Contact vs. systemic fungicides

▶ Contact fungicides are an older type of fungicide also known as protectants that intercept a fungus and prevent it from attacking or getting inside a grass plant. They don't penetrate plant tissues but inhibit fungi by interfering with the growth and development of fungi in a number of ways, i.e., multiple site inhibitors. This creates a very low risk that fungal resistance will develop.

▶ For a fungus to develop resistance, it needs to change its DNA. But contact fungicides are toxic to many different fungi, including many non-target fungi that are beneficial to your turf, and they must be applied frequently.

▶ Systemic fungicides "move" once applied to the turf and redistribute inside the plant. Some fungicides are locally systemic; meaning they only move a few cells away from the point of entry. A carrier is a material upon which the active ingredient is loaded, for the application and the carrier itself can have fungicidal activity and can greatly affect how the active ingredient reacts and enters a plant.

▶ Generally systemic fungicides require 3 to 5 days to become fully effective. To be effective, the disease severity at the time of application must be low, so it is important to scout your turf and look for the start of disease. — *Hank Wilkinson*

CONTACT FUNGICIDES[a]

Common name	Trade name	Chemical class
captan	Captan	carboximide
chloronebb	Terraneb SP	chlorinated aromatic
chlorothalonil	Daconil	nitrile
etridiazole (ethazole)[b]	Terrazole, Koban	triadiazole
mancozeb	Fore, Manzate	ethylene bis-dithiocarbamate
PCNB (quintozene)[b]	Turfcide, Terraclor	chlorinated aromatic
thiram	Spotrete	dithiocarbamate

a Also known as "protectant" fungicides. Contact fungicides remain on plant surfaces and don't penetrate into tissues. All are multi-site inhibitors and have low risk for supporting fungal resistance development.

b Purported to have some systemic activity.

COURTESY OF R.T. KANE AND H.T. WILKINSON

Why fungicides fail in ornamentals

By Bal Rao, Ph.D

Generally, fungicides fail because of the conditions to which they're exposed. Unreasonable expectations can also cause someone to call a fungicide application a failure. By following label specifications and using the process of elimination, you should be able to narrow down or identify the cause(s) of disease management failures. This will help you develop effective disease management strategies and correct or improve future failures.

Some of the following factors may be responsible for poor disease management on ornamentals.

- Not following label specifications
- Not knowing the disease or plants well through improper identification or not understanding resistance, plant sensitivity, disease characteristics or pathogen life cycle.
- Product failure due to improper selection, slow activity, low concentration, failure to penetrate surface, solvent causing phytotoxicity, product age or photodegradation or other breakdown, incompatibility of products, limited activity, short residual effect, label limitations or heavy disease pressure.
- Misunderstanding treatment methods by miscalculating active ingredient, improper or faulty mixing/cleaning, failure to add surfactant or other agents, failure on application, failure to water in, improper equipment or calibration, no follow-up applications, poor plant uptake, rain wash-off, wind drift, soil conditions, improper storage.
- Poor timing in application related to pathogen's life cycle, degree days, extended cool and moist periods favoring disease developments, activity after residual is gone or multiple flushes of pathogen growth.

— The author is Manager of Research and Technical Development at The Davey Tree Expert Co., Kent, OH.

SYSTEMIC FUNGICIDES GROUPED BY CHEMISTRY AND MODE OF ACTION [a]

Common name	Trade name	Mode of action	Resistance risk
(benzimidazoles):			
benomyl	Tersan 1991*	mitotic poison (SSI)	high
thiophanates	Fungo, Cleary 3336	mitotic poison (SSI)	high
(phenylamide):			
metalaxyl	Subdue, Apron	RNA synthesis inhibitor	high
mefanoxam	Subdue MAXX	RNA synthesis inhibitor	high
(1,2,4-triazoles):			
cyproconazole	Sentinel*	demethylase inhibitor	moderate
myclobutanil	Eagle	DMI	moderate
propiconazole	Banner	DMI	moderate
tebuconazole	Lynx	DMI	(expmtl)
triadimefon	Bayleton	DMI	moderate
triticonazole	Triton	DMI	(expmtl)
(pyrimidinemethanol):			
fenarimol	Rubigan	DMI	moderate
(strobilurins):			
azoxystrobin	Heritage	respiration inhibitor	moderate
kresoxim-methyl	Experimental	cytochrome bc complex	moderate
trifloxystrobin	Compass	in mitochondria	moderate
(dicarboximides):			
iprodione	Chipco 26019, GT	not well known	moderate
vinclozolin	Vorlan, Curalan	not well known	moderate
(benzamide):			
flutolanil	Prostar	multi-site	low
(carbamate):			
propamocarb	Banol	membrane disruption MSI	low
(phosphonate):			
fosetyl-aluminum	Aliette	indirect plant activity	low

(a) Some are single-site inhibitors (SSI), and a few are multi-site inhibitors (MSI). SSIs have a moderate to high risk of developing fungicide resistance.

