Accepted for publication 19 March 2010. Published 16 April 2010.

Using Cultural Practices and Leaf Mulch to Control Weeds in Established Turfgrass

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Kowalewski, A. R., Calhoun, R. N., Hathaway, A. D., and Rogers, J. N. III. 2010. Using cultural practices and leaf mulch to control weeds in established turfgrass. Online. Applied Turfgrass Science doi:10.1094/ATS-2010-0416-01-RS.

Abstract

Recent research has shown that leaves collected from a variety of tree species mulched into established turfgrass resulted in fewer common dandelions (*Taraxacum officinale* W.). However, the turfgrass in this research was managed at a low maintenance level to promote weed establishment. An experiment was initiated in October 2004 to develop a better understanding of how mulched leaves would effect dandelion populations in properly maintained turfgrass. The objective of this research was to quantify the effectiveness of leaf mulch as an organic weed control method when combined with frequent nitrogen fertilizer applications and a mowing height conducive to a cool-season turfgrass mixture. Research was initiated on 21 October 2004 in East Lansing, MI, on a sandy loam soil without irrigation. Main effects included leaf species, fertilization, and mowing height. Leaf species were sugar maple (*Acer saccharum* M.) and red maple (*A. rubrum* L.) applied at 1.5 kg/m², and a control. Fertilization included urea (46.0N-0.0P-0.0K) applied at 146.4 kg N per ha annually and a control. Mowing heights were 3.8 cm and 7.6 cm. Data collected in 2005 and 2006 included visual turfgrass quality (1-9 scale, 6 or greater acceptable), percent (0-100%) crabgrass (*Digitaria* spp.) cover and dandelion counts (dandelions per 10.2 m²). Fertilization increased turfgrass quality and the 3.8-cm mowing height increased crabgrass populations. Regarding dandelion populations, results obtained in 2005 indicate that mulched leaves, regardless of maple species, reduced dandelion counts by up to 84% after a single application. However, after a second leaf mulch application was made in 2005, there was no measured effect on dandelion populations in 2006.

Leaf Mulch as an Alternative Weed Control Method

Growing concern for environmental safety has urged researchers to explore organically derived weed control methods in the field of turfgrass management (1,14,17). Research conducted by Kowalewski et al. (11) and Nikolai et al. (13) has shown that fallen tree leaves, collected from maple and oak (*Quercus* spp.) species, mulched into established turfgrass as a leaf litter disposal method resulted in increased spring green-up and fewer common dandelions without producing any deleterious effects (Figs. 1 and 2). However, the Kentucky bluegrass (*Poa pratensis* L.) stand in the research conducted by Kowalewski et al. (11) was maintained with minimal inputs (no irrigation and low fertilization) and was regularly scalped to promote weed establishment, resulting in extremely high dandelion populations throughout the study and an eventual loss in differences. These findings suggest that mulched leaves alone cannot be used to provide high-end long-term weed control in poorly maintained turfgrass.

Fig. 1. Effects of sugar maple leaf mulch (applied at 1.5 kg/m² on 16 November 2004) on common dandelion populations in established Kentucky bluegrass observed by Kowalewski et al. (11), 8 May 2005, East Lansing, MI.

Fig. 2. Effects of no leaf mulch (control) on common dandelion populations in established Kentucky bluegrass observed by Kowalewski et al. (11), 8 May 2005, East Lansing, MI.

In response to these findings, a new experiment was initiated to develop a better understanding of how mulched tree leaves would affect dandelion populations in properly maintained cool-season turfgrass. The objective of this research was to quantify the efficacy of leaf mulch as an organic weed control method when combined with frequent nitrogen fertilizer applications and a mowing height conducive to a cool-season turfgrass mixture. The original hypothesis of this research was that leaf mulch applications, regardless of species, in combination with regular nitrogen fertilizer applications and an increased mowing height, would provide a well integrated turfgrass management system capable of providing long-term dandelion suppression.

