Best Management Practices
for Pesticide-Free, Cool-Season Athletic Fields

A Working Document




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UCONN TURFGRASS

Contents

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Introduction

Effective July 1, 2010, the state of Connecticut banned the use of all EPA-registered lawn care pesticides on athletic fields at public and private schools grades pre-K through 8. Violators of this new law can be fined up to $5000 and/or imprisoned up to one year. The only pesticides that can legally be applied in these cases are those classified as EPA 25b minimum-risk products. However, there are very limited data on the efficacy of these products at this time. Therefore, more emphasis will shift back to cultural practices in lieu of registered pesticides usage.

This publication will cover the five primary cultural practices for managing pesticide-free, cool-season athletic fields; **1) mowing, 2) fertilization, 3) cultivation, 4) pest control and 5) irrigation.** In addition, aggressive overseeding and compost topdressing will be discussed. Pesticide-free management fundamentally changes pest control. Until recently, many sports turf managers incorporated various chemical controls into their management regime to control weeds, insects and diseases preventatively and/or curatively. Since chemical controls are no longer an option, there is tremendous confusion regarding effective methods to control invasive weeds, damaging insects and potentially devastating diseases. This is a concern for all turfgrass managers that maintain high quality turfgrass, but particularly for sports turf managers. Athletic fields present a different challenge compared to other highly maintained turfgrass areas due the nature of the traffic they endure and the liability associated with their use. Athletic fields are in a constant state of re-establishment. Intense traffic and the subsequent reduction in turfgrass cover create an environment that is optimal for pest encroachment. Reduced turfgrass cover allows weed seeds to germinate and remain competitive. Loss of turfgrass cover has also been associated with an increase in player to surface injuries (Dest and Ebdon, 2011). Turfgrass diseases and/or insects may turn a well-established turfgrass stand into an unstable playing surface very quickly.

Implementing good cultural practices throughout the year will help maintain healthy turfgrass so the playing surface will be in the best possible condition when it is needed. Healthy turfgrass will be more likely to tolerate intense traffic, weeds, insects, diseases and drought stress. The purpose of this document is to provide guidelines for managing cool-season athletic fields most effectively given the pesticide-free restriction. Throughout this document, research-based information has been utilized to provide sound agronomic recommendations.

Mowing

Ideal mowing height can depend on factors such as sport, turfgrass species, irrigation, and field use. (Table 1) (Adapted from ASTM, 2005)

Table 1. Factors affecting mowing height selection.

Athletic Field Use	Grass Species	Mowing Height*
Baseball, Softball, Soccer, Football	Kentucky bluegrass (KB), perennial ryegrass (PR), or KB:PR mixture	1.5-2.5 in.
Intramural and Multiple use fields	Kentucky bluegrass, perennial ryegrass, KB/PR mixture, or tall fescue	2.0-3.5 in.

* If the field is not irrigated, the turfgrass should be mowed at the high end of the suggested range.

Mowing heights can be increased (0.5-1.5 in.) during the offseason and/or summer months to decrease the mowing frequency and help reduce weed encroachment. However, reducing the mowing height to competition height should begin 4-6 weeks before the first game/practice (Puhalla et al., 1999). Mowing height of cut (HOC) should be reduced gradually (Vanini and Rogers, 2008) (i.e. 0.5 in. at a time, allowing 3-5 days between mowings). Mow each HOC at least twice before reducing the HOC further.

Mow at least twice per week (Calhoun et al., 2002), remove no more than 1/3 of the leaf blade (Figure 1).

Higher mowing height can help reduce weed incidence (Calhoun et al., 2005). However, athletic fields are constantly subjected to traffic creating voids in the turfgrass canopy allowing opportunistic weed to germinate. Weed pressure will be constant, particularly in the high traffic areas.

Returning clippings can reduce nitrogen (N) fertilization requirements (up to 50%) without decreasing turfgrass quality in mixed turfgrass stands containing predominantly Kentucky bluegrass and perennial ryegrass (Kopp and Guillard, 2002).

Alternate mowing pattern each time to reduce potential wear patterns from mower.

Mow when turfgrass is dry to maximize clipping dispersion and sharpen blades often.

Figure 1. Consider using rotary mowers with contour decks. These mowers are easier to maintain than reel mowers, provide a high quality cut, disperse clippings very well and stripe nicely.

