THE EFFECTS OF TURVES WITHIN A REFINED WOOD FIBER MAT (ECOMAT®) OVER PLASTIC

By

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ABSTRACT

THE EFFECTS OF TURVES WITHIN A REFINED WOOD FIBER MAT (ECOMAT®) OVER PLASTIC

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Establishing sod within a refined wood fiber mat (Ecomat®) over plastic was investigated at the Hancock Turfgrass Research Center, East Lansing, MI. in 1995 and 1996. Three major areas of investigation included mulching, growth media comparison, and seeding and fertilizer applications. In addition, the establishment of four different turfgrass species was investigated. These turf species included Kentucky bluegrass (*Poa pratensis* L.), Supina bluegrass (*P. supina* Schreb.), perennial ryegrass (*Lolium perenne* L.), and tall fescue (*Festuca arundinacea* Schreb.). The objectives of the research was:

1) To determine the effect of different mulch types for aiding turfgrass establishment within Ecomat®.
2) To compare different growth media for sod production on plastic, as well as their effectiveness as an established turf for athletic field use.
3) To determine optimum seeding and fertilizer rates for turfgrass establishment within Ecomat® over plastic.

In the first experiment, mulching with straw, PennMulch™, and hydromulch, respectively increased turf cover (significantly) versus the other four mulches (fine grade compost, crumb rubber, native soil, and Germinator®) and the control (no mulch). In

addition, perennial ryegrass established a greater turf cover than Supina bluegrass. In the second experiment, SportGrass™ had significantly greater turfgrass cover then the Ecomat®, pine wood mulch and sand growth media. In the third experiment, increasing the seeding rate for four-turf species studied significantly increased turf cover. The use of an organic source of nitrogen (Milorganite®) established denser Kentucky bluegrass turf than ammonium nitrate. Additionally, as the rate of nitrogen increased (g N m^{-2}) so did turf density. In conclusion, establishing sod within Ecomat® over plastic is plausible. However, the high maintenance demanded deems large-scale sod production utilizing the Ecomat® potentially cost ineffective. This is apparent as a result of the watering problems encountered in Chapters 2 and 3.

DEDICATED

To my mom and dad

Shirley Jones and Sam Sorochan

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INTRODUCTION

High quality turfgrass stands on athletic fields and golf courses are in greater demand than ever before. Not only does the quality of the turf have to be acceptable, but also there is a growing demand to provide a turf stand for immediate playability. High quality turf that immediately readies for athletic play encompasses a dense wear resistant turf that provides a uniform and stable playing surface.

The rate of establishment is important for determining a satisfactory turf field. Conventional sodding provides instant turfgrass cover, but the newly sodded area will only be ready for play once the sheared roots have regenerated, which may take as long as 2 months.

Literature describing sodding practices date as far back as 1159, to the first Japanese book on gardening entitled, "Aatu-tei-kai" (Beard, 1992). Modern sod production began with the use of mechanical operations, where turfgrass cutting machines allowed easier and more accurate sod harvesting than manual harvesting (Beard, 1992). Conventional sod harvesting limits the stability of the turfgrass stand until the sheared roots have been regenerated. The lack of a dense or deep root structure decreases nutrient and water uptake for the turfgrass plants, leading to a lower quality turfgrass stand (Decker, 1991b). This may be particularly evident if sod is harvested during sub-optimal growing conditions such as hot and dry summers. In addition, soil layering can be a problem when using conventional sod. Root growth is severely limited with sod grown on a soil of finer texture than the root zone mix it is intended to cover, and the sod layering (finer textured soil over coarser textured soil) could be a problem in the future as macro pore space decreases. Although instant cover is provided, the turf is not immediately playable.

The shortcoming of conventional sodding practices can be avoided when turf is grown on non-soil media, over an impervious surface such as plastic. Some advantages of growing sod on plastic include the elimination of soil layering by selecting a specific growth medium, the elimination of root shearing during harvest, and producing a sod more rapidly in time for harvesting. This enables the sod to establish more quickly on the intended site (Decker, 1991b and Decker, 1975). The presence of the intact root system enables the newly laid sod to be fully established in a period much shorter than conventional sodding methods (Cairol and Chevallier, 1981). The sod produced is lightweight due to the absence of soil, allowing for cheaper shipping costs and larger sod pieces (Decker, 1991a). Sod pieces are held together by the binding of the roots and the growth media selected, making the sod very strong and easy to handle. This strength enables the production of turfgrasses with a bunch type growth habit. Typically, turfgrasses with a bunch type growth habit germinate and establish more rapidly than turves with a rhizomatous or stoloniferous growth habit allowing for an even more rapid sod to be produced. Traditional sod consists of turfgrasses with rhizomatous or stoloniferous growth habits only.

