

## 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 varida) 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.



**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.**

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- 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.

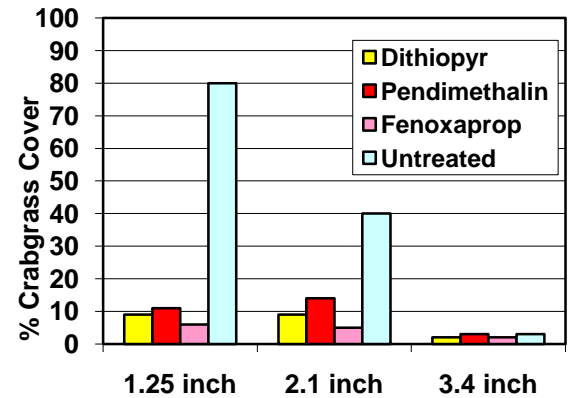


Figure 2: Crabgrass cover in tall fescue maintained at three mowing heights after PRE control with dithiopyr or pendimethalin or POST control with fenoxaprop. The higher the mowing height, the better the herbicidal control and the lower crabgrass cover in the untreated plots (Dernoeden et al., 1993).

### 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 ½ to ¾” 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.





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- 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

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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; Dernoeden, 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  $\frac{1}{2}$  to  $\frac{2}{3}$  the high label rate in late fall through May 1 followed by the other  $\frac{1}{2}$  to  $\frac{1}{3}$  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 tillered plants, but methylated seed oil must be included 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.

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**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 seedlings/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



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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 fenoxaprops 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, fluroxpyr (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.

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*Table 4. Label restrictions for PRE or POST crabgrass herbicides when used over newly established turf.*

Herbicide type	Example brand name	Common name	Label statements for use over newly seeded turf
Preemergence annual grass	Barricade	prodiamine	Wait 60 days after seeding or until after the second mowing, whichever is longer
Preemergence annual grass	Pendulum	pendimethalin	Applications made after turf has filled in and at least 4 mowings
Preemergence annual grass	PreM	pendimethalin	Use only on well established turfgrass with a dense and uniform stand
Preemergence annual grass	Ronstar	oxadiazon	Apply to established turf only
Preemergence annual grass	Team	benefin/ trifluralin	Apply to established turf only
Preemergence annual grass	Tupersan	siduron	Can be applied prior to seeding cool-season grasses and anytime after germination
Pre- and postemergence annual grass	Dimension	dihopyr	Applications to well-established turf with good root system and uniform stand and has received at least two mowings
Postemergence annual grass	Drive	quinclorac	Can be applied 7 days prior to seeding on any cool season turfgrass. Can be applied anytime after seeding on tall fescue, but must wait 28 days after emergence of creeping bentgrass, perennial ryegrass, or Kentucky bluegrass.
Postemergence annual grass (goosegrass)	Dismiss	sulfentrazone	Can be applied after the second mowing provided the stand is well established with a good root system.
Postemergence annual grass	Acclaim Extra	fenoxaprop	Limited to 9 oz/A on Kentucky bluegrass that has tillered and has emerged for 1 month. Can be applied to tall fescue, fine fescue, perennial ryegrass that is at least four weeks old.
Postemergence annual grass	Target	MSMA	Do not treat until after the third mowing.
Postemergence crabgrass, creeping bentgrass, etc	Tenacity	mesotrione	Prior to seeding, or two weeks to four mowings after emergence whichever is longer





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*Table 5. Equations for calculations with crabgrass control products.*

Calculating lbs product/A given the rate in lbs ai/A

$$\text{lbs product/Acre} = \frac{\text{lbs ai/A recommended}}{\% \text{ active ingredient (as a decimal)**}}$$

\*\* Be sure to convert % to decimal before calculating; 0.07%=.0007, 0.10%=.001

Calculating lbs ai/A given the rate in lbs product/A

$$\text{lbs ai/Acre} = \text{pounds product/A recommended} \times \% \text{ active ingredient (as a decimal)**}$$

\*\* Be sure to convert % to decimal before calculating; 0.07%=.0007, 0.10%=.001

Calculating lbs N/1000 sq ft /A given application rate in lbs product/A

$$1. \text{ lbs product/1000 sq ft} = \frac{\text{lbs product/Acre}}{43.56}$$

$$2. \text{ lbs N/1000 sq ft} = \text{lbs product/1000 sq ft} \times \% \text{ N (as a decimal)**}$$

\*\* Be sure to convert % to decimal before calculating; 0.07%=.0007, 0.10%=.001

Calculating price per acre:

$$\text{Price /Acre} = \frac{\text{price}}{\text{Unit (lbs)}} \times \text{lbs product recommended/acre}$$

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Table 6: Pounds/Acre of herbicide/fertilizer combo products need given the desired rate in lbs active ingredient in product.