(*) Systemic fungicides marked with an asterisk are no longer available.

COURTESY OF R.T. KANE AND H.T. WILKINSON

KEY LANDSCAPE PLANTS AND THEIR DISEASES

Ash (Fraxinus)
* Anthracnose

Ivy, Boston (Parthenocissus)
* Black rot

Azalea (Rhododendron)
* Botrytis blight
* Leaf gall
* Nematodes
* Ovulinia flower blight
* Powdery mildew
* Root rots

Ivy, English (Hedera)
* Colletotrichum leaf spot
* Bacterial leaf spot

Cherry (Prunus)
* Bacterial leaf spot
* Black knot
* Coccomyces leaf spot

Juniper (Juniperus)
* Cedar-apple and cedar-quince rusts
* Kabatina twig blight
* Phomopsis twig blight
* Root rot

Crabapple (Malus)
* Cedar-apple rust
* Fire blight
* Powdery mildew
* Scab

Lilac (Syringa)
* Bacterial leaf blight
* Powdery mildew
* Witches' broom

Dogwood (Cornus)
* Anthracnose\ Decline
* Septoria leaf spot

Oak (Quercus)
* Anthracnose
* Decline
* Leaf blister

Elm (Ulmus)
* Botryodiplidia canker
* Dutch elm disease
* Black leaf spot
* Phloem necrosis (yellows)
* Wetwood

Pachysandra (Pachysandra)
* Volutella blight

Hawthorn (Crataegus)
* Fire blight
* Leaf spot
* Rust

Pine (Pinus)
* Sphaeropsis (Diplodia) tip blight
* Needle blights
* Cyclaneusma Needlecast
* Lophodermium Needlecast
* Ploioderma (Hypoderma) Needlecast
* Root rots
* Gall and cankering rusts

Rhododendron (Rhododendron)
* Botryosphaeria dieback
* Cercospora leaf spot
* Ovulinia flower blight
* Phytophthora die-back and root rot

Spruce (Picea)
* Cytospora canker
* Rhizosphaera Needlecast

Rose (Rosa)
* Black spot
* Cankers
* Powdery mildew
* Rust

Sycamore (Platanus)
* Anthracnose
* Powdery mildew

SOURCE: PENN STATE UNIVERSITY COOPERATIVE EXTENSION

HOW TO MANAGE WOODY ORNAMENTALS AND THEIR DISEASES

	Dormant	Bud break	Summer	Autumn
Arborvitae (Thuja)				
Kabatina twig blight	P	BSp		BSp
Phomopsis twig blight	P	BSp		BSp
Root rot			D	
Ash (Fraxinus)				
Anthracnose				R
Azalea (Rhododendron)				
Botrytis blight		BSp		
Leaf gall		P-BSp*		
Leaf spots		BSp		R
Nematodes				F
Ovulinia flower blight		BSp		
Phytophthora dieback	P	BSp	CSp	CSp-P
Powdery mildew			BSp	CSp
Root rots		D	D	F
Boxwood (Buxus)				
Canker	P	BSp		BSp
Macrophoma leaf spot	P		I	
Nematodes				F
Root rot				F
Catalpa (Catalpa)				
Leaf spots				R
Powdery mildew				NT
Verticillium wilt				NT
Cherry (Prunus)				
Bacterial leaf spot		BSp	CSp	
Black knot	P-X*	BSp		
Coccomyces leaf spot			BSp	

	Dormant	Bud break	Summer	Autumn
Chestnut (Castanea)				
Blight	P-X*			
Leaf spot				R
Cotoneaster (Cotoneaster)				
Fire blight	P-BSp*	CSp	CSp	
Scab		BSp	CSp	
Crabapple (Malus)				
Cedar-apple rust			NT	
Fire blight	P-BSp*	CSp*	CSp*	
Powdery mildew			NT	
Scab		BSp	CSp	R
Dogwood (Cornus)				
Anthracnose	P	BSp	CSp	
Decline	P-X*	BSp	CSp-I	I
Septoria leaf spot		BSp	CSp	

