Weed resistance management and controlling perennial grassy weeds

Inland Empire Chapter GCSAA Golf Course Superintendents Association of America

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Outline for today's presentation

- Strategies to limit herbicide resistance development
- Perennial Grass Control – Top 10
- On-line resources for research-based information on turfgrass weed control

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Herbicide Resistance - Definition

- Genetic characteristic of a weed or plant biotype to survive a herbicide application

  Biotype = a group of plants within a species that has biological traits that are not common to the population as a whole.

- *Interestingly, plants also have a genetic capacity to develop resistance to many abiotic stresses like drought, heat, cold etc. based on exposure and subsequent selection pressure*

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Herbicide-resistance Mechanisms in Weeds

Target Site

- Altered site of action
  - Mutation in gene coding for herbicide target site; prevents herbicide binding.
  - Overproduction of the site of action.

Non-Target Site

- Reduced translocation - decreased absorption and translocation.
- Enhanced metabolism - converts herbicide to a form no longer toxic.
- Sequestration - isolation of herbicide in vacuoles or intracellular spaces.

Image from Herbicide Resistance: Development and Management. New Mexico State University.

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Herbicide Resistance

- **Cross resistance**
  - Weed biotype that has gained resistance to more than one herbicide with the same mode/mechanism of action. Same or different families.
    - Group 4 – synthetic auxins, i.e. 2,4-D, MCPA, dicamba, triclopyr
- **Multiple resistance**
  - Weed biotype that has developed tolerance to more than one herbicide (or stress) brought about by different selection pressures *(different modes/mechanism of action).*
    - Annual bluegrass (9 MOAs) and goosegrass (8 MOAs)

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Herbicide Resistance - Around the World *(2020)*

- 509 Resistant Biotypes
- Resistance identified in 21 of the 31 herbicide sites of action: 164 different herbicides
- 266 Species (153 dicots and 113 monocots)
- More than 270,000 locations in 71 countries

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The Beginning of Documented Weed Resistance

- 1968 (Washington)
- nursery crops
- common groundsel
- atrazine and simazine

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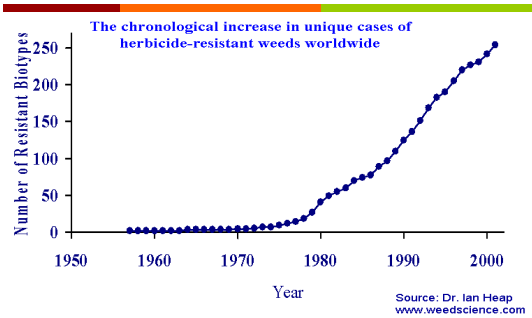

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Weed Characteristics That Favor Resistance

- Reproductive capability
  - High seed production
  - High germination rate
- Seed dispersal mechanisms
  - Method(s) by which plant spread seeds.
  - Wind, animals, equipment

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Equipment Examples

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Equipment Examples

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Herbicide Characteristics/Strategies Impacting Weed Resistance

- Single site of action
- Used multiple times during the growing season
- Used for consecutive growing seasons
  - Resistance can be developed within 2 years depending on species and/or herbicide
- Used without other control strategies

Single site of action herbicides

Several herbicide families only interfere with a single site of action. They include the following:

- ALS inhibitors (Group 2)
- ESPS synthase inhibitors (glyphosate) (Group 9)
- AACase inhibitors (Group 1)
- Seedling root inhibitors (Group 3)
- Photosynthesis inhibitors (Groups 5-7)
- Cell membrane disrupters (Groups 14 and 22)
- Pigment inhibitors (Groups 12, 13 and 27)

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Herbicide Resistance Should Only Be Suspected When ...

- Other causes of herbicide failure have been ruled out.
- The same herbicide or herbicides with the same mode of action have been used year after year.
- Weeds normally controlled are not, while others weeds of the same species are.
- Healthy weeds are mixed with controlled weeds (same species).
- Patch of uncontrolled weeds is spreading, following multiple applications of the same herbicide.

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Causes of Herbicide Failures

- Weed size
- Moisture
- Temperature
- Humidity
- Rate
- Application method
- Calibration
- Others

All possible reasons for reduced control which should be investigated before considering the possibility of resistance.

Image from Annual Bluegrass, Purdue University.