Fertilization

Maintain soil pH 5.9-6.5 to maximize nutrient availability. In Kentucky bluegrass swards with pH greater than 6.5 consider applications of ammonium sulfate or sulfur coated urea from late May to July to help reduce pH levels in the root zone and minimize summer patch severity.

According to Connecticut law, no phosphorus (P) fertilizer applications can be made Dec. 1-March 15. Phosphorus applications are not permitted unless a soil test within 2 years indicates a need for P. P applications are permitted without a soil test during establishment or if the fertilizer source contains $\leq$0.67% phosphate (P_2O_5).

Apply N at a rate of 3-4 lbs N/1000 ft^2/year and fertilize frequently when using soluble sources (6-8 applications, April-October) on 21-28 day intervals (Calhoun et al., 2002). Apply no more than 0.5 pound of soluble N/1000 ft^2 per application only when weather conditions permit. Apply when leaf tissue is dry and then irrigate immediately after application. Slow-release N sources (such as poly-coated sources) can be applied at higher rates less often) i.e. 1.5-2.0 pounds N in mid May and 1.5-2.0 pounds N in Aug.) (Figure 2).

Figure 2. Consider using high capacity broadcast spreaders to cover large areas quickly.

Soil test every 1-3 years to monitor soil nutrient levels and pH. Follow soil test recommendations for P and potassium (K). Maintain P levels at the low end of the optimal range to discourage annual bluegrass encroachment. The optimum range for P is 6-20 lbs per acre (modified Morgan). Results from other laboratories may vary due to the method used to measure soil available P. It is advisable to use the university laboratory in your state to eliminate confusion.

Tips for Obtaining a Representative Soil Sample

- Best time to sample is late fall or right before your next fertilizer application
- Select 20-25 random locations across the field
- Sample to a consistent 4in. depth using a soil probe or small shovel
- Remove and discard thatch and turfgrass from each subsample
- Mix subsamples in a clean plastic bucket
- Transfer one cup of soil mixture into a secure bag for shipping

Cultivation

The following dates and cultivation types are recommended for athletic fields predominately used in the fall. Athletic fields primarily used in the spring require a reverse cultivation strategy (solid-tine cultivation (STC) in the spring and hollow-tine cultivation (HTC) in the fall).

Hollow-tine cultivation (April 15-May 15)

HTC helps to alleviate soil compaction at the surface, increase infiltration rates, and prepare a quality seedbed for spring re-establishment efforts (Figure 3). The window for HTC is recommended to maximize turfgrass and root recovery following cultivation. Additionally, HTC has also been shown to provide some mechanical control for white grubs (McGraw and Holdrege, 2012). Generally in the spring, white grubs are actively feeding (located in the 3-4" soil depth range) from April 15 through June 1 (Figure 5). Therefore, the opportunity to inflict damage to the grubs also spans this range. Further delaying cultivation decreases root growth recovery time and extends the active feeding period.

Solid-tine cultivation (August 1-Sept 15)

STC is preferred at this time of year due to less surface disruption than HTC with anticipated heavy fall field usage. STC creates some voids at the surface for gas exchange and water movement, and will also provide some mechanical control for white grubs (McGraw and Holdrege, 2012). Generally in the fall, white grubs are actively feeding (located in the 3-4" soil depth range) from August 1 through November (Figure 5). Therefore, the opportunity to inflict damage to the grubs also spans this range. Further delaying cultivation extends the active feeding period and negatively impacts turfgrass recovery as growth slows with reduced temperatures.

Figure 3. Use only Power Take-Off (PTO) driven, vertically-operating, core cultivation units. These units can provide consistent penetration depth to 3-4". Avoid drum-type core cultivators whenever possible due to their shallow, inconsistent penetration depth.

Tips to Optimize HTC and STC Efficacy

- Use 5/8 in. tines, 2 in.× 2 in. spacing, 2 passes
- Use only a PTO powered, vertically operating unit to provide consistent tine penetration depth to 3-4 in. (Figure 3)
- Return cores using a heavy drag mat (HTC only)

Pest Control

Weeds

The best defense against weed encroachment is maintaining a healthy turfgrass stand through proper mowing and fertilization. Applying nitrogen alone (3 lbs N/1000 ft^2 per year) compared to none has been shown to significantly reduce white clover and dandelion infestations (Calhoun et al., 2005).

Weed infestation can negatively affect playing surface characteristics (Figure 4). Aggressive overseeding has been shown to significantly reduce weed populations (grassy annuals and perennial broadleaves) in pesticide-free management programs (Elford et al., 2008, Miller and Henderson, 2012). Overseeding is currently the most effective pesticide-free method for reducing weed populations (see aggressive overseeding section).