ABBREVIATIONS of suggested control techniques to employ at each key management time:

*	Only if the disease had been severe
BSp	Begin spray schedule-discontinue when weather dries
CSp	Continue spraying if wet-discontinue when weather dries
D	Apply soil drench fungicides
F	Fumigate before planting
I	Irrigate to prevent drought stress
NT	No treatment required
P	Prune
R	Rake and destroy fallen leaves
X	Remove infected plant

Visit our Web site's "This Month's Features" page (www.landscapemanagement.net) to see a more comprehensive list of woody ornamentals and their diseases.

SOURCE: PENN STATE UNIVERSITY COOPERATIVE EXTENSION

SUGGESTED WEED IDENTIFICATION GUIDES FOR TURF AND LANDSCAPE INDUSTRIES

Weeds of Southern Turfgrass

Publication Distributions Center
IFAS Building 664
P. O. Box 110011
University of Florida
Gainesville, Florida 32611
(904-392-1764)
$8.00 / Particularly useful for weeds of turf and landscapes in the Coastal Plain but appropriate for turf throughout Southeastern US. Color photographs and brief descriptions of each species.

Weeds of the Northeast

Cornell University Press
P.O. Box 6525
Ithaca, NY 14851_6525
607-277-2211
$29.95 (+ shipping) / Appropriate to the Northern tier of the US (south to North Carolina) and southern Canada. About 300 species are covered. Several color photographs and drawings for each species, descriptions, and identification keys.

Weeds of the West

University of Wyoming
U.W. Coop. Extension Service Bulletin Room
University of Wyoming
PO Box 3313
Laramie WY 82071-3313
$24.50 / A full color guide focused primarily on weeds of western US agriculture. Multiple color photos of each weed and brief descriptions are included. There is no key.

Weed ID Guide

Southern Weed Science Society
1508 West University Ave.
Champaign, IL 61821_3133
$97.00 (includes all six sets of weed sheets, index and a binder)
CD_ROM Weeds of the United States is $120 A 'high-end' and relatively expensive resource, this is available in notebook form (so it can be continually updated) and also a CD_ROM. High quality photographs with brief descriptions. No key is included.

Color Atlas of Turfgrass Weeds

Ann Arbor Press
310 North Main Street
P.O. Box 20
Chelsea Michigan 48118
800-487-2323
$79.95 (plus shipping) / A color guide to turfgrass weeds. This guide covers weeds of warm-season and cool-season areas. Several photographs of each species and brief descriptions. Control guidelines are included.

NEWSS web site

http://www.ppws.vt.edu/newss/newss.htm The Northeastern Weed Science Society web site has a listing of internet sources for weed identification guides.

How to get maximum control of summer weeds

Maximum control of summer annual weeds with preemergence herbicides can be achieved by following these basic guidelines:

1. ***Apply the product at the recommended time and rate.*** Weather varies from year to year and it may be necessary to apply earlier than normal. Reference to 30-day weather forecasts can help with this decision.

2. ***Apply the product before rain is expected or water it in with two inches of irrigation water.*** Numerous instances of poor weed control occur each year because of the lack of rain or an irrigation event within seven days of preemergence application. Additionally, irrigating-in the herbicide is an excellent method to prevent losses due to volatility and lateral herbicide leaching. Turfgrass preemergence herbicides essentially do not leach in downward direction beyond a depth of one to three inches due to binding to soil colloids and organic matter. But they can move laterally, particularly if heavy rainfall occurs shortly after application. Thus, irrigation will usually improve weed control and will help to prevent lateral movement.

3. ***Calibrate all application equipment.*** Uniform application is critical to achieving good weed control.

4. ***If fertilizer/herbicide formulations are to be used, select a product that has uniform particle size.*** Be sure the product is applied with a sufficient number of particles to ensure even, uniform application. Also, be sure that the herbicide load is sufficient to apply the recommended rate of the product. Johnson and Murphy (1993) showed that dithiopyr rates can be reduced if applied on a dry granular carrier (Table 3). However, with most other preemergence herbicides the amount of active ingredient applied per acre should be the same either for sprayable or dry formulations.

