

Heat warning for cool-season grasses

July 16, 2011

As mentioned in last week's earlier Turf iNfo's, the extended forecast with highs in the 90's is fast creating a tough summer for cool-season turfgrasses like creeping bentgrass, Kentucky bluegrass, and tall fescue. The primary reasons for this boils down to how the grass creates and uses energy:

- Plants use photosynthesis to captures energy from the sun in the eventual form of carbohydrates, proteins, etc.
- Plants use these storage compounds for respiration which are essentially maintenance processes to keep the plant alive.
- Photosynthesis of cool-season turfgrasses declines once daytime temperatures exceed 70-75F (Almost no photosynthesis occurs in cool-season plants >95F.)
- At the same time, respiration is increasing with higher temperatures.
- At temperatures greater than 80-90F, cool-season turfgrass plants are in an energy debit where energy demand is higher than energy production.
- The plant uses energy reserves produced mostly last fall to make up for this energy debit, and short periods of an energy debit are normal.
- Energy stores are depleted with extended heat, and the plant weakens and becomes susceptible to any number of stresses.
- This energy depletion is exaggerated during warm nights when the plant is using up much more stored energy for respiration than during cool nights.
- Warm-season grasses like buffalograss, zoysia, crabgrass, and nimblewill thrive in hot weather because they have a different mechanism for photosynthesis (C4 in warm-season grasses, C3 in cool-season grasses)

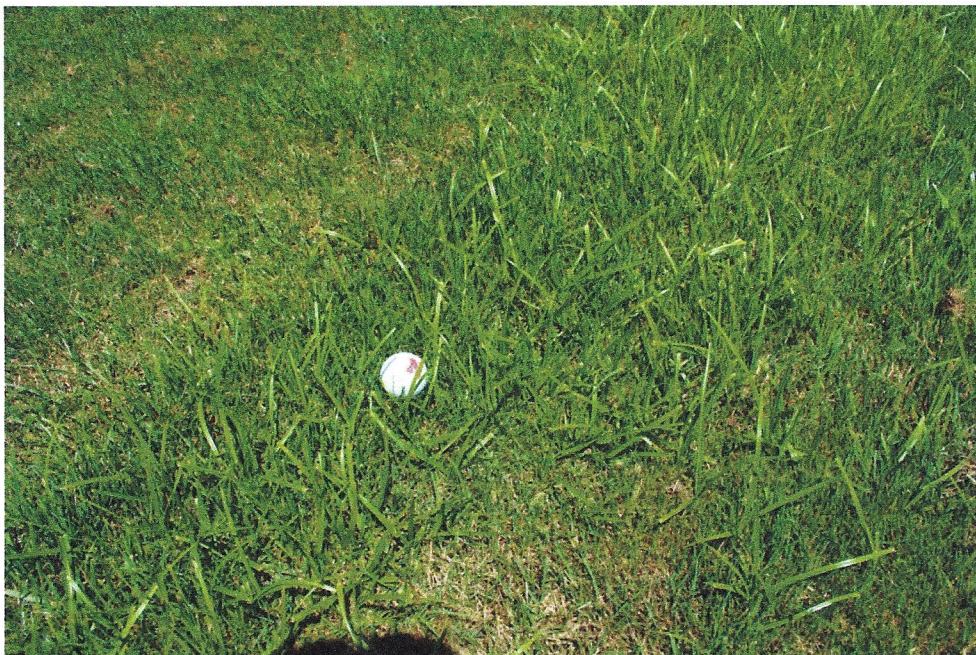
This energy deficit in cool-season grasses almost never directly results in turf death, but instead leads to a weakening of the grass and it becomes susceptible to any number of diseases or insects and to other stresses like drought, traffic, etc. Furthermore, this weakening depends not only on the species and cultivar, but also on degree of shade (especially in the morning), fertility this year and last fall, mowing height and frequency, soil compaction, drainage, irrigation, etc. Though not directly related to this energy imbalance, these hot summer conditions are further complicated with frequent rains or over-irrigation as roots cannot respire well in warm saturated soils, leading to premature root death and shallow root systems (<http://turf.unl.edu/pdfcarticles/junewetsoils.pdf>). Plus frequent rains and humid conditions increases disease pressure. The end result is that extended hot days and nights can indirectly lead to turf damage, but this damage is likely highly variable. The previous Turf iNfo <http://turf.unl.edu/pdfcarticles/julyheat.pdf> provides pointers for maintaining turf through summers like this.