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Strategies for Control/Prevention of Resistance

Light-green annual bluegrass in trafficked, compacted soil. Image from Annual Bluegrass, Purdue University.

- Proactive vs. reactive
- Use other weed management tactics (healthy turf, mowing, compaction control, deficit irrigation)
- Rotate herbicides with different MOA
- Prevent seed production
- Clean mowing and cultivation equipment

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Ross Braun
@Ross_Braun

These two lawns were established with the same sod at the same time (2017). Both lawns have never received a pesticide application. However, one is fertilized twice a year (mainly fall) and mowed higher all year. #Lowinputturf pic.twitter.com/2l4Hy0nEYp

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Note: both receive similar amounts of water (rain only with no in-ground irrigation) with the one on the right receiving hose sprinkler watering when minimal rain has occurred for 3+ weeks.

Management matters (KB in Indiana)

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Herbicide-resistant weeds in turfgrass: Current status & emerging threats (Brosnan et al, 2020)

Documented cases:

- smooth crabgrass (NJ)
- goosegrass (SE-US; cross resistance)
- annual bluegrass (world; cross resistance)
- annual sedge (*Cyperus* sp; SE-US)
- spotted spurge (SE-US)
- yellow nutsedge (in rice; halosulfuron)
- buckhorn plantain (IN, PA)
- barnyard grass
- green foxtail

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How does it happen? Two possibilities.

- Survival of the fittest (*I did everything right!*)
  - Selects for naturally occurring resistance in pest population.
  - Selection pressure.
- What happened to my genes (*mutagenesis*)?
  - Induced physiological changes in plant.
  - Extremely rare in plants, confined mostly to virus and other "simple" organisms.

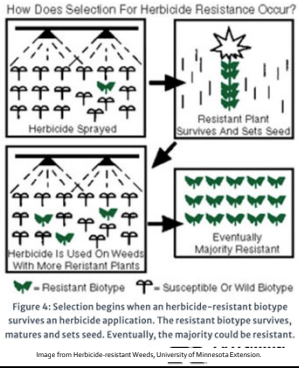

Figure 4: Selection begins when an herbicide-resistant biotype survives an herbicide application. The resistant biotype survives, matures and sets seed. Eventually, the majority could be resistant.

Image from Herbicide-resistant Weeds, University of Minnesota Extension.

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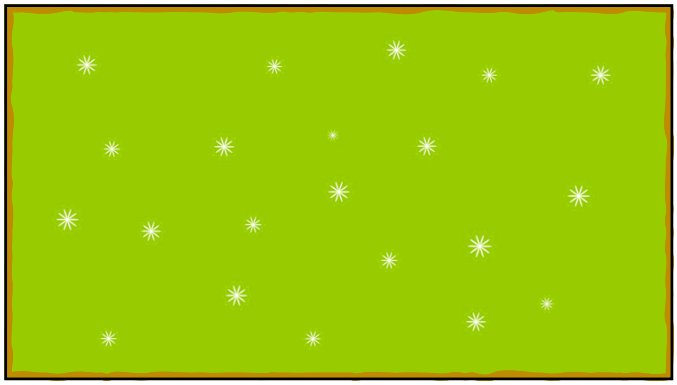

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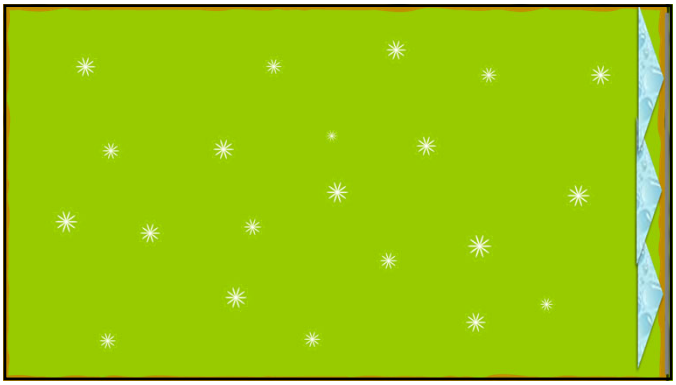