An immediately playable turf stand provided by sod grown on plastic is very beneficial to turf managers. For instance, a soccer field manager could replace the worn turf in a soccer goal area between games (Cairol and Chevallier, 1981), perhaps as frequently as once per week.

Commercially, sod grown on plastic uses either wood mulch, compost or sand as the growth medium. A refined wood fiber mat (Ecomat®) is an erosion control mat produced by Canadian Forest Products Ltd. in New Westminster, British Columbia and has the potential to be an effective growth medium. It will be placed over top of the plastic. Previous research has shown the use of an organic fiber medium can produce a sod when grown over plastic (Hensler *et al.*, 1996). Selecting a refined wood fiber mat as the growth media adds many benefits to establishing sod on plastic. For instance, the refined wood fiber mat (Ecomat®), which is made from a blend of residual wood fibers, provides an adequate seedbed without the use of soil. An adequate seedbed consists of a smooth and uniform surface for seeding. In addition, the mat layer has the ability to provide flexible support for the turfgrass during and after establishment. Used as an erosion control mat, the refined wood fiber is available in large rolls (1.2 m by 41 m). This makes it possible to establish large pieces of sod that are more light weight then conventional pieces of sod of the same size.

While there are many advantages to using sod produced on plastic over conventional sod, further research is warranted, particularly with the use of the refined wood fiber mat as a growth medium. Unlike conventional sod production, producing sod on plastic using a non-soil growth medium, like the refined wood fiber mat, presents many problems. For instance, water holding capacity is low, seeding and fertilizer recommendations have not been determined, and the actual plausibility of using the wood fiber mat as a growth medium also needs to be determined. As a result three main objectives exist to test the use of the refined wood fiber mat as a growth medium for sod production on plastic. The three main objectives are:

1) To determine the effect of different mulch types for aiding turfgrass establishment using a refined wood fiber mat (Ecomat®).
2) To compare different growth media for sod production on plastic, as well as their effectiveness as an established turf for athletic field use.
3) To determine optimum seeding and fertilizer rates for turfgrass establishment on plastic using the refined wood fiber mat (Ecomat®).

Chapter 1

THE EFFECT OF MULCH TYPE ON TURFGRASS ESTABLISHMENT ON PLASTIC

ABSTRACT

The germination and establishment of *Lolium perenne* (bunch type) and *Poa supina* (stoloniferous) within a refined wood fiber mat (Ecomat®) placed on plastic sheeting was evaluated using seven mulches and a control with no mulch. Percent turfgrass cover (0-100%) as a measure of germination density was evaluated at 7, 14, 21, and 28 days after seeding. The study began on 3 July 1995 and was repeated on 29 September 1995, 5 July 1996, and 1 October 1996. The four seeding dates were chosen to show the effects of mulches under optimal and sub-optimal growing conditions for cool season turfgrasses. The seven mulches consisted of hydrated fiber mulch, copolymer of sodium acrylamide, crumb rubber, straw, fine grade compost, pelletized fiber mulch, and a native clay loam soil. Two turfgrass species differed significantly among the seven mulch treatments and the control, and the four seeding dates. *Lolium perenne* achieved slightly higher turfgrass cover than *Poa supina* on two dates tested. The straw, pelletized fiber mulch, and hydrated fiber mulch resulted in the greatest turfgrass cover regardless of seeding date. However, crumb rubber performed equally well only during the 29 September 1995 seeding trial. In summary, the use of a particular mulching material (straw, pellet mulch, and hydro mulch) will enhance turfgrass density during seed germination; with the benefits of these mulches increasing with increasing seed germination times.

INTRODUCTION

Conventional sod production is restricted to turfgrasses with a stoloniferous and/or rhizomatous growth habit because the rhizomes and stolons provide cohesiveness for the sod, even after the roots are sheared during harvest. Bunch type grasses have many practical uses in a turfgrass setting; for e.g., *Festuca arundinacea* (tall fescue) is an excellent grass for dry shady conditions, and could be produced if the roots remained intact during sod harvesting. Recent experiments at Michigan State University have shown that growing sod on plastic using a refined wood fiber mat (Ecomat®) allows harvesting of bunch type sods without root shearing (unpublished data). Establishing sod over an impervious layer like plastic and within a soil-less growing medium (Ecomat®) will eliminate root shearing during harvest. This enables the intact roots to provide the necessary strength for turfgrasses with a bunch type growth habit to be grown as sod. Therefore, growing sod in Ecomat® allows for a greater variety of turfgrass species to be grown.