	Recommended rate of herbicide in lbs ai/Acre																					
	0.13	0.25	0.30	0.35	0.38	0.40	0.45	0.50	0.55	0.65	0.70	0.80	0.90	1.00	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00
0.07	179	357	429	500	543	571	643	714	786	929	1000	1143	1286	1429	1786	2143	2500	2857	3214	3571	3929	4286
0.10	125	250	300	350	380	400	450	500	550	650	700	800	900	1000	1250	1500	1750	2000	2250	2500	2750	3000
0.125	100	200	240	280	304	320	360	400	440	520	560	640	720	800	1000	1200	1400	1600	1800	2000	2200	2400
0.15	83	167	200	233	253	267	300	333	367	433	467	533	600	667	833	1000	1167	1333	1500	1667	1833	2000
0.20	63	125	150	175	190	200	225	250	275	325	350	400	450	500	625	750	875	1000	1125	1250	1375	1500
0.21	60	119	143	167	181	190	214	238	262	310	333	381	429	476	595	714	833	952	1071	1190	1310	1429
0.25	50	100	120	140	152	160	180	200	220	260	280	320	360	400	500	600	700	800	900	1000	1100	1200
0.29	43	86	103	121	131	138	155	172	190	224	241	276	310	345	431	517	603	690	776	862	948	1034
0.35	36	71	86	100	109	114	129	143	157	186	200	229	257	286	357	429	500	571	643	714	786	857
0.40	31	63	75	88	95	100	113	125	138	163	175	200	225	250	313	375	438	500	563	625	688	750
0.43	29	58	70	81	88	93	105	116	128	151	163	186	209	233	291	349	407	465	523	581	640	698
0.45	28	56	67	78	84	89	100	111	122	144	156	178	200	222	278	333	389	444	500	556	611	667
0.50	25	50	60	70	76	80	90	100	110	130	140	160	180	200	250	300	350	400	450	500	550	600
0.55	23	45	55	64	69	73	82	91	100	118	127	145	164	182	227	273	318	364	409	455	500	545
0.60	21	42	50	58	63	67	75	83	92	108	117	133	150	167	208	250	292	333	375	417	458	500
0.66	19	38	46	53	58	61	69	76	84	99	107	122	137	152	191	229	267	305	343	381	419	457
0.70	18	36	43	50	54	57	64	71	79	93	100	114	129	143	179	214	250	286	321	357	393	429
0.75	17	33	40	47	51	53	60	67	73	87	93	107	120	133	167	200	233	267	300	333	367	400
0.80	16	31	38	44	48	50	56	63	69	81	88	100	113	125	156	188	219	250	281	313	344	375
0.86	15	29	35	41	44	47	52	58	64	76	81	93	105	116	145	174	203	233	262	291	320	349
0.90	14	28	33	39	42	44	50	56	61	72	78	89	100	111	139	167	194	222	250	278	306	333
1.00	13	25	30	35	38	40	45	50	55	65	70	80	90	100	125	150	175	200	225	250	275	300
1.10	11	23	27	32	35	36	41	45	50	59	64	73	82	91	114	136	159	182	205	227	250	273
1.20	10	21	25	29	32	33	38	42	46	54	58	67	75	83	104	125	146	167	188	208	229	250
1.31	10	19	23	27	29	31	34	38	42	50	53	61	69	76	95	115	134	153	172	191	210	229
1.40	9	18	21	25	27	29	32	36	39	46	50	57	64	71	89	107	125	143	161	179	196	214
1.50	8	17	20	23	25	27	30	33	37	43	47	53	60	67	83	100	117	133	150	167	183	200

Pounds/Acre = lbs ai/A recommended + % active ingredient\*\*  
 \*\*\*Note convert percent to decimal before calculation by dividing by 100 (.07% = .0007, or 0.1% = .001)





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

Table 7: Amount of fertilizer or fertilizer herbicide combo required given the percent fertilizer in the product and desired rate in lbs N/1000 sq ft or lbs N/Acre.