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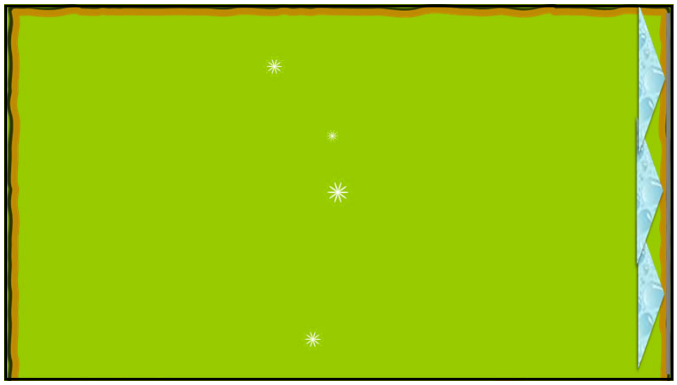

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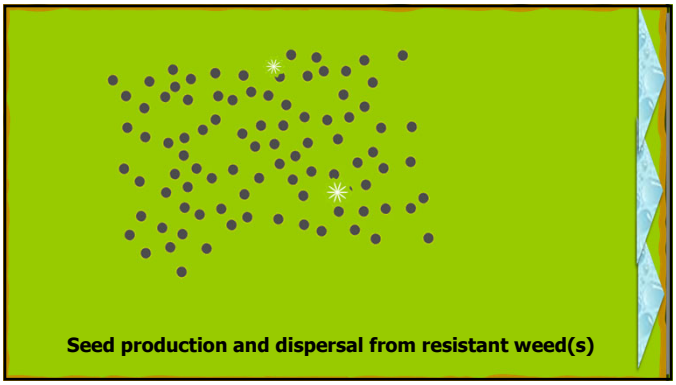

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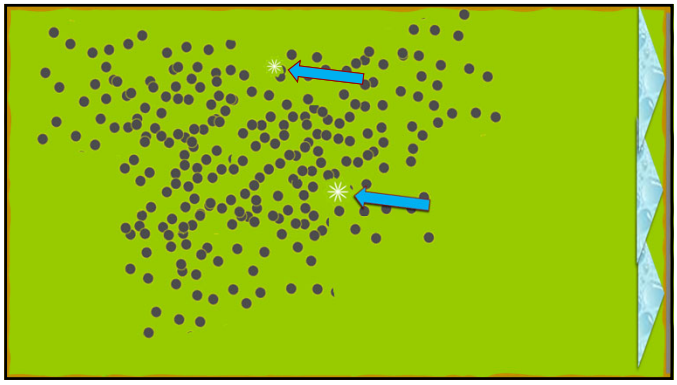

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Summary of Herbicide Mechanism of Action According to the Weed Science Society of America (WSSA)

1 — **Acetyl CoA Carboxylase (ACCase) Inhibitors**

Aryloxyphenoxypropionate (FOPs) cyclohexanedione (DIMs) and phenylpyrazolin (DENs) herbicides inhibit the enzyme acetyl-CoA carboxylase (ACCase), the enzyme catalyzing the first committed step in *de novo* fatty acid synthesis (Burton 1989; Focke and Lichtenthaler 1987). Inhibition of fatty acid synthesis presumably blocks the production of phospholipids used in building new membranes required for cell growth. Broadleaf species are naturally resistant to cyclohexanedione and aryloxyphenoxy propionate herbicides because of an insensitive ACCase enzyme. Similarly, natural tolerance of some grasses appears to be due to a less sensitive ACCase (Stoltenberg 1989). An alternative mechanism of action has been proposed involving destruction of the electrochemical potential of the cell membrane, but the contribution of this hypothesis remains in question.

2 — **Acetolactate Synthase (ALS) or Acetohydroxy Acid Synthase (AHAS) Inhibitors**

Imidazolinones, pyrimidinylthiobenzoates, sulfonylaminocarbonyltriazolinones, sulfonylureas, and triazolopyrimidines are herbicides that inhibit acetolactate synthase (ALS), also called acetohydroxyacid synthase (AHAS), a key enzyme in the biosynthesis of the branched-chain amino acids isoleucine, leucine, and valine (LaRossa and Schloss 1984). Plant death results from events occurring in response to ALS inhibition and low branched-chain amino acid production, but the actual sequence of phytotoxic processes is unclear.