Ecomat® alone does not provide constant enough conditions for seed germination, and in the absence of soil, water and nutrient availability is reduced. Mulching is one way to correct this problem, but the relative effectiveness of various mulching materials is not known.

Any lifeless material can be used as a mulch (Turgeon, 1991). For over 100 years it has been known that mulching is one way to preserve a uniform degree of moisture (Saunders, 1866) because it reduces the rate of evaporation from the soil surface (Warington, 1900). Mulches can also increase or decrease surface temperatures during adverse growing conditions (Wooding and Sparrow, 1979), reduce potential seed loss to runoff and splashing caused by rain or irrigation, and greatly reduce wind erosion (Beard, 1973). In the turfgrass industry, most research on mulches has concentrated on prevention of seed and soil erosion. The potential of mulches for aiding germination and turf establishment, particularly on a soil-less growing medium like Ecomat®, has yet to be investigated.

Many types of mulching materials are available; selection of a given type is based on its availability, cost, ease of application, potential for preventing weeds, effectiveness in erosion control, and the microenvironment it provides for seed germination (Beard, 1973). The unique physical characteristics of each mulch type determine how they perform for turfgrass establishment. For instance, the color and water holding capacity of the mulch may determine the time of year when a particular mulch is most effective; during adverse growing conditions (e.g., mid-summer heat and drought) a particular mulch may exacerbate the already unfavorable growing conditions (Dudek *et al.*, 1966). Therefore, it is important to compare mulch types that may differ in effectiveness under various environmental conditions.

Seven mulches were chosen for comparison: hydrated fiber mulch, copolymer of sodium acrylate and acrylamide, crumb rubber, straw, fine grade compost, pelletized fiber mulch, and a native clay loam soil. The copolymer of sodium acrylate and acrylamide serves as a sticking agent intended to maintain moisture levels and prevent erosion. Straw is a traditional mulch that allows good air movement and is relatively inexpensive. However, straw has the potential to introduce weed seeds. A fine grade compost provides nutrients in organic forms and improves surface moisture retention (Beard, 1973). Crumb rubber (5 to 6 mm particle size) can provide higher temperatures for longer periods of time as a result of its black color. Easily applied, crumb rubber protects the crowns of turfgrass plants, which is important for sod survival in heavy traffic situations (Rogers *et al.,* 1998). Hydrated fiber mulch consists of shredded paper pre-mixed with water into a slurry and applied through a hydroseeder or hydroplanter (Beard, 1973). Hydroseeders and hydroplanters are bulky machines that are relatively costly compared to other methods of mulching. Pelletized fiber consists of compressed pellets of shredded paper applied by a drop spreader. When the mulch is irrigated the pellets swell and provide a uniform cover. Clay loam native soil as a mulch mimics traditional seed establishment conditions, combining seed-to-soil contact with an adequate nutrient holding capacity.

This experiment was designed to assess the effect of these different mulches on turfgrass germination and establishment, specifically under soil-less growing conditions (Ecomat® on plastic). The experimental design included comparison of two turfgrass species: *Poa supina* (supina bluegrass with a stoloniferous growth habit), and *Lolium perenne* (perennial ryegrass with a bunch type growth habit).

MATERIALS AND METHODS

The experimental design was a 2 x 8 x 4 (species x mulch type x seeding date) split-plot randomized complete block design with three replications. Each of the 48 refined wood fiber plots measured 1.2 m x 0.9 m. The refined wood fiber (Ecomat®) is an erosion control mat produced by Canadian Forest Products in New Westminster, British Columbia. Plots were located at the Hancock Turfgrass Research Center on the Michigan State University campus in East Lansing, Michigan. Two turf species, *Poa supina* "Supranova" (Saatzucht Steinach GmbH, Steinach, Germany) and *Lolium perenne* "Manhattan II" (Turf Merchants, Hubbard, Oregon), were seeded at the recommended rate of 7.6 g m^{-2} and 20 g m^{-2} respectively. Four mulches (pellet mulch, hydro mulch, crumb rubber, and native soil) were applied at rates that resulted in equal coverage to a 0.6 cm depth; where, no seed was visible to direct sunlight. The polymer mulch was applied at 5 g m^{-2}, and the straw was laid at a depth of about 1 bail per 45 m^{-2}. A control treatment without mulch was included. The four seeding dates, 3 July 1995, 29 September 1995, 5 July 1996, and 1 October 1996, represented traditionally both adverse (summer) and ideal (fall) seeding times for establishment of cool season grasses. Fertilizer was applied to all plots once per week for four weeks using 13-25-12 starter fertilizer at 4.9 g P m^{-2}. Frequent fertilization was necessary because of the absence of a soil medium to hold nutrients for the developing turfgrass plants. No additional micronutrients were provided for the duration of the experiments. Percent cover was visually estimated every 7 days after seeding (DAS) for 4 weeks to determine turfgrass density (0-100%). Daily high and low temperatures were recorded for the 28 DAS, and irrigation was applied as needed. The data were analyzed for statistical differences using analysis of variance. Treatment means were separated using Fischer's LSD with a $\alpha/2$ of 0.05.