Zac Reicher, Professor of Turfgrass Science, zreicher2@unl.edu

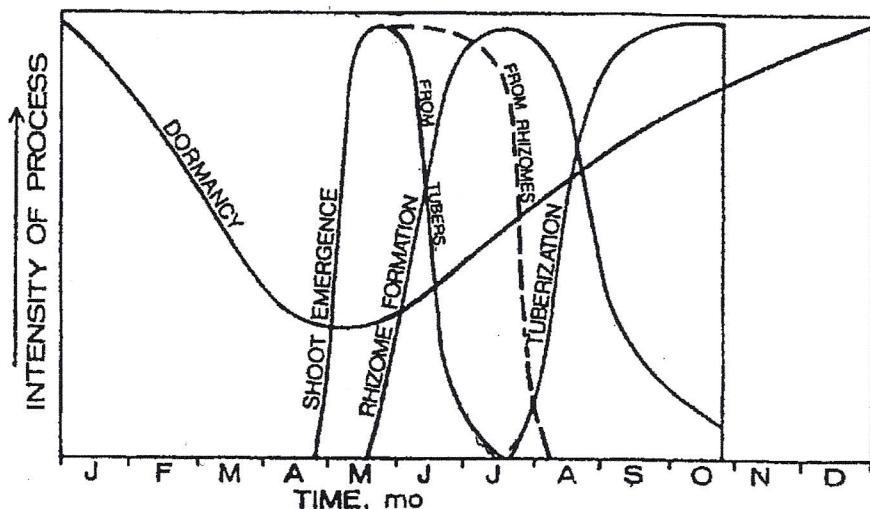
Yellow nutsedge thriving in lawn, sports, and golf turf

July 22, 2010

Yellow nutsedge is now one of the most common weeds in lawns, athletic fields and golf turf. Even though all textbooks say it thrives in wet areas, some of our worst yellow nutsedge infestations occur in dry years when turf thins. Though yellow nutsedge acts like an annual, it is technically a perennial surviving from tubers year to year. Tubers germinate and plants emerge in mid- to late May, mature throughout the summer if left untreated, begin forming new tubers in July once daylength returns to 14 hours, and then the above-ground portion of the plant dies with frost. Yellow nutsedge tubers may lay dormant in the soil for three years or more and they can germinate multiple times in a season if the original emerging plant does not survive (due to late frost, herbicides, hand-pulling etc.). Add to this waxy leaves and a rhizome system that does not translocate herbicides effectively, and yellow nutsedge becomes one of the most difficult to control weeds that we have in the Midwest. Cultural controls will always help, so mowing at the highest practical height for the lawn, sports, or golf area, irrigation to prevent summer thinning, and aggressive fall fertilization to maximize density are all important. Standard postemergence herbicides include Basagran, SedgeHammer or ProSedge (formerly Manage), and Certainty. FMC's Dismiss is the most recent postemergence product labeled for yellow nutsedge and is very effective. Since yellow nutsedge can regrow from rhizomes or tubers, multiple applications are needed and the problem will likely persist for multiple years. Much more information on biology and preemergence control can be found in an earlier Turf iNfo at <http://turf.unl.edu/pdfctarticles/aprilYNSbiologyroch.pdf>.



Yellow nutsedge thriving in a thin Kentucky bluegrass stand. Yellow nutsedge grows much faster than turfgrass in the summer and thus requires more frequent mowing.



Graphic representation of the complexity of a yellow nutsedge lifecycle. Shoot emergence from tubers occurs from May to June while shoot emergence from rhizomes occurs from May through August. Tuber formation begins in July and lasts through the first frost. Control would ideally be timed in late June through mid July prior to tuber formation.