3 **15** **23** — **Mitosis Inhibitors**

Benzamide, benzoic acid (DCPA), dinitroaniline, phosphoramidate, and pyridine herbicides (Group 3) are examples of herbicides that bind to tubulin, the major microtubule protein. The herbicide-tubulin complex inhibits polymerization of microtubules at the assembly end of the protein-based microtubule but has no effect on depolymerization of the tubule on the other end (Vaughn and Lehnen 1991), leading to a loss of

Sample Partial Page

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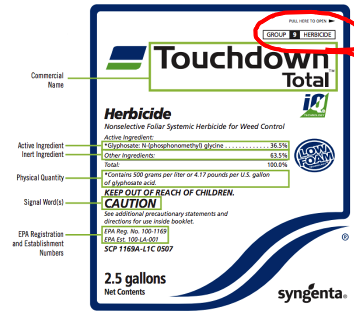
PULL HERE TO OPEN
GROUP 9 HERBICIDE
Commercial Name
Touchdown Total
Herbicide
Nonselective Foliar Systemic Herbicide for Weed Control
Active Ingredient:
Active Ingredient
*Glyphosate: N-(phosphonomethyl) glycine 36.5%
Inert Ingredient
Other Ingredients: 63.5%
Total: 100.0%
LOW FOAM
Physical Quantity
*Contains 500 grams per liter or 4.17 pounds per U.S. gallon of glyphosate acid.
KEEP OUT OF REACH OF CHILDREN.
Signal Word(s)
CAUTION
See additional precautionary statements and directions for use inside booklet.
EPA Registration and Establishment Numbers
EPA Reg. No. 100-1169
EPA Est. 100-LA-001
SCP 1169A-L1C 0507
2.5 gallons
Net Contents
syngenta

Mechanism/Mode of Action

Be Aware: **Generic pesticides may not have the designation on the label**

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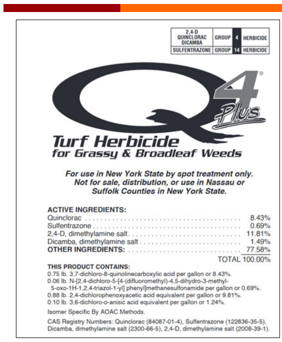
2,4-D QUINCLORAC DICAMBA GROUP 4 HERBICIDE
SULFENTRAZONE GROUP 14 HERBICIDE
Q4 Plus
Turf Herbicide
for Grassy & Broadleaf Weeds
For use in New York State by spot treatment only.
Not for sale, distribution, or use in Nassau or Suffolk Counties in New York State.
ACTIVE INGREDIENTS:
Quinclorac 8.43%
Sulfentrazone 0.69%
2,4-D, dimethylamine salt 11.81%
Dicamba, dimethylamine salt 1.49%
OTHER INGREDIENTS: 77.58%
TOTAL 100.00%
THIS PRODUCT CONTAINS:
0.75 lb. 3,7-dichloro-8-quinolinecarboxylic acid per gallon or 8.43%.
0.06 lb. N-[2,4-dichloro-5-[4-(difluoromethyl)-4,5-dihydro-3-methyl-5-oxo-1H-1,2,4-triazol-1-yl] phenyl]methanesulfonamide per gallon or 0.69%.
0.88 lb. 2,4-dichlorophenoxyacetic acid equivalent per gallon or 9.81%.
0.10 lb. 3,6-dichloro-o-anisic acid equivalent per gallon or 1.24%.
Isomer Specific By AOAC Methods.
CAS Registry Numbers: Quinclorac (84087-01-4), Sulfentrazone (122836-35-5), Dicamba, dimethylamine salt (2300-66-5), 2,4-D, dimethylamine salt (2008-39-1).

<u>4 active ingredients;</u>
3 are Group 4
1 is Group 14

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Examples

- Rotate halosulfuron (***Group 2***) with mesotrione (***Group 27***) or sulfentrazone (***Group 14***) or bentazon (***Group 8***) for postemergence yellow nutsedge control
- Rotate pendimethalin, prodiamine, dacthal, dithopyr, benefin, oryzalin (***Group 3***) with mesotrione (***Group 27***) or oxadiazon (***Group 14***) or bensulide (***Group 8***) or siduron (***Group 7***) for pre-emergence annual grass control
- Rotate 2,4-D, dicamba, MCPA, clopyralid, fluroxypyr (***Group 4***) with carfentrazone (***Group 14***) or mesotrione (***Group 27***) or quinclorac (***Group 26***) for postemergence broadleaf weed control

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<u>Pesticide resistance can be reduced by:</u>

1. Using a pesticide until resistance develops than switch to another one.
2. ~~Rotate different pesticides.~~
3. Rotate pesticides with different mode/mechanism of action (MOA) along with appropriate weed management practices.