Project Design

A field experiment was initiated 21 October 2004 at the Hancock Turfgrass Research Center (HTRC), East Lansing, MI, to examine the effects of leaf mulch, mowing height and nitrogen fertilizer applications on an established cool-season turfgrass stand. Experimental design was a 3 × 2 × 2 factorial, completely randomized, with three replications. Total experimental area was 572.3 m², containing 36 treatments (3.0 m wide × 3.4 m long). Factors included tree leaf species (sugar maple and red maple, compared to a control), fertilizer (146.4 kg N per ha applied annually and a control), and mowing height (3.8 and 7.6 cm).

Research was conducted on a sandy loam soil [62.5% sand (0.05 to 2.0 mm), 23.3% silt (0.002 to 0.05 mm) and 14.2% clay (< 0.002 mm); MSU Soil and Plant Nutrient Laboratory, East Lansing, MI], with a well established cool-season turfgrass mixture, chewings fescue (*Festuca rubra* L. var. *commutata*) (19.6% 'Moxie' and 19.5% 'Raymond'), Kentucky bluegrass (19.6% 'Ronde,' 9.8% 'Cannon,' and 9.8% 'Gnome'), and perennial ryegrass (*Lolium perenne* L.) (9.8% 'ASP410' and 9.7% 'SR4200'), seeded in 1998. A composite soil sample was collected from the research area and used to assess existing soil pH and soil nutrient levels (soil pH 7.4, phosphorus 31.0 mg/kg, and potassium 182.0 mg/kg). This research area was selected because it did not have irrigation, a common practice utilized in low-maintenance turf sites (6),and a situation that home owners across the United States of America could face as water use regulations intensify (2,7).

A three-way broadleaf herbicide, 2,4-D (2,4-dichlorophenoxyacetic acid), clopyralid (3,6-dichloro-2-pyridinecarboxylic acid), and dicamba (3,6-dichloro-o-anisic acid) (Millennium Ultra²; Nufarms Americas Inc., Burr Ridge, IL) applied at a rate of 1.26, 0.08, and 0.16 kg ai/ha, respectively, was administered on 21 October 2004. This application provided an experimental site free of broadleaf weeds so the preemergence activity of leaf mulch could be evaluated.

Leaf Mulch Collection and Application (2004)

Freshly fallen deciduous tree leaves were collected at the W.K. Kellogg Experimental Forest (Augusta, MI) from monoculture, pesticide-free stands of red and sugar maple on 13 November 2004. A lawn blower/vacuum (Poulan PRO #BMV-200 Gas Blower/Vac; Electrolux Home Products, Nashville, AR) was used to collect the leaves. The leaves were transported to the HTRC where they were later applied to the experimental site as mulch.

On 19 November 2004, prior to leaf mulch application, dandelion (*Taraxacum officinale* W.) seed (V & J Seed, Woodstock, IL) was evenly spread over the experimental site to increase the seed bank level of broadleaf weeds. Dandelion seeds were applied at a rate of 2716.0 seeds/m^2, equivalent to approximately 2.3 actively seeding dandelions per square meter (15). The Michigan Department of Agricultural Control Laboratory (East Lansing, MI) determined a germination rate of 5.0% using a 21-day germination test with a daily cycle of 16 h at 20.0°C and 8 h at 30.0°C, conforming to the Association of Official Seed Analysts rules for testing dandelion (Association of Official Seed Analysts, 2002). Later that day, tree leaves, with a particle size ranging from 2.5 to 6.4 cm^2, were applied at rate of 1.5 kg/m^2 (dry weight), a leaf mulch application rate derived from Kowalewski et al. (11). The tree leaves were then incorporated into the turfgrass canopy using a rotary push mower set at a 5.1-cm mowing height (Fig. 3).

Fig. 3. Sugar maple leaves being mulching into an established Kentucky bluegrass stand, November 19, 2005, East Lansing, MI.