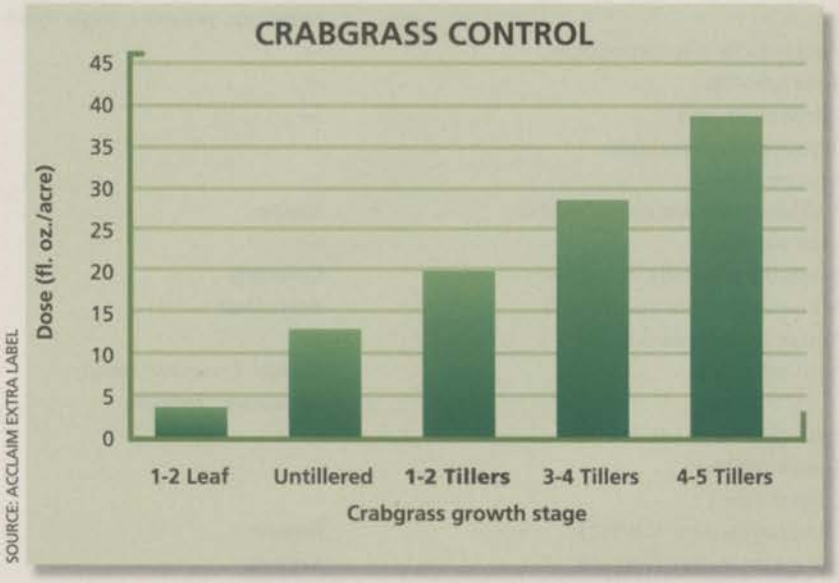
5. ***Delay mowing until after a rainfall or irrigation event.*** Studies have shown that mowing and bagging operations can remove significant quantities of a preemergence herbicide if conducted before the herbicide is moved into the soil by rain or irrigation water.

6. ***Properly maintain the turfgrass.*** Following recommended cultural practices that promote normal turfgrass growth and development will enable the turfgrass to compete with weeds. The first line of defense against weed infestations has been, and probably always will be, a thick, healthy, properly maintained turfgrass. Adherence to recommended soil fertility and pH levels, proper irrigation, controlling other pests, and mowing at the correct height and frequency will improve the effectiveness of most chemical weed control programs.

Why herbicides fail

1. Not reading and/or following label specifications
2. Improper weed identification
3. Improper herbicide selection
4. Improper method of application
5. Improper timing of application
6. Unfavorable temperature and/or moisture conditions affecting poor weed growth
7. Age and growth stage of the weed plant — young vs. mature target weed
8. Temperature too hot or too cold
9. Skipped area — spot treating/poor overlapping resulting in poor coverage
10. Foliage not wet — product failed to penetrate leaf hairs
11. Low concentration of mix — not enough active ingredient to manage weed
12. High concentration of herbicide killed the top, not the roots
13. Wind drift — failure to deliver herbicide to the target
14. Rain following application washed off treatment
15. Product too old — deactivated
16. Product caked — spoiled
17. Product separated into layers
18. Chemical and/or physical incompatibility
19. Alkaline (high pH of water) hydrolysis and herbicide degradation
20. Droplet size too large — some herbicides perform better if particle size is finer
21. Improper mixing sequence while using multiple products
22. Insufficient agitation while mixing
23. Past residue in the tank
24. Improper tank cleaning — herbicide residues are difficult to rinse
25. Failure to agitate or shake product containers to mix ingredients before using
26. Failure to add surfactant as needed
27. Weed is difficult to control — morphological, waxy cuticle
28. Failure to incorporate into soil, if required
29. Too much organic matter such as mulch ties up herbicide
30. Product is a contact herbicide and not translocated
31. Pre-emergent activity only
32. Post-emergent activity only
33. Poor systemic activity — foliar vs. root absorbed
34. High temperature closed the stomata opening
35. Large number of weed seeds remains viable in soil for a long time
36. Open bare ground — no mulch or other cover
37. Not post watered in, if needed
38. Water quality of mix — muddy water ties up some herbicides
39. Weed resistance from repeated use of a specific herbicide-resistant biotypes
40. Host plant age — newly planted vs. established trees and shrubs
41. Winter annual weeds in established plantings may need fall or early winter application
42. Booster application not received
43. Booster application not complimentary — e.g. Princep followed by Ronstar
44. Application of herbicide over top of plants may cause injury
45. A combination of pre- and post-herbicides may be needed
46. Insufficient time for the herbicide to act — activity may start in a few days, weeks or may be delayed for a year
47. Weeds blownor carried from nearby areas
48. Susceptible plants — some ground covers may not be labeled
49. Plant with deep growing parts in soil — rhizomes or tubers
50. High weed pressure — too many weed seeds: crabgrass, dandelion or annual bluegrass

— Bal Rao, Ph.D.