Variability in tuber germination and growth, thus allowing the yellow nutsedge to survive inclement weather, herbicide applications, etc.

Yellow nutsedge and crabgrass flourishing with heat, but don't attempt control

July 22, 2011

Yellow nutsedge and crabgrass are thriving as the cool-season turfgrasses thin with the withering heat gripping the north central US. Though it is tempting to try controlling either of these now, think twice before doing so. Not only are herbicides potentially more damaging to cool season grasses anytime temperatures are above 80F, cool-season grasses under extended heat stress are especially more susceptible to damage from applied pesticides and fertilizers. Though neither weed should be controlled currently, these weeds should be controlled well before they are obvious in the turf. We'll have a number of crabgrass and yellow nutsedge control experiments on display at our Field Day on Aug 10.

Registration and details are at <http://turf.unl.edu/TurfFieldDay2011.pdf>

More information on yellow nutsedge is at: <http://turf.unl.edu/pdfctarticles/julyyellownutsedge.pdf>

More information on crabgrass can be found at

<http://turf.unl.edu/pdfcaextpub/LCOProSeriesCrabgv6.pdf>

Zac Reicher, Professor of Turfgrass Science, zreicher2@unl.edu

Lawn Care Pro Series: Crabgrass and Other Summer Annual Grassy Weeds

University of Nebraska-Lincoln Turfgrass Science Program | turf.unl.edu

Pub. 2010d Pro Series

Crabgrass (*Digitaria* spp.) is one of the most problematic annual grassy weeds in turfgrass, especially in summer during its aggressive growth period. Crabgrass is a summer annual, germinating in spring when soil temperatures are sustained between 55 and 60F, begins flowering and setting seeds in July, and is killed by fall frost. A mature crabgrass plant can produce up to 700 tillers and 150,000 seeds in areas like the upper Midwest. There are thirteen weedy *Digitaria* species in the United States, but the two most common species in Nebraska and the Upper Midwest are smooth crabgrass (*D. ischaemum*) and large or hairy crabgrass (*D. sanguinalis*). (Figure 1). Green (*Setaria viridis*) and yellow foxtails (*Setaria glauca*) are also summer annual grasses common in lawns in the north central US. Both of these grasses germinate slightly later than crabgrass, with prolonged soil temperatures at 60 to 65F. Green foxtail has a tightly packed cylindrical seedhead, while yellow foxtail has a looser cylindrical seedhead (Figure 1). Goosegrass (*Eleusine indica*) is not common in lawns, but is common on lower mowed sports turfs, next to busy sidewalks, and other compacted areas. Goosegrass is prostrate growing and has silvery to white leaves near its base, thus often referred to as silver crabgrass (Figure 1). This grass germinates slightly later than the foxtails, at soil temperatures 60 to 70F.

Cultural Controls

Crabgrass and other summer annual grassy weeds invade a lawn often because growing conditions favor its growth over the desirable turf. Improving growing conditions for the desired turf will help it outcompete crabgrass and other weeds, plus improve effectiveness of herbicide applications (Figure 2).

Mowing:

- Kentucky bluegrass, perennial ryegrass, tall fescue, or buffalograss should be mowed throughout the year at 3.0 to 3.5 inches
- Mowing should be frequent enough to remove only 1/3 of the turfgrass leaf at one time. This means you may have to mow once or twice a week in the spring, but every two weeks during the summer. It is better to mow more frequently than not frequently enough.

Extension is a Division of the Institute of Agriculture and Natural Resources at the University of Nebraska-Lincoln cooperating with the Counties and the United States Department of Agriculture. University of Nebraska-Lincoln Extension education programs abide with the nondiscrimination policies of the University of Nebraska-Lincoln and the United States Department of Agriculture. The University of Nebraska-Lincoln does not discriminate based on gender, age, disability, race, color, religion, marital status, veteran's status, national or ethnic origin, or sexual orientation.