	Nitrogen rate in lbs N/1000 sq ft or lbs N/Acre																					
	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre	lbs N/1000	lbs N/Acre						
1	0.25	11	0.40	17	0.50	22	0.60	26	0.70	30	0.75	33	0.80	35	0.90	39	1.00	44	1.25	54	1.50	65
2	25	1089	40	1742	50	2178	60	2614	70	3049	75	3287	80	3485	90	3920	100	4356	125	5445	150	6534
3	13	545	20	871	25	1089	30	1307	35	1525	38	1634	40	1742	45	1960	50	2178	63	2723	75	3287
4	8.3	363	13.3	581	17	726	20	871	23	1016	25	1089	27	1162	30	1307	33	1452	42	1815	50	2178
5	6.3	272	10.0	436	13	545	15	653	18	762	19	817	20	871	23	980	25	1089	31	1361	38	1634
6	5.0	218	8.0	348	10	436	12	523	14	610	15	653	16	697	18	784	20	871	25	1089	30	1307
7	4.2	182	6.7	290	8.3	363	10	436	12	508	13	545	13	581	15	653	17	726	21	908	25	1089
8	3.6	156	5.7	249	7.1	311	8.6	373	10	436	11	467	11	498	13	560	14	622	18	778	21	933
9	3.1	136	5.0	218	6.3	272	7.5	327	8.8	381	9.4	408	10	436	11	490	13	545	16	681	19	817
10	2.8	121	4.4	194	5.6	242	6.7	290	7.8	339	8.3	363	8.9	387	10	436	11	484	14	605	17	726
11	2.5	109	4.0	174	5.0	218	6.0	261	7.0	305	7.5	327	8.0	348	9.0	396	10	436	13	545	15	653
12	2.3	99	3.6	158	4.5	188	5.5	238	6.4	277	6.8	297	7.3	317	8.2	356	9.1	396	11	495	14	594
13	2.1	91	3.3	145	4.2	182	5.0	218	5.8	254	6.3	272	6.7	290	7.5	327	8.3	363	10	454	13	545
14	1.9	84	3.1	134	3.8	168	4.6	201	5.4	235	5.8	251	6.2	268	6.9	302	7.7	335	9.6	419	12	503
15	1.8	78	2.9	124	3.6	156	4.3	187	5.0	218	5.4	233	5.7	249	6.4	280	7.1	311	8.9	389	11	467
16	1.7	73	2.7	116	3.3	145	4.0	174	4.7	203	5.0	218	5.3	232	6.0	261	6.7	290	8.3	363	10	436
17	1.6	68	2.5	109	3.1	136	3.8	163	4.4	191	4.7	204	5.0	218	5.6	245	6.3	272	7.8	340	9.4	408
18	1.5	64	2.4	102	2.9	128	3.5	154	4.1	179	4.4	192	4.7	205	5.3	231	5.9	256	7.4	320	8.8	384
19	1.4	61	2.2	97	2.8	121	3.3	145	3.9	169	4.2	182	4.4	194	5.0	218	5.6	242	6.9	303	8.3	363
20	1.3	57	2.1	92	2.6	115	3.2	138	3.7	160	3.9	172	4.2	183	4.7	206	5.3	229	6.6	287	7.9	344
21	1.3	54	2.0	87	2.5	109	3.0	131	3.5	152	3.8	163	4.0	174	4.5	196	5.0	218	6.3	272	7.5	327
22	1.2	52	1.9	83	2.4	104	2.9	124	3.3	145	3.6	156	3.8	166	4.3	187	4.8	207	6.0	259	7.1	311
23	1.1	50	1.8	79	2.3	99	2.7	119	3.2	139	3.4	149	3.6	158	4.1	178	4.5	198	5.7	248	6.8	297
24	1.1	47	1.7	76	2.2	95	2.6	114	3.0	133	3.3	142	3.5	152	3.9	170	4.3	189	5.4	237	6.5	284
25	1.0	45	1.7	73	2.1	91	2.5	109	2.9	127	3.1	136	3.3	145	3.8	163	4.2	182	5.2	227	6.3	272
26	1.0	44	1.6	70	2.0	87	2.4	105	2.8	122	3.0	131	3.2	139	3.6	157	4.0	174	5.0	218	6.0	261
27	1.0	42	1.5	67	1.9	84	2.3	101	2.7	117	2.9	126	3.1	134	3.5	151	3.8	168	4.8	209	5.8	251
28	0.9	40	1.5	65	1.9	81	2.2	97	2.6	113	2.8	121	3.0	129	3.3	145	3.7	161	4.6	202	5.6	242
29	0.9	39	1.4	62	1.8	78	2.1	93	2.5	109	2.7	117	2.9	124	3.2	140	3.6	156	4.5	194	5.4	233
30	0.9	38	1.4	60	1.7	75	2.1	90	2.4	105	2.6	113	2.8	120	3.1	135	3.4	150	4.3	188	5.2	225
31	0.8	36	1.3	58	1.7	73	2.0	87	2.3	102	2.5	109	2.7	116	3.0	131	3.3	145	4.2	182	5.0	218
32	0.8	34	1.3	54	1.6	68	1.9	82	2.2	95	2.3	102	2.5	109	2.8	123	3.1	136	3.9	170	4.7	204
33	0.7	32	1.2	51	1.5	64	1.8	77	2.1	90	2.2	96	2.4	102	2.6	115	2.9	128	3.7	160	4.4	192
34	0.7	29	1.1	46	1.3	57	1.6	69	1.8	80	2.0	86	2.1	92	2.4	103	2.6	115	3.3	143	3.9	172
35	0.7	28	1.1	44	1.3	55	1.6	67	1.8	78	2.0	84	2.1	89	2.4	101	2.6	114	3.3	143	3.9	172
36	0.5	24	0.9	38	1.1	47	1.3	57	1.5	68	1.6	71	1.7	76	2.0	85	2.2	95	2.7	118	3.3	142

Pounds N /1000 sq ft = N rate in lbs N/1000 + % N\*\*

Pounds N /Acre = N rate in lbs N/A + % N\*\*

\*\*Note convert percent to decimal before calculation by dividing by 100 (.07% = .0007, or 0.1%=.001)