As crabgrass grows, higher herbicide doses are required to obtain control. This chart illustrates the doses of Acclaim Extra recommended to control different sized crabgrass plants.

URBAN TOLERANT TREES

BOTANICAL NAME	VARIETY	COMMON NAME
■ Abies concolor	—	White fir
■ Acer campestre	`Evelyn'	Queen Elizabeth hedge maple
■ Acer x freemanii	Autumn blaze/celebration	Freeman maple
■ Acer griseum	—	Paperbark maple
■ Acer nigrum`greencolumn'	Greencolumn	Black maple
■ Acer rubrum `franksred'	Red sunset	Red maple
■ Acer saccharum	Fairview, legacy, green mountain	Sugar maple
■ Acer tataricum	—	Tatarian maple
■ Acer truncatum x platanoides `warrenred'	Pacific sunset	Shantung maple
■ Amelanchier x grandiflora `autumn brilliance'	Autumn brilliance	Serviceberry
■ Betula utilis var. jacquemontii	Whitebarked Himalayan	Birch
■ Betula nigra `heritage'	Heritage	River birch
■ Carpinus betulus `fastigata'	Pyramidal	European hornbeam
■ Cercidiphyllum japonicum	—	Katsura tree
■ Cladrastis lutea	—	Yellowwood
■ Cornus hybrid	Aurora, celestial, stellar Pink constellation, Ruth Ellen, star dust	Stellar series
■ Cornus kousa `Milky Way'	Milky Way	Kousa dogwood
■ Corylus colurna	—	Turkish hazelnut
■ Eucommia ulmoides	—	Hardy rubber tree
■ Ginkgo biloba `PNI 2720'	Princeton sentry	Ginkgo
■ Gleditsia triacanthos inermis	Moraine, shademaster, skyline	Honeylocust
■ Halesia tetraptera	—	Carolina silverbell
■ Kalopanax pictus	—	Castor-aralia
■ Koelreuteria paniculata	—	Goldenrain tree
■ Lagerstroemia indica	Apalachee, biloxi, Byers white, centennial spirit	Crape myrtle
■ Maackia amurensis	—	Amur maackia
■ Magnolia hybrid	—	Galaxy magnolia
■ Magnolia virginiana	—	Sweetbay magnolia
■ Malus species	Adams, centurion, golden raindrops, prairifire, sugar tyme	Crabapple
■ Metasequoia glyptostroboides	—	Dawn redwood
■ Nyssa sylvatica	—	Black tupelo
■ Ostrya virginiana	—	American hop hornbeam
■ Oxydendrum arboreum	—	Sourwood
■ Parrotia persica	—	Persian parrotia
■ Phellodendron amurense `macho'	Macho	Amur corktree
■ Pinus parviflora	—	Japanese white pine
■ Platanus x acerifolia `columbia'	Columbia	London planetree
■ Prunus subhirtella `rosy cloud'	Rosy cloud	Cherry
■ Pseudotsuga menziesii	—	Douglas fir
■ Pyrus calleryana	Capital, Cleveland select, Edgewood, redspire	Callery pear
■ Pyrus calleryana var. fauriei	—	Pea pear
■ Quercus bicolor	—	Swamp white oak
■ Quercus rubra	—	Northern red oak
■ Sophora japonica `PNI 5625'	Regent	Scholar tree
■ Syringa reticulata `ivory silk'	Ivory silk	Tree lilac
■ Taxodium distichum `mickelson'	Shawnee brave	Bald cypress
■ Tilia tomentosa	Green mountain, sterling	Silver linden
■ Ulmus americana `princeton'	Princeton	American elm
■ Zelkova serrata `village green'	Village green	Zelkova