Figure 1: Large crabgrass (top) which germinates first among the summer annuals, yellow foxtail (middle) which is more common in thinner turfs, and goosegrass (bottom) with the white to silvery sheath and common in compacted soils.

Lawn Care Pro Series: Crabgrass and other summer annual grassy weeds

- Return clippings to the lawn to return valuable nutrients to the soil. Returning clippings does not increase thatch.
- Alternate mowing patterns to distribute wear and improve aesthetics of the lawn. Generally mowing at four different angles is most attractive.
- Avoid repeatedly mowing in the same wheel tracks for the “clean-up” pass around the perimeter of the lawn, especially with ride-on mowers.
- Turn on drives and walks whenever possible to minimize turf wear and soil compaction.

Fertilization:

- Actual fertilization rates will be affected by expectations, age and condition of the turf, soil type, irrigation or rainfall, species, etc.
- Cool-season grasses like Kentucky bluegrass, perennial ryegrass, or tall fescue should be fertilized primarily in the fall with 60% or more of the annual nitrogen being applied in September and November.
- Kentucky bluegrass and perennial ryegrass should receive from 3.0 to 4.5 lbs N/1000 sq ft/yr whereas tall fescue should receive between 2.0 and 3.0 lbs N/1000 sq ft/yr.
- Warm-season grasses like buffalograss or zoysiagrass should receive from 1.0 to 2.0 lbs N/1000 sq ft/yr, applied primarily in June or July.

Irrigation:

- Turfgrasses prefer drier soils versus wet soils, whereas the relatively shallow rooted crabgrass thrives in over-irrigated areas. Furthermore, over-irrigation promotes thatch and diseases.
- Water to wet the soil to the depth of rooting and then do not water again until the first signs of drought stress (when turfgrass turns bluish gray color or footprints remain in turf after walking).
- Increase irrigation frequency in summer because roots of cool-season turfgrass plants become shallower and evapotranspiration is higher.

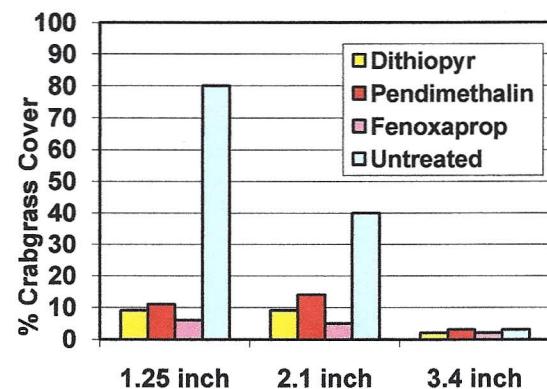


Figure 2: Crabgrass cover in tall fescue maintained at three mowing heights after PRE control with dithiopyr or pendimethalin or POST control with fenoxaprop. The higher the mowing height, the better the herbicidal control and the lower crabgrass cover in the untreated plots (Dernoeden et al., 1993).

Aerification:

- Aerification reduces compaction, improves water and air movement into the soil and helps limit thatch.
- Most lawns should be aerified once every one to three years, but sodded lawns, lawns with clay soils, or lawns with excess traffic may need aerification once or twice annually.
- Punching 20-40 holes/sq ft with the $\frac{1}{2}$ to $\frac{3}{4}$ " hollow tines is recommended.
- Aerification should be done primarily when the grass is actively growing in spring or fall, but can be done almost any time of the year on lawn height turf as long as soil conditions allow.
- Aerification after spring application of preemergence herbicides does not affect efficacy (Branham and Rieke, 1986; Johnson, 1987.).

Hotspots:

Areas next to sidewalks and drives, south facing slopes, and areas next to brick or reflective surfaces are considered “hotspots” for annual grasses because the desired turf does not compete well. These hotspots are also the first to warm in the spring. Furthermore, many of these areas are difficult to apply products accurately and so they often receive over- or under-applications of fertilizer, irrigation, or pesticides.