Fertilization and Mowing (2005)

Nitrogen applications and two mowing heights were maintained throughout the 2005 growing season. Fertilization treatments totaled 146.4 kg N per ha annually. To achieve these annual rates, urea (46.0N-0.0P-0.0K) (Andersons, Maumee, OH) was applied on 30 May 2005 (48.8 kg N per ha), 4 July 2005 (24.4 kg N per ha), 5 September 2005 (24.4 kg N per ha), and 24 November 2005 (48.8 kg N per ha) using a shaker jar, similar to the experimental design used by Calhoun et al. (4). This was compared to control treatments, which did not receive any fertilizer. Mowing was maintained at two different heights, 3.8 cm and 7.6 cm, using a rotary mulching mower during the 2005 growing season, 28 April to 21 November 2005.

Leaf Mulch Collection and Application (2005), Fertilization and Mowing (2006)

The same treatments received a second consecutive application of sugar and red maple leaves, collected from the same monoculture stands, in the fall of 2005. Leaves were collected on 3 November 2005 at the W.K. Kellogg Experimental Forest, transported to East Lansing, applied at the same application rate, 1.5 kg/m^2, and mowed into the turfgrass canopy on 19 November 2005. Experimental treatments that received fertilizer in 2005 were again fertilized on 31 May 2006 (48.8 kg N per ha), 4 July 2006 (24.4 kg N per ha), 4 September 2006 (24.4 kg N per ha), and 25 November 2006 (48.8 kg N per ha) with urea. The treatments were maintained at the previously specified

mowing heights throughout the 2006 growing season, 28 April to 18 November 2006.

Data Collection (2005 and 2006)

Turfgrass quality, crabgrass cover (0 to 100%), and dandelion populations (dandelions per 10.2 m^2) were evaluated after the first leaf mulch application on 17 August 2005 and again after the second leaf mulch application on 10 August 2006. Turfgrass quality was based on the National Turfgrass Evaluation Program (NTEP) system of rating, 1 being the poorest possible or dead, 9 being perfect or ideal turfgrass and 6 or greater being acceptable (12).

Statistical Analysis

Data were analyzed as a factorial, completely randomized design with three replications using Agricultural Research Management (ARM) (8). The three studied factors included tree leaf species (red maple, sugar maple and control), nitrogen fertilizer applications (146.4 kg N per ha annually and control) and mowing height (3.8 cm and 7.6 cm). Mean separations were analyzed using Fisher's least significant difference (LSD) value at a 0.05 level of probability. The 2005 and 2006 data were analyzed and presented separately to evaluate the effects of one and then two years of experimental treatment (fall leaf mulch, fertilizer and mowing height) applications.

Effects of One Fall Leaf Mulch Application, Nitrogen Fertilization and Mowing Height (2005)

Main effects of leaf species, fertilizer and mowing height on turfgrass quality were insignificant in 2005, while significant leaf mulch × mowing height and fertilizer × mowing height interactions were observed (Table 1). However, mean values were disorderly and illogical, and inconclusive due to minimal separations between means (leaf mulch × mowing means ranged from 4.7 to 5.8, and fertilizer × mowing height means ranged from 4.7 to 5.7 on a 1 to 9 scale), indicating a probable lack of biological significance. All results were less than 6 (an acceptable rating according to the NTEP scale), likely due to the environmental stresses observed leading up to the data collection date in August, a peak temperature of 33.4°C in July 2005 and water deficits (evapotranspiration > precipitation) in April, May, June, and August 2005 (HTRC Rain Bird Maxi Weather Station, Model WS-200; Rain Bird, Glendora, CA).

Table 1. ANOVA results for turfgrass quality (1 being poorest possible, 9 being perfect and ≥ 6 being acceptable), crabgrass cover (0-100%) and dandelion populations (dandelions per 10.2 m^2), East Lansing, MI, 17 August 2005.