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Perennial Grass Control

"The best way to control undesirable perennial grasses in the lawn is to spot treat with glyphosate." (1994)

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Perennial Grass Control Top 10

- Windmillgrass
- Nimblewill
- Tall Fescue
- Orchardgrass
- Quackgrass
- Creeping Bentgrass
- Rough Bluegrass
- Smooth Brome
- Bermudagrass
- Zoysiagrass

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Windmillgrass – *Chloris verticillata*

- Warm-season, native perennial
- Topramezone (Pylex) plus triclopyr provide the best control
- Mesotrione (Tenacity) and Acclaim Extra (fenoxaprop) less expensive option
- Adding triclopyr (Turflon Ester Ultra or Triclopyr 4) at 1 qt/A to either topramezone, fenoxaprop, or mesotrione will significantly improve control.
- Apply at least 2 times, target applications in the late spring and early summer

Image from Midwest Weeds and Wildflowers, Missouri State University.

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Nimblewill – *Muhlenbergia schreberi*

- Warm-season, perennial
- Mesotrione (Tenacity) applied in the spring (with NIS), two or three applications.
  - For three applications, use the 5 fl oz/A rate (or 6, 6 and 4 fl oz/A) due to label restrictions.
  - Late summer and fall applications will work but start by August for best results.
- Topramezone (Pylex) at 1-1.5 fl oz/A at 21- to 28-day intervals starting in late April; include a methylated seed oil.

Above image from Midwest Weeds and Wildflowers, Missouri State University.

Above and right image from Purdue University.

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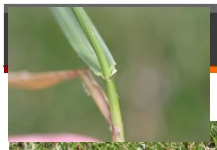
Tall Fescue – *Schedonorus arundinaceus*



Above images from University of Missouri Plant Sciences.

- Cool-season, perennial
- Chlorsulfuron (Telar XP and Chlorsulfuron 75DF) is a selective herbicide registered for tall fescue control, previously sold as Corsair, which is now off market.
- Telar XP and Chlorsulfuron 75DF contain the same active ingredient as Corsair, *only labelled for industrial sites and roadsides*

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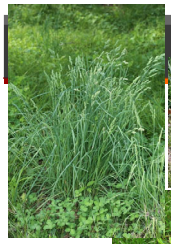
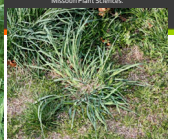
Orchardgrass – *Dactylis glomerata*



Right image from PennState Plant Science.

Left and below images from University of Missouri Plant Sciences.



- Perennial, cool season grass
- Bluish-green foliage
- Upright, hollow, flattened stems
- Fibrous root system, rarely with short rhizomes.

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Quackgrass – *Elymus repens*

- Cool-season, perennial
- Lax blue-green leaves
- Extensive rhizomes and a fibrous root system

Images above and immediate left from PennState Plant Science.

Images far left from Aaron J. Patton, Purdue University.

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Creeping Bentgrass – *Agrostis stolonifera*

- Cool season, perennial
- Mesotrione (Tenacity) is safe for use in Kentucky bluegrass (5-8 fl oz/A), perennial ryegrass (5 fl oz/A), tall fescue (5-8 fl oz/A), and fine fescue (5 fl oz/A) and will control creeping bentgrass
- Timing is critical. Begin applying in early September. Three or four applications at two-week intervals. At least three applications are required for best results. Loses effectiveness later in the fall.
- Spring and summer applications provide less consistent control.

Images at right from University of Minnesota Extension.

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Rough Bluegrass – *Poa trivialis*

Images above from Rutgers Turf Blog, turfblog.Rutgers.edu.

- Cool-season, perennial
- Bispyribac-sodium (Velocity SG) is registered on golf courses and sod farms, but no other turf sites.
- Availability is limited.
- Raising the mowing height (3 inches tall or greater) will help to reduce rough bluegrass over time.
- Extremely shade tolerant.