Lawn Care Pro Series: Crabgrass and other summer annual grassy weeds

- Check the soil for concrete, sand, gravel, and other construction debris next to sidewalks and drives. Remove and reestablish turf if necessary.
- Consider replacing turf with ornamental plants more tolerant of the growing conditions, or with pavers, mulch, etc.
- Remove as much traffic as possible
- Aerify as often as possible

Preemergence control

Preemergence (PRE) herbicides are the most effective chemical option for controlling summer annual grassy weeds. It is critical to apply these herbicides prior to germination, but many strategies can be used in professional lawn care system.

Product selection

There are three primary active ingredients readily available including dithiopyr, pendimethalin, and prodiamine. Our research shows that as long as they are applied at reasonable rates, these three herbicides tend to perform similarly for season-long crabgrass control. In any given year, one active ingredient may out-perform the other two or vice versa, but overall these three are equally effective when applied at appropriate rates. Control from every PRE herbicide can vary from year to year, or location to location. Therefore, judging the performance of a product or a specific rate of that product on one year's experience is difficult. These active ingredients are available in a wide range of formulations and loaded on a wide range of fertilizers, including generic and proprietary products. With the sheer number of formulations, it is difficult to compare all the product and rate combinations. Therefore, we prefer to use lbs ai/A for comparisons as listed in Table 1. Equations for calculating lbs ai/A for

any particular product can be found in Table 5 or Table 6 can be used for converting pounds active ingredient to lbs product and vice versa.

Granular vs sprayable formulations

There are few differences in control between using granular or sprayable formulations when applied at the same rate of active ingredient. The one exception to this is dithiopyr where granular formulations are more active than sprayable formulations, and thus the differing rates in Table 1. Choosing between granular or sprayable formulations is a personal or practical choice rather than an agronomic choice. However, if a granular fertilizer/PRE herbicide combination is chosen, purchase a product with smaller particle size to improve distribution. Furthermore, also purchase a product low in nitrogen. Lawns receiving urea at the last mowing in the fall may need little or no nitrogen in the spring with the PRE to encourage greenup. Few lawns will require more than 0.75 lbs N/1000 sq ft with the PRE application. Simply lowering the rate of a fertilizer/herbicide combination to lower the N rate will also lower the herbicide rate compromising effectiveness. Therefore, purchasing the correct product is critical. Table 7 lists the rate in lbs N/1000 applied, given the specific product and application rate. The equations in Table 5 can also be used to determine N application rates for any product.

Timing of application

Applying PRE herbicides as close to crabgrass germination is desired so the residual activity will provide adequate control season-long. Traditional timing as listed on herbicide labels is "two weeks prior to crabgrass germination" which should be April to early May in the north central US. Others have recommended that

Table 1: Ranges of labeled rates of preemergence herbicides for the north central US (Check the actual label as rates may increase as you move south).

	Low	Medium	High
—lbs ai/Acre—			
Dithiopyr 2EW (liquid formulations)	0.25	0.38	0.5
Dithiopyr on fertilizer	0.125	0.18	0.25
Pendimethalin on fertilizer or sprayable	1.5	2.0	3.0
Prodiamine on fertilizer or sprayable	0.38	0.5	0.65



Lawn Care Pro Series: Crabgrass and other summer annual grassy weeds

crabgrass germinates at about the same time as *Forsythia* blooms are declining. However, this is not reliable today because of many new cultivars of *Forsythia* that now have a wider range of flowering. Other spring flowering plants are also problematic for scheduling PRE herbicide applications (Fry et al., 2001). Five consecutive days with one inch soil temperatures at 55F is another predictor. A Michigan State growing degree day model is another predictor at 250-500 GDD base 32F. Exact timing of PRE herbicides may not be as critical as once thought. Research in Iowa, Indiana, Illinois, and Maryland found little difference between fall and spring applications of PRE herbicides (Agnew and Christians, 1989; Dernoeeden, 1993; Fermanian and Haley, 1994; Reicher et al., 1993). The highest recommended rate should be used for best results if a single application of PRE herbicide is applied in late fall or early spring. This strategy has not been tested yet in the extreme summers of Nebraska, but studies are underway. Our current recommendation is to apply PRE herbicides in Nebraska between Apr. 15 and the first week of May. Any crabgrass that may germinate prior to that window will likely be killed by frost.