Source of variation	DF	Turfgrass quality (1-9)	Crabgrass cover (0-100%)	Dandelions per 10.2 m^2
		P > F		
Leaf species (L)	2.0	ns[x]	ns	*
Fertilizer (F)	1.0	ns	ns	ns
Mowing height (M)	1.0	ns	*	ns
L × F	2.0	ns	ns	ns
L × M	2.0	*	ns	ns
F × M	1.0	*	ns	ns
L × F × M	2.0	ns	ns	ns

* Significant at a 0.05 level of probability.

[x] NS = nonsignificant at the 0.05 probability level.

Mowing height produced significant main effects on crabgrass cover in 2005, while leaf species and fertilizer were insignificant (Table 1). The low mowing height, 3.8 cm, produced the greatest crabgrass cover, suggesting an inverse correlation between mowing height and crabgrass population (Table 2). Dernoeden et al. (5) also determined that tall fescue (*F. arundinacea* L.) maintained at 8.8 cm, the highest mowing height in the study, was the most resistant to crabgrass invasion, following pre- and postemergence herbicide applications. Analogous to these findings, Busey (3) points out that decreased mowing height is a well documented cultural factor responsible for increased crabgrass invasion.

Table 2. Effects of leaf species, fertilizer rate, and mowing height (cm) on turfgrass quality (1 being poorest possible, 9 being perfect, and ≥ 6 being acceptable), crabgrass cover (0-100%) and dandelion populations (dandelions per 10.2 m²), East Lansing, MI, 17 August 2005.

		Turfgrass quality (1-9)	**Crabgrass cover** (0-100%)	**Dandelions per 10.2 m²**
Leaf species[v]	sugar maple[w]	5.3 a[x]	17.9 a	2.8 a
	red maple	5.2 a	20.8 a	5.0 a
	control	5.5 a	15.9 a	17.8 b
Fertilizer N rate	0.0 kg/ha	5.1 a	20.2 a	8.1 a
	146.4 kg/ha[y]	5.5 a	16.2 a	8.9 a
Mowing height[z]	3.8 cm	5.4 a	24.6 b	3.5 a
	7.6 cm	5.2 a	11.8 a	13.6 a

[v] Leaf mulch applications were made on 28 November 2004 at a rate of 1.5 kg/m².

[w] Number of replications for all treatments = 3.

[x] Within columns, means followed by the same letter are not significantly different according to LSD (0.05).

[y] Fertilizer applications were made on 30 May 2005 (48.8 kg N per ha), 4 July 2005 (24.4 kg N per ha), 5 September 2005 (24.4 kg N per ha), and 24 November 2005 (48.8 kg N per ha).

[z] Mowing was maintained at these heights from 28 April to 21 November 2005.

Leaf species produced significant main effects on dandelion populations, while no differences between nitrogen fertilization rates or mowing heights were observed (Table 1). Mean dandelion counts were lowest in treatments that received leaf mulch applications, regardless of maple species (Table 2). Similar to these findings, Kowalewski et al. (11) and Nikolai et al. (13) observed reduced dandelion populations in plots treated with maple leaf mulch. Bingaman and Christians (1) determined that corn gluten meal, a naturally derived weed control product, reduced the survival, shoot length and root development of a variety of dicotyledon and monocotyledon weeds, including common dandelion and smooth crabgrass [*Digitaria ischaemum* (Schreb.) Shreb. Ex Muhl.]. Heckman and Kluchinski (9) found that freshly fallen red maple leaves contained 7.8 g N per kg, 0.6 g P per kg, and 5.4 g K per kg and sugar maple leaves contained 6.6 g N per kg, 1.7 g P per kg, and 5.3 g K per kg. These findings suggest that a red or sugar maple leaf mulch application of 1.5 kg/m² can provide substantial N, P, and K levels to the turfgrass system, 9.9 to 11.7 g N per m², 0.9 to 2.6 g P per m², and 8.0 to 8.1 g K per m². Johnson and Bowyer (10) observed decreased dandelion populations in plots that were fertilized with N, P, and K, regardless of rate [low (300.0 kg N per ha, 90.0 kg P per ha, and 170.0 kg K per ha) or high (600.0 kg N per ha, 130.0 kg P per ha, and 250.0 kg K per ha)]. Turner et al. (18) observed that increasing rates of P, from 0 to 680 kg P per ha, linearly decreased dandelion populations. Conversely, Tilman et al. (16) observed increased, 17- to 20-fold, dandelion populations within well established turfgrass plots fertilized with 225 kg K per ha. Contrary to the lack in significant mowing height differences observed in this research, Calhoun et