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Smooth Brome – *Bromus enermis*

- Cool-season, perennial
- Research conducted at Nebraska with Mesotrione (Tenacity) + NIS
  - 5.3 fl. oz./acre three times 10 days apart or
  - 8 fl. oz./acre applied two times 10 days apart,
  - applied in July resulted in about 85% control by Sept. 15.
- Spring applications had <30% control.

Image above from Katy Chayka, Minnesota Wildflowers.

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Bermudagrass, *Cynodon spp.*

Images from Aaron J. Patton, Purdue Extension Turf Tips.

- Warm-season, perennial
- No "efficient" selective herbicides in cool-season turf.
- Three applications of topramezone (Pylex) at 1.33 fl oz/A at 21-day intervals starting in late summer to *suppress* bermudagrass. For best results, tank-mix triclopyr at 1 qt/A and include a MSO.
- Repeat applications of fenoxaprop (Acclaim Extra) 28 fl oz/A during late spring and late-summer/fall provide suppression. Adding triclopyr improve turfgrass safety and suppression.
- Use with with an overseeding of a desirable cool-season turfgrass post last application; repeat for 2-3 consecutive years.

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Zoysiagrass – *Zoysia spp.*

- Warm-season, perennial
- No "efficient" selective herbicides in cool-season turf.
- Like bermudagrass, three applications of topramezone (Pylex) at 1.33 f l oz/A with MSO at 21-day intervals starting in late summer will *suppress* zoysiagrass (no triclopyr).
- Use with an overseeding of a desirable cool-season turfgrass after the last application; repeat for 2-3 consecutive years.
- Expect 50-75% zoysiagrass removal per year with this topramezone, plus overseeding strategy.

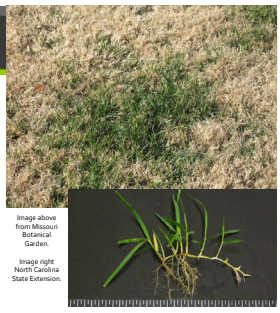

Image above from Missouri Botanical Garden.

Image right North Carolina State Extension.

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"The best way to control undesirable perennial grasses in the lawn is to spot treat with glyphosate."

- ~~Windmillgrass~~
- ~~Nimblewill~~
- ***Tall Fescue***
- ***Orchardgrass***
- ~~Creeping Bentgrass~~
- ***Rough Bluegrass***
- ***Quackgrass***
- ~~Smoothbrome~~
- ~~Bermudagrass~~
- ~~Zoysiagrass~~

Options now exist for 60% of the top ten!

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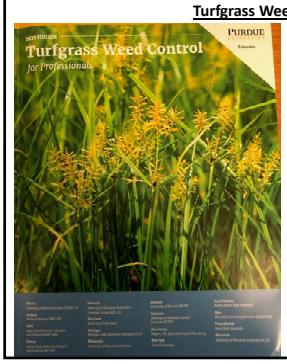
Turfgrass Weed Control for Professionals



https://mdc.itap.purdue.edu/item.asp?Item_Number=TURF-100

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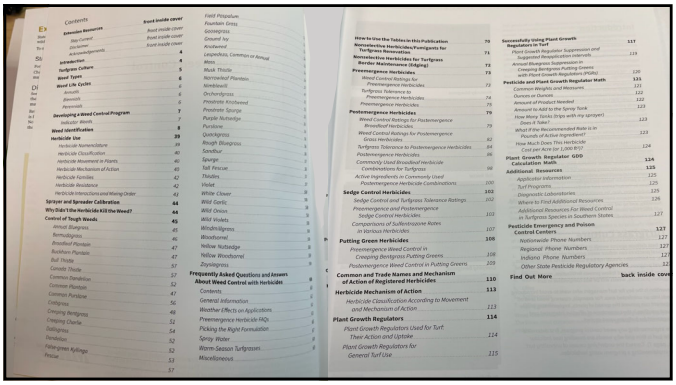

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Other resources:

- http://www.mobileweedmanual.com/ Jim Brosnan, Ph.D.

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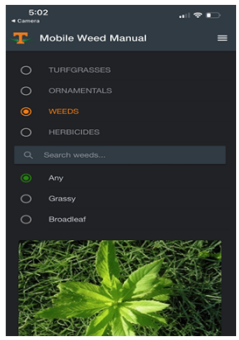

Very user friendly with both turf and ornamentals, no cost to end user

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Contact Information

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Thank you!

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