Sequential applications

Increasing the annual application rate with sequential applications of PRE herbicides is recommended to maximize efficacy throughout Nebraska. Applying ½ to 2/3 the high label rate in late fall through May 1 followed by the other ½ to 1/3 of the high label rate in early June 1 is our current recommendation. Furthermore, sequential applications should be made with identical active ingredients for the most consistent control according to a 1991 study (Reicher et al., 1991). Our current research at University of Nebraska and at Purdue University is reexamining this strategy.

Application accuracy

Preemergence herbicides have very low water solubility and they do not move in the soil, so accurate and uniform application is critical. Control from granular PRE herbicide/fertilizer combinations largely depends on granular size and the specific active ingredient used (Kelly and Coates, 1999). It is important to use smaller granules with prodiamine or pendimethalin, but not as important with dithiopyr. Furthermore, when using

herbicide/fertilizer combinations, it is important to check the calibration AND distribution of your spreaders. Improper calibration or inconsistent application across the area can lead to crabgrass breakthrough.

Rate of application

Though tempting for economical reasons, it is usually not worth lowering the application rate. Control could be sacrificed requiring more expensive rescue treatments and extra labor. However, on very thick lawns or lawns that have received many years of PRE herbicides, rates can often be reduced or the PRE herbicide possibly eliminated. Also consider using only spot applications in hot spots next to sidewalks, etc.

Post emergence (POST) control

Though PRE herbicides are the most effective chemical option for summer annual grassy weeds, POST herbicides may be needed to rescue breakthroughs from PRE herbicides or on lawns that never received a PRE herbicide in the spring.

Product selection

The typical PRE herbicides containing pendimethalin or prodiamine may provide control of very small (one to two leaf stage) crabgrass (Figure 3). Conversely, dithiopyr is a good PRE herbicide and also has good POST activity on non-tillered crabgrass. Quinclorac is widely used and would be considered the industry standard. Quinclorac is effective on crabgrass from one- to two-leaf stage all the way to tilled plants, but methylated seed oil must be include as an additive to improve control. Fenoxaprop (Acclaim Extra) is also available and effective on crabgrass, but not as widely used. The newest herbicide is mesotrione (Tenacity) from Syngenta. It has been labeled for golf courses and sports fields, and should be labeled for spot-treating residential lawns in spring 2011. It will control a wide variety of broadleaf and grassy weeds, and it is also very effective as a POST crabgrass herbicide.

Lawn Care Pro Series: Crabgrass and other summer annual grassy weeds



Figure 3. Crabgrass development stages from left to right: 3-leaf, 1-tiller, and 4-tiller. Smaller crabgrass is easiest to control with postemergence herbicides with the least risk to the desired turf.

Application timing

Application of POST herbicides is most effective on small crabgrass and thus June applications are preferred. However, crabgrass will continue to germinate well into August, so a PRE should be included in the tankmix at least throughout June and potentially into July. Applications into August can be effective on mature crabgrass plants, but applying these herbicides in temperatures over 80 to 85F risks damage to the cool-season turf. Additionally, higher rates are often required for larger crabgrass plants, which increases the risk of damage to desired turf. Crabgrass will start to decline with decreasing daylight hours and cooling temperatures in late August, and will die with the first frost, thus making late-season control less practical.

Multiple applications

Though most of the POST herbicides can control crabgrass with a single application, control will improve with a second application applied two weeks after the first. The second application will improve control on larger crabgrass plants as well as controlling plants that germinated since the initial application.

Controlling summer annuals: Frequently asked questions

Can PRE or POST herbicides be used over the top of new seedings/sod? PRE herbicides should not be used prior to seeding or sodding

with the exception of siduron (Tupersan). However, siduron does not last long and reapplications will need to be made every 3 to 4 weeks. Mesotrione (Tenacity) can be applied in a seedbed to help control crabgrass and other weeds without damaging the desired turf. Applications of PRE or POST herbicides over the top of new seedlings is a risk-reward decision in that, even though a herbicide treatment may injure the desired grass, removal of weed competition could allow herbicide-damaged turf to fill quickly. Conversely, waiting too long to apply or choosing a safer but less effective product may not provide adequate weed control, thus reducing establishment of the desired species. Table 4 list both PRE and POST herbicides for use over cool-season turfgrass seedlings.