CONVENTIONAL INSECTICIDES FOR TURF PESTS

Insects	acephate	bendiocarb (Turcam)1	carbaryl (Sevin)1	cyfluthrin (Tempo)1	ethoprop (Mocap)1	halofenozide	imidacloprid (Merit)1
white grubs		x	x		x	x	x
Ataenius	x	x			x	x	x
bluegrass billbug	x l	x l	x a	x a,l		x l	x l
sod webworms	x	x	x	x	x	x	
cutworms	x		x	x	x	x	
armyworms			x	x		x	
leafhoppers	x	x	x				
greenbugs	x						
chinch bugs	x	x	x	x	x		
ants		x	x	x			

a=adult, l=larvae, 1=an example of a trade name, inclusion does not imply endorsement

isofenphos (Oftanol)1	metaldehyde	trichlorfon
x		x
x		x
x a,l		
x		x
x		x
x		
x		

INSECT PESTS OF COOL-SEASON GRASSES

BENTGRASS
- * Mole cricket
- * Sod webworm

BLUEGRASS
- * Sod webworm
- * Billbug

TALL FESCUE
- * Ants
- * Army/cutworms
- * Bees/wasps
- * White grubs
- * Green june beetles
- * Ground pearls
- * Leafhoppers/spittlebugs
- * Sod webworms

RYEGRASS
- * Fall armyworm
- * Leafhoppers

INSECT PESTS OF WARM-SEASON GRASSES

BERMUDAGRASS
- * Billbug
- * Sod webworm

CENTIPEDEGRASS
- * Ground pearls
- * Hunting billbug
- * Two-lined spittlebug

ZOYSIAGRASS
- * Billbug

ST. AUGUSTINEGRASS
- * Ground pearls
- * Hunting billbugs

SOURCE: NORTH CAROLINA COOPERATIVE EXTENSION

Why insecticides and miticides fail

A. Failures related to label: not reading and/or following label specifications

B. Failures related to identification: not knowing the pest or plants well

C. Failures related to products: not knowing the products well

D. Failures related to methods: not knowing the method of treatment well

E. Failures related to timing: improper timing of application

– Bal Rao, Ph.D.

TABLE 1. BEHAVIORS/CHARACTERISTICS OF VARIOUS PLANTS

Plant	Location
Cornus florida (flowering dogwood)	**Michigan:** understory tree, protect from wind & salt
	North Carolina: full sun turf tree, street
Buddleia davidii (butterfly bush)	**Michigan:** tender woody plants, dies back down to ground, grows 4 to 6 ft., good use in a perennial garden
	New Mexico: woody shrubs, grows 6 to 15 ft., use in perennial border or informal shrub mass
Tsuga canadensis	**Kentucky:** can use for street tree (Canadian hemlock) **Michigan:** needs wind and salt protection, partial shade
Rhododendron catawbiense	**Michigan:** avoid western and southern exposure, protect from northern winds, grows 4 to 6 ft., possibly a little larger if well cared for.
	Pennsylvania: good evergreen screen, grows 10 to 16 ft.

TABLE 2. PLANT SUBSTITUTION SUGGESTIONS

Plant	Substitution
Cornus florida (flowering dogwood)	*Cornus kousa* (kousa dogwood)
Hemerocallis (daylily)	*Liriope spicata* (creeping lily turf)
Craetaegus sp. (hawthorne)	*Chionanthus virginicus* (white fringe tree)
Acer sacharum (sugar maple)	*Cladrastis lutea* (yellowwood)
Euonymous alata 'Compacta' (burning bush)	*Viburnum dentatum* (arrowwood viburnum)
Syringa vulgaris (common lilac)	*Vitex agnus negundo* (lilac chaste tree)
Azalea sp. (rhododendron)	*Daphne x burkwoodii* (burkwood daphne)
Juniperis horizontalis	*Microbiota decussata* (Russian cypress)
Spiraea bumalda 'Goldflame'	*Callicarpa dichotoma* (beautyberry)
Picea abies 'Conica' (dwarf alberta spruce)	*Sciadopitys verticillata* (Japanese umbrella pine)
Cotoneaster horizontalis (rockspray cotoneaster)	*Erica or Caluna sp.* (heath or heather)
Hydrangea sp.	*Aronia melanocarpa* (black chokeberry)
Amelanchier sp.	*Amelanchier sp.* (nothing beats a good amelanchier!)