al. (4) observed decreased dandelion populations as mowing height was increased from 5.0 to 10.0 cm. In support of Calhoun et al. (4), Busey (3) provides a number of references that have observed increased weed population as a result of a low mowing height. The high crabgrass populations observed at the lower mowing height in this research is likely the reason that dandelion populations were not affected by mowing. A lack in crabgrass pressure would have allowed dandelion to capitalize on the reduced mowing height.

Effects of Two Consecutive Fall Leaf Mulch Application, Nitrogen Fertilization and Mowing Height (2006)

Significant main effects of fertilizer on turfgrass quality were observed in 2006, while leaf species and mowing height produced no significant differences (Table 3, Fig. 4). A significant fertilizer × mowing height interaction was also observed in 2006.

Fig. 4. Effects of fertilization [146.4 kg N per ha (left) and unfertilized (right)] on turfgrass quality and mowing height [7.6 cm (left) and 3.8 cm (right)] on crabgrass cover observed after the ambient temperature has reached freezing, 12 October 2006, East Lansing, MI.

Table 3. ANOVA results for turfgrass quality (1 being poorest possible, 9 being perfect, and ≥ 6 being acceptable), crabgrass cover (0-100%), and dandelion populations (dandelions per 10.2 m²), East Lansing, MI, 10 August 2006.

Source of variation	DF	Turfgrass quality (1-9)	Crabgrass cover (0-100%)	Dandelions per 10.2m²
		P > F		
Leaf species (L)	2.0	ns[x]	ns	ns
Fertilizer (F)	1.0	***	*	ns
Mowing height (M)	1.0	ns	*	ns
L × F	2.0	ns	ns	ns
L × M	2.0	ns	ns	ns
F × M	1.0	*	ns	ns
L × F × M	2.0	ns	ns	ns

*** Significant at a 0.001 level of probability.
* Significant at a 0.05 level of probability.
[x] NS = nonsignificant at the 0.05 probability level.

Nitrogen fertilizer applications produced the greatest turfgrass quality, greater than 6 (considered acceptable according to the NTEP scale) (Table 4). Treatments that did not receive regular fertilizer applications produced turfgrass quality ratings less than 6. Similar to these findings, Dernodoeden et al. (5) observed improved spring and fall tall fescue quality as a result of high nitrogen (196.0 kg/ha) application rates.

Table 4. Effects of leaf species, fertilizer rate, and mowing height (cm) on turfgrass quality (1 being poorest possible, 9 being perfect, and ≥ 6 being acceptable), crabgrass cover (0-100%), and dandelion populations (dandelions per 10.2 m²), East Lansing, MI, 10 August 2006.

		Turfgrass quality (1-9)	**Crabgrass cover** (0-100%)	**Dandelions per 10.2 m²**
Leaf species[v]	sugar maple[w]	6.5 a[x]	22.1 a	14.0 a
	red maple	6.6 a	21.1 a	19.9 a
	control	6.8 a	14.6 a	28.6 a
Fertilizer N rate	0.0 kg/ha	5.6 b	23.6 b	20.1 a
	146.4 kg/ha[y]	7.7 a	14.9 a	21.6 a
Mowing height[z]	3.8 cm	6.8 a	22.8 b	21.2 a
	7.6 cm	6.5 a	15.7 a	20.4 a

[v] Leaf mulch applications were made on 19 November 2005 at a rate of 1.5 kg/m².