At the present time, there are no documented, selective, post-emergent, EPA minimum risk 25(b) products to control weeds. The only products currently available for use are nonselective, contact defoliants of leaf and stem tissue. Re-growth of most weeds (and turf) naturally occur within 3-4 weeks; therefore multiple, repeated applications are required throughout the season. Clove oil, citric acid, and/or acetic acid are ingredients used most frequently in 25(b) minimum risk products considered to have post-emergent weed control activity.

Corn gluten meal (CGM), an organic, pre-emergent herbicide noted to exhibit root-inhibiting properties that also has a nitrogen component (usually 9-10%), has been shown to significantly reduce crabgrass germination when applied at the recommended rate (20-25 lbs/1000 ft^2) (Christians, 1993). However, crabgrass suppression was not effective in other research (Miller and Henderson, 2012, St. John and DeMuro, 2013). CGM has herbicidal activity, preventing root formation of some germinating plants. Therefore, efficacy can be enhanced when CGM-affected weeds are subjected to a period of water stress.

Figure 4. Weeds do not have the same traffic tolerance as turfgrasses. Therefore, percent cover can be reduced dramatically when fields are heavily used, decreasing traction and increasing surface hardness. This is particularly a concern when crabgrass begins to go dormant in the fall, as seen above.

Tips to Optimize Corn Gluten Meal Efficacy (Christians, 2002)

- Apply in the spring 2-4 weeks before summer annuals (i.e. crabgrass) germinate. Crabgrass will germinate when the soil temperature reaches 55° F. Once soil temperatures consistently reach low to mid 50's, apply CGM at the recommended rate (20 lbs/1000ft^2). This results in approximately 2 lbs N/1000 ft^2 per application.
- If no precipitation occurs within 5 days of application, apply 0.25 in. water.
- Following weed seed germination, ***do not irrigate*** to encourage weed desiccation. Weeds will germinate, forming only a shoot, but not a root. If the soil is too wet, the weed can recover and form a root.
- CGM will ***inhibit turfgrass germination*** when applied at seeding. Inhibitory effects will last for approximately 5-6 weeks. Therefore, CGM should not be used 6 weeks before desirable grasses are seeded. If over-seeding is required in the spring, timing of CGM application is critical. CGM should not be applied until all turfgrasses germinate.
- The N will release slowly over a 3-4 month period following application. A follow-up application can be made in August to help control some perennial weeds germinating in late summer while providing an additional 2 lbs N/1000 ft^2.

Insects

Surface feeding

Surface feeding insects that present the greatest potential for damage in cool-season turfgrasses are chinch bugs, sod webworms and bluegrass billbugs. A strategy for deterring these pests is selecting endophyte-enhanced, improved cultivars of perennial ryegrass and/or tall fescue. Additionally, many surface feeding insects thrive in thatch. Manage thatch depth (<0.5 in.) utilizing core cultivation, verti-cutting, and topdressing (see cultivation section).

Frequent scouting for insect presence should be completed as part of a comprehensive management plan. This will enable turfgrass managers to alter their cultural practices (i.e. increase frequency of irrigation cycles and fertility applications) to help mask the damage and encourage turfgrass recovery.

Root feeding

White grubs are considered the most destructive insect pest of cool-season turfgrasses. The endophyte-enhanced turfgrasses do not deter these root feeding insects. The white grub species most damaging in New England are European chafer, Oriental beetle, Japanese beetle and Asiatic garden beetle.

Life cycle

These species have an annual (1-year) life cycle (Figure 5). Adults emerge late May to late June, mate and lay their eggs from late June to mid-August. Eggs hatch in 2-3 weeks and larvae begin feeding immediately and will continue to feed until the first frost. Turfgrass damage occurs once larvae have grown to second or third instars (Sept-Oct), and where there are >15 larvae per ft^2. Acceptable threshold levels are likely much less for athletic fields due to surface stability concerns. This warrants early scouting (Aug. 1-Sept. 1) prior to signs of turfgrass damage. Once soil temperatures drop in the fall, the grubs move deeper into the soil to overwinter. Grubs will resurface in early spring (March or April) to resume feeding until they pupate in late May/early June (Potter, 1998).