RESULTS

Critical time during seed germination is the first 28 DAS, and differences among the four seeding dates occurred as a result of the different environmental conditions that existed (Figure 1). For the fall 1996 seeding date (D), the daily temperatures were well below the optimum growing temperatures for cool season turfgrasses. Significant differences between turf species, mulch type and seeding date occurred throughout the experiment (Table 1).

Lolium perenne developed significantly greater cover than *Poa supina* when the synthetic polymer, crumb rubber, straw, and compost were used as mulches (Table 2). The pelletized fiber mulch, hydrated fiber mulch and straw, regardless of turf species, produced significantly greater turfgrass cover than the control while the synthetic polymer, crumb rubber, and compost only showed greater turfgrass cover with *Lolium perenne* indicating an interaction between turf species and mulch type.

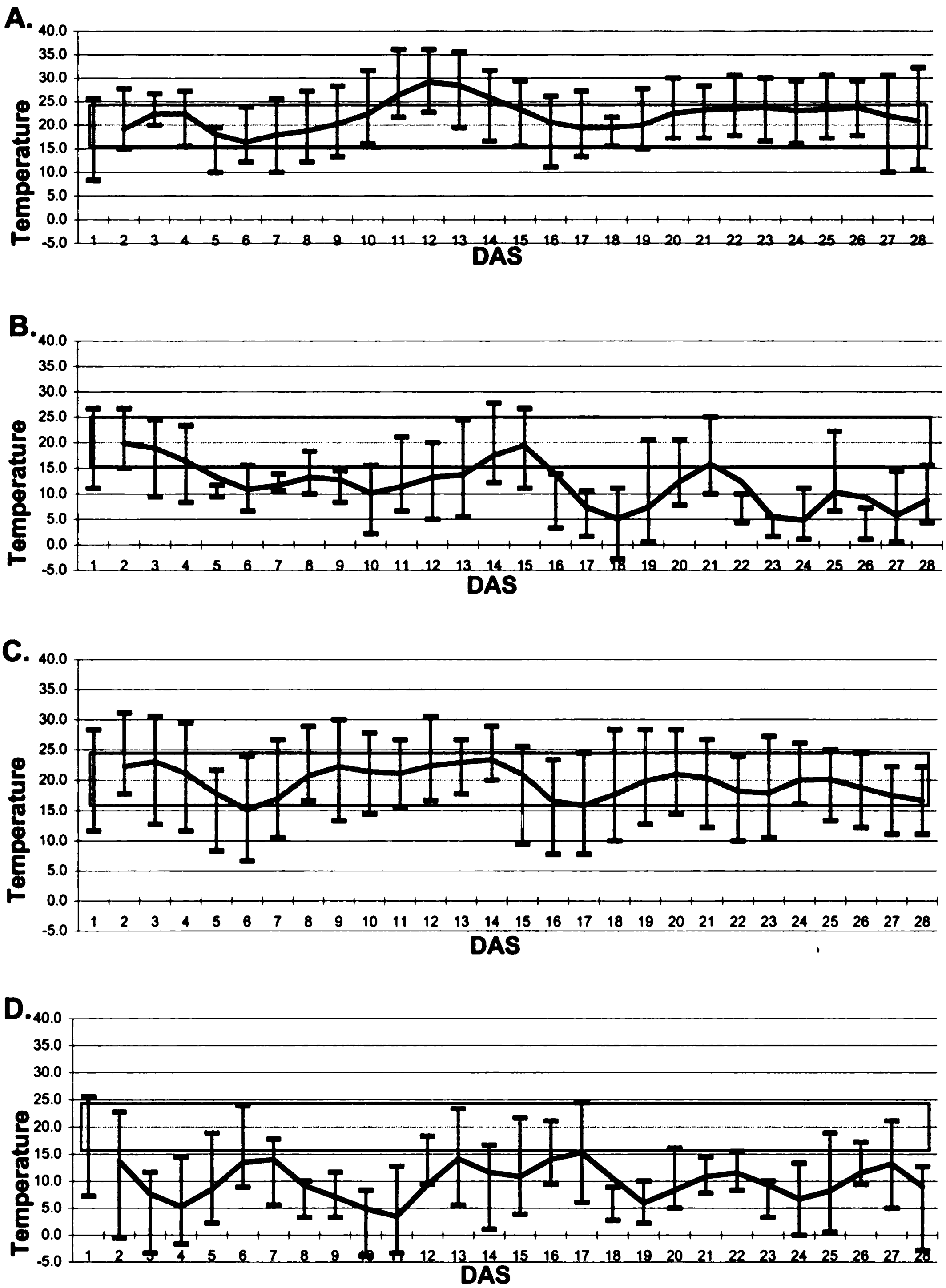

Figure 1.1 Daily high and low temperatures (C) 28 days after seeding (DAS) for 3 July 1995 (A), 29 September 1995 (B), 5 July 1996 (°C), and 1 October 1996 (D) seeding dates. □ Indicates optimal temperature range for cool season turfgrass growth. — Indicates daily average temperature.

Table 1. Significance of treatment effects for turfgrass cover on Ecomat® mulching study, East Lansing, MI. 1995-96.

	Days after seeding			
Source	7	14	21	28
Turf sp. (TS)	**	**	**	**
Mulch type (M)	**	**	**	**
T x M	NS	**	*	*
Seeding date (D)	**	**	**	**
TS x D	**	**	**	**
M x D	**	**	**	**
TS x M x D	*	ns	ns	ns

*, ** Significant at the 0.05, 0.01 probability levels, respectively.
ns Not significant at the 0.05 probability level.

Table 2. Turf species by mulch type interaction 28 days after seeding averaged over four seeding dates, East Lansing MI. 1995-96.

	Percent cover (%)	
Mulch type	*Poa supina*	*Lolium perenne*
Control	11.9	11.3
Polymer	11.9	22.8
Pellet mulch	42.7	44.0
Hydro mulch	34.5	42.8
Crumb rubber	19.8	30.3
Native soil	9.3	11.8
Straw	36.8	54.1
Compost	13.8	30.2
$LSD_{(0.05)}$	9.0	