What is the delay for seeding back into a PRE herbicide application? Most herbicide labels state that reseeding should be delayed for three to four months after a PRE herbicide depending on the rate and active ingredient, and this assumes a typical Apr or May application. Recent research found a delay of 11, 10, or 16 weeks was required when slit-seeding Kentucky bluegrass into dithiopyr at 0.5 lbs ai/A, pendimethalin at 3.0 lbs ai/A, or prodiamine at 0.75 lbs ai/A, respectively (Keeley and Zhou, 2005). However, they also found that simply broadcasting (seeds resting on the soil surface) required only 6, 8, or 14 weeks delay after application of dithiopyr at 0.5 lbs ai/A, pendimethalin at 3.0 lbs ai/A, or prodiamine at



Lawn Care Pro Series: Crabgrass and other summer annual grassy weeds

0.75 lbs ai/A, respectively. The authors suggested this difference was because plants germinating in the slits were exposed to herbicide as their roots penetrated down and as the coleoptiles grew up, while plants developing from seeds resting on the surface were only exposed to herbicides via their roots penetrating into soil.

Can the overall amount of PRE herbicide used be reduced? Avoid reducing the application rates of typical spring PRE applications, but consider omitting the PRE herbicide out of the first round (early spring) application entirely in favor of a PRE or a PRE/POST product in second round. Dithiopyr would be the best choice for this strategy because it would be less expensive than combining quinclorac plus a PRE herbicide. We consistently find good season-long control from dithiopyr-containing products applied shortly after germination of crabgrass.

Do PRE herbicides need to be watered-in? For most effective control, water-in within 48 hours of application to limit photodegradation and to move the herbicide down to where it will be active.

Can crabgrass develop resistance to PRE or POST herbicides? Crabgrass resistance to PRE herbicides used in turf has not been documented. Resistance to POST herbicides is very rare, but it has been reported with quinclorac on golf course tees (Fischer, 2002; Reicher et al., 2009). This is likely due to naturally occurring biotypes that were insensitive to quinclorac.

Can sandbur be controlled with PRE or POST crabgrass herbicides? Sandbur germinates later than crabgrass and thus sequential applications of pendimethalin or prodiamine are thought to provide best control. POST herbicide fenoxaprop or quinclorac can also provide some control, especially when the weed is in the seedling stage, but timing is difficult because this weed matures rapidly.

Can prostrate spurge be controlled with PRE herbicides? Yes, late fall or very early spring

applications of pendimethalin or prodiamine are most effective.

Can goosegrass be controlled with PRE herbicides? Since it germinates slightly later than crabgrass, sequential applications are most effective.

What effect do PRE herbicides have on yellow nutsedge? Since yellow nutsedge germinates from tubers and not seeds, typical PRE herbicides for crabgrass have little effect on this weed. Only the newest PRE herbicide Echelon from FMC (prodiamine+sulfentrazone) has been shown to control yellow nutsedge PRE.

With the wide range of brands, formulations, and application rates, what is the best way to compare prices between products? Comparing the cost of herbicides must be done on a per acre basis. It cannot be done by simply comparing the cost of one 50 lb bag to another 50 lb bag. See Table 5 for the equations.

Is MSMA going off the market? Yes, MSMA will no longer be sold as of Dec. 31, 2010. However, products containing MSMA can still be used after that date until supplies are gone.

Can goosegrass be controlled selectively with a POST herbicide? Fenoxaprop is probably the most effective POST goosegrass herbicide though mesotrione has potential. Early data suggests sulfentrazone (Dismiss) can be effective. Quinclorac is not effective on goosegrass.