[w] Number of replications for all treatments = 3.

[x] Within columns, means followed by the same letter are not significantly different according to LSD (0.05).

[y] Fertilizer applications were made on 31 May 2006 (48.8 kg N per ha), 4 July 2006 (24.4 kg N per ha), 4 September 2006 (24.4 kg N per ha), and 25 November 2006 (48.8 kg N per ha).

[z] Mowing was maintained at these heights from 28 April to 18 November 2006.

A significant fertilizer × mowing height interaction was observed, with the low mowing height producing a greater turfgrass quality when combined with nitrogen fertilization (Fig. 5). Contrary to these findings, Dernoeden et al. (5) observed decreased summer turfgrass quality when tall fescue was maintained at a reduced mowing height, 3.2 or 5.5 cm, in comparison to a 8.8 cm mowing height and suggests that increased mowing height, rather than fertilization, is the best cultural practice for maintaining a high quality turfgrass stand.

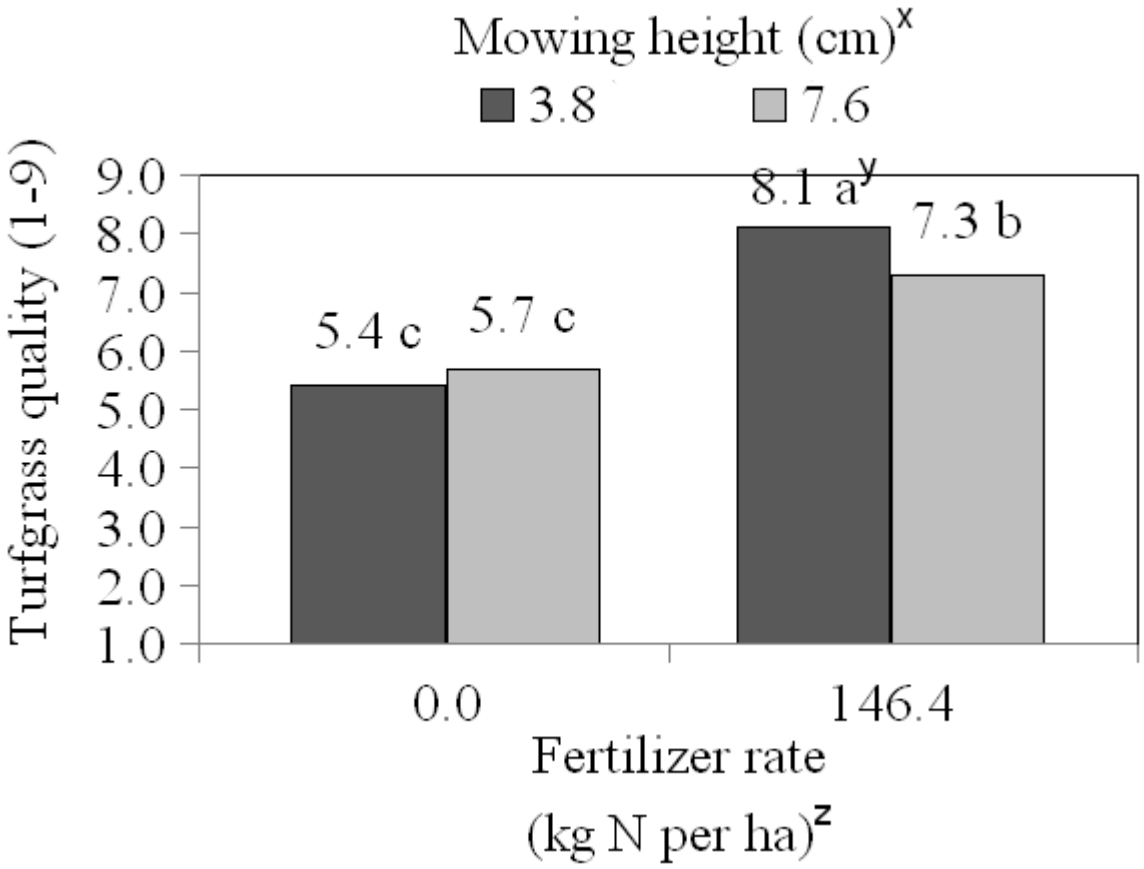

Fig. 5. Effects of fertilizer rate x mowing height on turfgrass quality (1 being poorest possible, 9 being perfect, and ≥ 6 being acceptable), East Lansing, MI, 10 August 2006.

[x] Mowing was maintained at these heights from 28 April to 18 November 2006.

[y] Within columns, means followed by the same letter are not significantly different according to LSD (0.05).

[z] Fertilizer applications were made on 31 May 2006 (48.8 kg N per ha), 4 July 2006 (24.4 kg N per ha), 4 September 2006 (24.4 kg N per ha), and 25 November 2006 (48.8 kg N per ha).

Main effects of fertilizer and mowing height on crabgrass cover were observed, while leaf species produced no differences (Table 3, Fig. 4). The control treatments (0.0 kg N per ha) had more crabgrass than treatments that received 146.4 kg N per ha annually (Table 4). Similar to these findings, Dernoeden et al. (5) observed reduced smooth crabgrass [*Digitaria ischaemum* (Schreb.) Schreb. ex Muhl.] populations in non-herbicide-treated plots that received high nitrogen levels (196.0 kg/ha annually) in comparison to low nitrogen levels (96.0 kg/ha annually). Johnson and Bowyer (10) also observed improved large crabgrass (*Digitaria sanguinalis* L.) control in plots treated with preemergence herbicides combined with any fertility rate (low or high) compared to turfgrass that received preemergence herbicides only. Similar to results observed in 2005, a lower mowing height (3.8 cm) resulted in increased crabgrass cover observed throughout the duration of the data collection period (Table 4). In support of these findings, Calhoun et al. (4) observed increased, up to 75%, dandelion and white clover (*Trifolium repens* L.) populations in plots maintained at a low, 5.0-cm mowing height without fertilization.