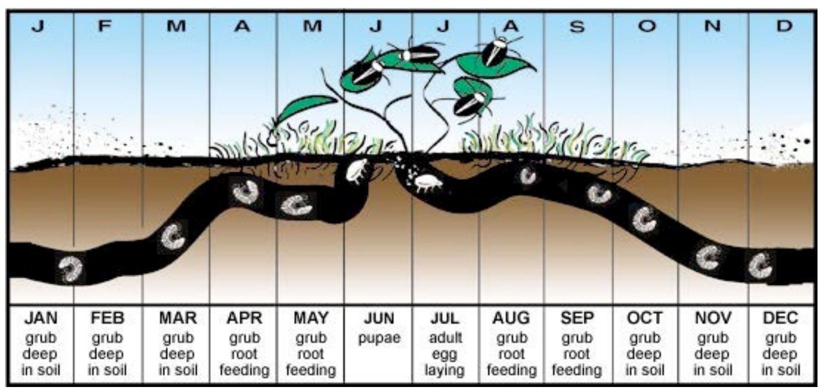

Figure 5. White grub life stages and locations throughout the year (Hadley and Hawley, 1934).

Entomopathogenic nematodes (EPN), most often *Heterorhabditis bacteriophora*, are microscopic, worm-like organisms that can be used to control white grubs. EPNs enter the white grub's body and then reproduce with the help of a symbiotic bacterium. This results in the death of the infected white grub and additional cycles of infection in other grubs. EPNs live in the upper 10 in. of soil and are often applied as a liquid suspension directly onto the playing surface. EPN are often applied curatively, however, in areas where white grubs have previously been a problem, consider preventative

EPN applications in late July/early August. This targets immature grubs which are most vulnerable to infection. When using EPNs as a treatment, care must be taken to maximize nematode survival until they reach the grub host.

Disease

A turfgrass disease outbreak requires a susceptible host, virulent pathogen, and a conducive environment. Although pesticides are not an option, the turfgrass manager can minimize disease incidence through proper turfgrass selection and cultural practices to make the environment less favorable for disease.

Turfgrass Selection

Utilize turfgrass mixtures (seeding more than one species, i.e. Kentucky bluegrass/perennial ryegrass) and/or blends (using more than one cultivar of the same species) to increase the genetic diversity of the turfgrass stand. Select disease resistant cultivars to help prevent the establishment of certain diseases (Figure 6). The National Turfgrass Evaluation Program website (NTEP.org) has current information on the latest disease resistant cultivars.

Environment

Leaf wetness is the most important factor when trying to limit foliar diseases (Smiley et al., 1993). Irrigation should be applied early in the mornings (i.e., 3 – 6 am) when the canopy is likely already wet with dew. Avoid irrigating during early evening before dew forms, or late in the morning. Irrigating at these times will likely extend leaf wetness duration and encourage disease. If multiple irrigation cycles are required during the day (i.e. at establishment), the last application should allow leaves to dry before nightfall. Correct surface drainage (athletic fields constructed using native soil should be sloped $\geq$ 1.5% and lengths of these slopes should not exceed 200 ft) and subsurface drainage problems. Water accumulation in low areas can encourage foliar and root diseases as well as abiotic decline, particularly where thatch is excessive.

Caution should be exercised when managing diseased areas to prevent further dissemination of pathogens. Equipment should be washed when moving from infected fields to disease free areas to prevent further spread of disease.

Tips to Optimize Infection Rate of Grub Host

- Select the best timing of application - Late July through mid-September provides an immature host and ideal soil temperatures for infection (nematodes are more active and bacteria replicate more readily in soil temperatures above 65 degrees F) (Grewal et al., 2004).
- Purchase nematodes as close to application date as possible due to their short shelf life.
- Pre-soak the area prior to EPN application if the soil is dry. Adequate soil moisture provides optimum conditions for nematode survival because EPNs travel in a film of water on soil particles to reach their hosts. Maintaining adequate soil moisture 2-3 days following an application can enhance efficacy. Do not saturate the soil, as low oxygen conditions can be lethal for the nematodes.
- Do not use sprayers with piston pumps, as these can injure nematodes.
- Remove screens from spray tips to prevent clogging.
- Do not allow spray water containing nematodes to overheat.
- EPNs are very sensitive to UV light. Spray in the evening or on cloudy days.
- Irrigate immediately following or during application of nematodes, or apply nematodes through irrigation water.

Figure 6. Gray leaf spot can be a devastating disease for perennial ryegrass. Selecting disease resistant cultivars is critical. Photo courtesy of John Inguagiato.