WOODY ORNAMENTALS RESISTANT OR IMMUNE TO CROWN GALL

Abelia
Ailanthus (tree-of-heaven)
Albizia (silk tree)
Amelanchier (serviceberry)
Berberis (barberry)
Betula (birch)
Buxus (boxwood)
Calluna (heather)
Carpinus (hornbeam)
Catalpa
Cedrus (cedar)
Cercis (redbud)
Cladrastis (yellowwood)
Cotinus (smoke tree)
Cryptomeria
Deutzia
Fagus (beech)
Ginko (maidenhair tree)
Gymnocladus (Kentucky coffee-tree)
Ilex (holly)
Kalmia (mountain laurel)
Koelreuteria (golden-rain tree)
Laburnum (golden-chain tree)
Larix (larch)
Leucothoe
Liquidambar (sweet gum)
Liriodendron (tulip tree)
Magnolia
Mahonia (Oregon grape, holly grape)
Nyssa (sour gum)
Picea (spruce)
Pieris (andromeda)
Pyracantha (firethorn)
Rhus (sumac)
Sambucus (elderberry)
Sassafras
Tsuga (hemlock)
Zelkova

SOURCE: VIRGINIA COOPERATIVE EXTENSION, VIRGINIA TECH AND VIRGINIA STATE UNIVERSITIES

Use the following chart to determine the correct amount of fertilizer when applying nitrogen required per 1000 square feet.

Fertilizer analysis	lbs of nitrogen desired per 1000 sq. ft.			
	1/2	1	1.5*	2.0*
	lbs fertilizer per 1000 sq. ft.			
6-2-0	8.3	16.6	25.0	33.0
10-10-10	5.0	10.0	15.0	20.0
12-4-8	4.1	8.3	12.5	17.0
16-8-8	3.1	6.2	9.4	12.0
20-0-16	2.5	5.0	7.5	10.0
23-3-7	2.1	4.3	6.5	8.6
28-0-12	1.8	3.6	5.3	7.2
31-0-0	1.6	3.2	4.8	6.4
33.5-0-0	1.5	3.0	4.5	6.0
38-0-0	1.3	2.6	3.9	5.2
46-0-0	1.1	2.2	3.2	4.4

SOURCE: VIRGINIA COOPERATIVE EXTENSION, VIRGINIA TECH AND VIRGINIA STATE UNIVERSITIES

TABLE 1

Nitrogen Sources	Value	Release Mechanisms
Urea	46-0-0	Water, temperature, microbial
Ammonia sulfate	21-0-0	Water, moderate temperature
Nitrate (ammonia)	33-0-0	Water, low temperature

TABLE 2

Product Category	Release Factors				
Coating	*thickness*	*temp.*	*pH*	*microbes*	*water*
Polymer coated sulfur coated ureas (SCU) (42-0-0)	XX	XX	X	X	XX
Methelyene ureas (40-0-0)	—	XX	X	X	XX
Ureaform (38-0-0)	—	XX	X	XX	X
IBDU (31-0-0)	—	X	—	—	XXX
Polymer coated ureas (i.e. Polyon), (42,43,44-0-0)	XXX	XXX	—	—	—

Degree of influence

— = NONE **X** = MINIMAL **XX** = MODERATE **XXX**= MAJOR

LOW TO HIGH RANGES OF SEEDING/ESTABLISHMENT RATES

Grass type	Rate
Kentucky bluegrass	1.5 to 3.0 lbs/1,000 sq. ft.
Perennial ryegrass	2 to 4 lbs./1,000 sq. ft.
Fine fescue	2 to 4 lbs./1,000 sq. ft.
Tall fescue	9 to 10 lbs./1,000 sq. ft.
Bermudagrass	1 bushel of springs/1,000 sq. ft. or 2-in. plugs on 6-in. spacings
Zoysiagrass	2-in. plugs on 6-in. spacings in rows 6 in. apart

SOURCE: JOHN FECH, UNIVERSITY OF NEBRASKA

Turfgrass management factors that can affect the "health" of your turf mowing:

PGRs
clippings
topdressing
irrigation
fertilization
overseeding
sodding
herbicides
shading
surfactants
nematicides
aerification
compaction
soil reaction
weeds
seed mixtures
seed blends
drainage (runoff)
organic amendments
soil amendments
biological agents (living)
growth stimulators
heat
irradiation
humidity (dew)
air circulation (drying)
fungicides

— Hank Wilkinson

RECOMMENDED MOWING HEIGHTS FOR TURFGRASSES

Turfgrass	Mowing Heights (inches)
Kentucky bluegrass	11/2 to 21/2
Tall fescue	2 to 3
Creeping red fescue	2 to 3
Perennial ryegrass	11/2 to 21/2
Bermudagrass	1/2, to 1
Zoysiagrass	3/4 to 1

SOURCE: VIRGINIA COOPERATIVE EXTENSION, VIRGINIA TECH AND VIRGINIA STATE UNIVERSITIES