Neither leaf species, fertilizer nor mowing height produced a significant main effect on dandelion populations in 2006 (Table 3). Similar to results observed by Kowalewski et al. (11), significant differences were lost due to substantial variability across the treatments as mean populations increased over time. These findings are likely the result of summer desiccation, due to a lack in irrigation combined with abiotic stress, and subsequent weed colonization (3,6). Environmental stresses included peak temperatures of 33.4°C in July 2005, and 34.7°C in July and August 2006, and water deficits (evapotranspiration >

precipitation) in April, May, June, August and October, 2005, and June, July and August, 2006 (HTRC Rain Bird Maxi Weather Station, Model WS-200; Rain Bird, Glendora, CA).

Conclusion

In 2006, N fertilization was more important than mowing height and leaf mulch when trying to maintain a high quality cool-season turfgrass stand without irrigation. Findings also determined that an increased mowing height reduced crabgrass populations over the two years data was collected (2005 and 2006), while increased N fertility reduced crabgrass in 2006, after two consecutive annual applications. Leaf mulch produced a significant effect on dandelion populations in 2005 only, while fertilization and mowing height produced no effect on dandelion populations. Results suggest that mulched leaves, regardless of maple species, can be used to reduce dandelion counts in the first year following a broadleaf herbicide application, but cannot provide sustained dandelion control on a site that is not irrigated even when combined with proper mowing and fertilization. These findings support the idea that mulched leaves provide some preemergence dandelion control, and do not provide postemergence effects once dandelions have become established. As discussed in previous research by Kowalewski et al. (11), findings have yet to determine if leaf mulch is simply forming a physical barrier that prevents sunlight from reaching the dandelion seeds preventing germination.

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