Irrigation

Irrigation is absolutely essential for maintaining acceptable playing surface quality on natural turfgrass athletic fields. ***In the absence of irrigation, the expectations for playing surface quality should be dramatically reduced.*** Due to intense traffic, athletic fields are in a perennial state of re-establishment. Adequate moisture is necessary to initiate/complete the germination process, and encourage seedling development. Irrigation is also imperative for the success and ease of completing other cultural practices such as fertilization, cultivation, and pest control. Light and frequent irrigation can also be extremely helpful during recovery from insect damage, disease damage, or intense traffic.

Photo courtesy of Brian Tencza.

Utilize wilt-based irrigation or wait until mild drought stress is visible (leaf folding and foot printing) before irrigating to replace moisture lost by evapotranspiration for maintaining established, mature, healthy turfgrass stands (Lewis et al., 2012).

If an in-ground irrigation system is not available, self-retracting water reels are an easy to use, inexpensive substitute. However, water reels need to be closely monitored while using to ensure proper operation. Regardless of system type, ensure all irrigation heads are operating correctly and coverage is uniform.

Aggressive Overseeding

Aggressive overseeding is one of the most important cultural practices required to maintain acceptable turfgrass quality and playing conditions on a high traffic/pesticide-free athletic field. Aggressive overseeding can be defined as applying seed (at rates exceeding the typical recommended ranges for seedling establishment) onto well-established turfgrass areas, regardless of turfgrass density, in an effort to maintain/increase desirable species on athletic fields subject to intense traffic (Minner et al., 2008).

Selection of turfgrass species and timing of application depends heavily on when the most intense athletic field use occurs (Table 2). Given budgetary restrictions, overseeding efforts can be focused on concentrated traffic areas. Perennial ryegrass is the preferred turfgrass species for aggressive overseeding due to its quick germination, speed of establishment and its ability to develop under heavily trafficked conditions (Minner et al., 2008). However, consider a Kentucky bluegrass/perennial ryegrass (70:30) mixture (by weight) for spring re-establishment to help maintain Kentucky bluegrass populations on fall use athletic fields (Stier et al., 2008). Kentucky bluegrass has a rhizomatous growth habit that helps wear recovery. Maintaining multiple species on the playing surface (i.e. KB:PR) also helps maintain genetic diversity for disease management.

Seed should be broadcast immediately prior to a cleated practice or game allowing players to work seed into the soil and optimize seed to soil contact. If traffic is not imminent, seed should be applied using a spike seeder that will maximize seed to soil contact while minimizing damage to the existing turfgrass stand (Figure 7). If the athletic field is used May-August, apply 3-5 lbs of PR seed/1000ft^2 per month.

Figure 7. In the absence of imminent cleated traffic, seed should be applied using a spike seeder that will maximize seed to soil contact while minimizing damage to the existing turfgrass stand.

September 1st, apply up to 20 lbs seed/1000ft^2. Research has shown that applying seed as a single, early application of perennial ryegrass more than doubled the amount of turfgrass cover, compared to dividing the same amount of seed into multiple, smaller amounts applied each week before a game or practice (Minner et al., 2008). The amount of seed applied should be based on the amount of anticipated field use, intensity of traffic, and previous experience with each individual field. Generally, the more seed applied will result in greater turfgrass cover retention in late fall and fewer weeds the subsequent spring.

Set a total target rate of 35-45 lbs of seed/1000ft^2 per growing season (turfgrass species selection depends on field use, time of year, and presence of irrigation).

For perennial ryegrasses, select 3-4 cultivars to create a seed blend. Select 1-2 cultivars that have medium to high wear tolerance and 1-2 cultivars that have grey leaf spot resistance. Consider other cultivar qualities such as spring green-up and drought tolerance. Please refer to www.ntep.org for cultivars that have been evaluated in your region. University Extension Specialists are a valuable resource for more information.

Table 2. Overseeding strategies based on time of athletic field use.