Can fenoxaprop be mixed with 2,4-D? No, mixing fenoxaprop with 2,4-D will limit crabgrass control. However, fluroxypyr (Spotlight) can be mixed with fenoxaprop with no antagonism (McCullough et al., 2009).

What are the best herbicides for foxtails? Any of the PRE herbicides should work effectively on foxtail, but a sequential application will likely improve control on the late germinating foxtails. The most effective POST herbicide is fenoxaprop followed by products containing quinclorac.



Lawn Care Pro Series: Crabgrass and other summer annual grassy weeds

Literature Cited

1. Agnew, M.L. and N.E. Christians. 1989. Influence of application dates on the effectiveness of four preemergence herbicides for crabgrass control. Proceedings of the Sixth International Turfgrass Research Conference. p. 299-301.
2. Branham, B. E., and P. E. Rieke. 1986. Effects of Turf Cultivation Practices on the Efficacy of Preemergence Grass Herbicides. Agron. J. 78(6):p. 1089-1091.
3. Dernoeden, P.H. 1993. November applied preemergence herbicides for smooth crabgrass control the following summer International Turfgrass Society Research Journal. 7: p. 291-297.
4. Dernoeden, P. H., M. J. Carroll, and J. M. Krouse. 1993. Weed management and tall fescue quality as influenced by mowing, nitrogen, and herbicides. Crop Sci. 33(5):p. 1055-1061.
5. Fermanian, T.W., and J.E. Haley. 1994. Fall application of prodiamine for spring crabgrass (*Digitaria spp.*) control. Weed Technol. 8(3) p. 612-616.
6. Fischer, A. 2002. Group 0/4 resistant smooth crabgrass (*Digitaria ischaemum*) USA: CA. <http://www.weedscience.org/Case/Case.asp?RecordID=5134>
7. Fry, J., S. Rodie, R. Gaussoin, S. Wiest, W. Upham, and A. Zuk. 2001. Using flowering ornamentals to guide application of preemergence herbicides in the Midwestern U.S.. Int. Turfgrass Soc. Res. J. 9(Part 2):p. 1009-1012.
8. Johnson, B. J. 1987. Effect of core cultivation on preemergence herbicide activity in bermudagrass. HortScience. 22(3):p. 440.
9. McCullough, P.E., J.T. Brosnan, and G.K. Breeden. 2009. Fluroxypyr compatibility with fenoxaprop for smooth crabgrass and white clover control in tall fescue. Online. App. Turfgrass Sci. doi:10.1094/ATS-2009-1204-01-RS.
10. Keeley, S. J. and H. Zhou. 2005. Preemergence herbicides and seeding method effects on seedling growth of Kentucky bluegrass. Weed Technology 19:43-46.
11. Kelly, S.T. and G.E. Coates. 1999. Influence of fertilizer particle size on efficacy of dithiopyr, prodiamine, oryzalin, and oxadiazon for southern crabgrass (*Digitaria ciliaris*) control. Weed Technol. 13:385-389
12. Reicher, Z.J., and C.S. Throssell. 1993. Efficacy of fall and spring-applied preemergence herbicides for annual grass control in Kentucky bluegrass. International Turfgrass Society Research Journal. 7: p. 273-276.
13. Reicher, Z.J., C.S. Throssell, and J.L. Lefton. 1991. Annual grass control in cool season turf with sequential applications of unlike preemergence herbicides. Weed Technol 5:387-391.
14. Reicher, Z. J., K. J. Miller, and T. Kahle. 2009. First report of quinclorac-tolerant biotype of smooth crabgrass in Indiana. Purdue turfgrass research report. Online: http://www.agry.purdue.edu/turf/report/2009/PDF/14_Reicher.pdf
15. Voigt, T.B., T.W. Fermanian, and J.E. Haley. 2001. Influence of mowing and nitrogen fertility on tall fescue turf. Int. Turfgrass Soc. Res. J. 9:953-956.

Authors:

Zac Reicher and Roch Gaussoin,
Professors, Department of Agronomy
and Horticulture, University of
Nebraska-Lincoln