. A professional equivalency formula is provided to allow comparison of active ingredients and rates of consumer products to the rates proven to work at Virginia Tech and used by professionals.

Active Ingredient(s)	No. of Consumer Products in VA	Average Percent Active Ingredient in Consumer Products[1]	Professional Equivalency Constant (use formula)[2]	Special Notes
Bentazon	5	44	N/A[3]	Requires good coverage and repeat treatment after two weeks.
Halosulfuron	1	75	N/A[3]	Avoid stress, add surfactant, repeat treatment after four weeks if needed.
Sulfentrazone + 2,4-D + Dicamba + MCPP	9	0.07 + 3.0 + 0.27 + 1.0	$3.5_{Granular}$ 53.7_{Liquid}	Both granular and spray products available. Also controls broadleaf weeds.
Sulfentrazone + Prodiamine	13	0.18 + 0.1	1.7	Also provides residual control of crabgrass, goosegrass, and other annual grasses.
Sulfentrazone + 2,4-D + Dicamba + Quinclorac	3	0.53 + 9.19 + 1.1 + 5.3	65.9	Also controls broadleaves and crabgrass.

How to use professional equivalency constants:

(Go to www.ppws.vt.edu/~saskew/PEC.ppt for more information)

What is needed:

A = the sum of all active ingredients found under the "Active Ingredients" section of the product label (if the product contains 0.1% sulfentrazone and 0.2% prodiamine, enter "0.3")

B = total product weight in pounds for granules or volume in fluid ounces for liquids (for a 16 pound bag, enter "16" and for a 32 ounce bottle, enter "32")

C = the area treated by the product expressed in thousand square feet (for example if the bag or bottle treats 5800 square feet, enter 5.8)

Place these parameters into the following formula: Fraction of Professional rate = $\frac{\left(\frac{A \times B}{C}\right)}{\text{Equivalency Constant}}$

[1] These numbers represent the average percentage of active ingredient when combining all consumer products in Virginia that contain the same active ingredients. When selecting a product, examine the percentage active ingredient and compare to these averages. A larger number means more herbicide per unit weight but the actual amount applied to the lawn depends on the recommended rate expressed on the product label.

[2] The result of these constants when used in the formula represents the fraction of the professional rate tested at Virginia Tech and found to work. For example, a concentrate product that contains 3.74% 2,4-D plus 0.43% dicamba plus 1.79% quinclorac plus 0.22% sulfentrazone and covers 5000 square feet with a 32 fluid ounce bottle will be found to be 0.60 times the professional rate using the formula. It is against the law to increase the consumer product rate above that recommended on the product label. To combat this problem, one can either apply the product more frequently (if the label allows) or buy another product to make up the difference. Just because the product exhibits a lower rate than that tested by Virginia Tech does not necessarily mean it will not work. By using the professional equivalency formula, however, one can make intelligent decisions regarding product choice. Choose the product that is closest to the professional rate (gives a value in the formula closest to 1.0).

[3] Both bentazon and halosulfuron are available to consumers at agricultural cooperatives, distributors of professional turfgrass products, and high-end nurseries in small containers. The formulations and labels of these are the same as used by professionals so a professional equivalency constant is not needed.

VIII. Weed Control at Seeding

Seedling emergence is the most delicate stage of the turfgrass life cycle. Only a few herbicides can be applied to young turfgrass or be used for residual weed control while turfgrass is germinating.

When planning to seed new turfgrass:

- *KILL THE OLD* - Use a nonselective herbicide, such as glyphosate, to kill existing vegetation where a complete lawn renovation is desired. Apply glyphosate at least a week in advance of seeding, but longer is better. If bermudagrass or other hard-to-kill perennials are present allow four weeks or more for repeat treatment of escaped plants.

- *SOIL TEST* - If renovating the lawn, take the opportunity to conduct a soil test and add the appropriate soil amendments before seeding the new lawn grass.

- SEED-TO-SOIL CONTACT - Do seeding preparations, such as vertical mowing, raking, or tilling, before applying siduron for crabgrass prevention during seedling establishment.

- *KNOW HERBICIDE HISTORY* - Most herbicides require a 30 day wait before turfgrass seeding is allowed. Turfgrass seeding may be restricted for 60 to 120 days following treatment with preemergence crabgrass preventers. Check herbicide labels for seeding restrictions when planning to seed.

- *SEED IN FALL* - Seeding in fall avoids summer annual weeds, like crabgrass, from choking out desirable turfgrass seedlings. If seeding in spring, seed as early as possible and use one of the 13 products marketed in Virginia that contain siduron.

- *CONTROL WEEDY GRASSES IN SPRING* - Siduron and mesotrione are preemergence herbicides that controls crabgrass and many other summer annual grasses without harming germinating cool-season turfgrasses. Siduron and mesotrione kill warm-season turfgrass seedlings. Siduron does not control annual bluegrass and is typically not needed when fall seeding. Apply siduron or mesotrione the same day as seeding. Many products include siduron or mesotrione can be combined with starter fertilizer for convenience. Look for product names like “Seed Starter” or “Starter Fertilizer with Tupersan , or Turf Builder Starter Food for New Grass + Weed Prevente,” and check that the product contains contains siduron or mesotrione in the active ingredients section.

- *CONTROL BROADLEAF WEEDS* - Carfentrazone is an active ingredient often added to broadleaf herbicides to provide rapid symptoms on weeds. Unfortunately, most broadleaf herbicides can’t be applied to young turfgrass seedlings, but carfentrazone can be applied to seedling turf. Quicksilver is a professional product that only contains carfentrazone and is sold in small, affordable packages. Quicksilver controls seedling broadleaf weeds (under three inches tall) and will not harm emerging turfgrass. If Quicksilver can not be found, wait until the second mowing of newly-established turfgrass and then use one of many broadleaf herbicides registered for use in the lawn. Check the label for specific restrictions on when to apply after seeding.

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