Season of Predominant Athletic Field Use	Overseeding Strategy	
	April 25	Sept 1
Fall	70:30 (KB:PR)*	100% perennial ryegrass†
Spring	100% perennial ryegrass	70:30 (KB:PR)

* Target seeding rate for the 70:30 KB:PR mixture is 3lbs/1000ft^2

†Target seeding rate for the 100% perennial ryegrass is 20lbs/1000ft^2

Compost Topdressing

Topdressing with compost as part of an athletic field management program requires careful consideration. Routine topdressing with compost is not recommended unless the soil is monitored for soil test phosphorus values by testing the soil 1-3 months after every topdressing application. Contrary to many current recommendations, compost topdressing should *not* be considered an essential component to a pesticide-free management program. However, compost can have beneficial effects. Research has shown topdressing with compost can: 1) help retain greater percent cover after wear, 2) decrease bulk density, 3) increase water retention, and 4) decrease surface hardness (McNitt et al. 2004, Tencza and Henderson, 2012). However, compost topdressing can be labor intensive to apply and it is easy to apply excessive amounts of P when manure-based composts are applied. Additionally, when applying compost as topdressing, incorporation into the soil is extremely difficult (Figure 8). Consider the following:

Soil test to determine current soil phosphorus levels. Modified Morgan extractable P values should be less than 20 lbs/acre. Fields with values greater than 20 lbs/acre should not receive P applications from fertilizer, compost or soil amendments.

Fields constructed with native soils will have greater moisture holding capacity if soil organic matter (SOM) content is 4-6%. If the SOM is <4%, and the soil test P value is less than 20 lbs/acre modified Morgan extractable P, consider compost applications to increase SOM levels into the 4-6% range. Use a compost low in P (<0.3% P_2O_5), and test soil for P 1-3 months after every compost application. Amounts of phosphate applied for various depths of application and concentrations of phosphate in compost are listed in (Table 3). If the field is a sand-based constructed field, increasing SOM content greater than about 1% is not recommended.

Figure 8. Compost topdressing is extremely difficult to incorporate into the existing soil. Topdressing should coincide with aggressive hollow-tine cultivation to mix the compost as much as possible with the existing soil. However, a topdressing layer is still likely to form, as seen above.

Tips for Responsible Compost Applications

- Soil test to determine current soil phosphorus levels. Modified Morgan extractable P values should be less than 20 lbs/acre.
- Use only compost sources containing less than 0.3% phosphate (P_2O_5) such as leaf compost
- Test compost before purchase for organic matter quality (ASTM, 2002). Target ranges for desirable compost characteristics are listed in (Table 4).
- Screen compost before application to at least 1/2 in. (1/4 in. preferred)
- Topdressing should coincide with hollow-tine cultivation to help mix compost with the existing soil (See cultivation section).
- Apply no more than 1/4 in. of compost per topdressing.
- Test soil for P 1-3 months after every compost application.

Table 3. Total pounds of phosphate (P_2O_5) applied per 1000 ft^2 using composts with various percentages of phosphate concentration when applied at various rates.								
Application rate			Percent Phosphate (P_2O_5) in Compost					
Depth (in.)	Yd/Acre*	Tons/Acre	0.05%	0.5%	1%	1.5%	2%	2.5%
			------ Pounds phosphate (P_2O_5) applied per 1000 ft^2 ------					
1/8	16.9	6.8	0.2	1.6	3.1	4.7	6.2	7.8
1/4	33.8	13.5	0.3	3.1	6.2	9.3	12.4	15.5
1/2	67.5	27.0	0.6	6.2	12.4	18.6	24.8	31.0
1	135.0	54.0	1.2	12.4	24.8	37.2	49.6	62.0
2	270.0	108.0	2.5	24.8	49.6	74.4	99.2	124.0
Adapted from the Composting Council, University of Missouri Extension, 2011.								
*Based on an average compost weight of 800 lb./cubic yard (wet weight).								

Table 4. Target ranges for chemical characteristics, physical characteristics and maturity level of desirable compost topdressing materials (Adapted from Landschoot, 2013).									
	Chemical Characteristics						Physical Characteristics		Maturity
Parameter	pH	Soluble Salts (mmhos cm^{-1})	N (%)	P (%)	K (%)	C:N Ratio	Organic Matter (%)	Moisture Content (%)	Respirometry (mg CO_2-C/g*)
Target Range	6.0-8.0	< 6	0.5-3.0	0.2-0.9	0.2-0.5	$\leq$ 30:1	> 30	30-50	< 8 †
* mg CO_2-C/g organic matter/day – Respirometry(CO_2 evolution) provides a measurement of the relative microbial activity in a compost. Therefore, this can be used as an estimate of compost stability.									
† Interpretive index from the U.S. Compost Council Test Methods, <2 = Very Stable – Well cured compost, no continued decomposition, no odors, 2-8 = Stable – cured compost, odor production not likely, minimal impact on soil carbon and nitrogen dynamics.									

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