Overall, the straw, pelletized fiber mulch, and hydrated fiber mulch appeared to be the best mulches for turfgrass cover regardless of the seeding date (Table 3). All three mulches resulted in consistently greater turfgrass cover than the control with the exception of the fall 1996 seeding date. The crumb rubber in the fall of 1995 showed a significantly greater turfgrass cover versus the other three seeding dates. This is likely a result of the dark color, and poor water holding capacity of the crumb rubber where, during hot and dry growing conditions (summer seeding trials) the crumb rubber was not able to hold sufficient moisture. The compost as mulch showed significant differences in turfgrass cover versus the control for the first two seeding dates but not during the second year of seeding. The consistency of the compost may have deteriorated from the first year (1995) giving inconsistent results during the second year of testing, because the turfgrass cover for the compost treatment was much greater during both seeding dates in 1995 than in 1996. The percent turfgrass cover for the fall 1996 seeding date is likely a result of the low temperatures limiting turfgrass germination (Figure 1). Daily temperatures for the first 28 DAS were below optimal growing conditions for turfgrass growth, including 5 days where the temperatures dropped below freezing. Even on days where the temperatures reached optimal growing conditions, the average temperature for that day was still too cold. Therefore, sub-optimal growing conditions existed for all 28 DAS.

Table 3. Mulch type by season[†] interaction 28 days after seeding averaged over turfgrass species[‡], East Lansing, MI. 1995-96.

	Percent cover (%)			
Mulch type	Summer 1995	Fall 1995	Summer 1996	Fall 1996
Control	11.5	14.2	19.8	1.0
Polymer	21.5	19.5	26.7	1.8
Pellet mulch	45.0	64.2	55.2	9.0
Hydro mulch	44.2	51.5	53.8	5.0
Crumb rubber	9.0	65.2	18.3	7.7
Native soil	7.3	12.7	21.5	0.8
Straw	44.3	52.5	79.7	5.2
Compost	33.5	40.7	10.8	3.0
LSD[§] $_{(0.05)}$		13.0		
LSD[¶] $_{(0.05)}$		16.6		

† Includes 1995 (3 July, 29 September) and 1996 (5 July and 1 October) seeding dates.

‡ Species includes *Poa supina* and *Lolium perenne.*

§ LSD $_{(0.05)}$ for different mulches within the same seeding date.

¶ LSD $_{(0.05)}$ for different seeding dates within the same mulch type.

Both turfgrass species showed significant differences in turfgrass cover for the four seeding dates (Table 4). The summer 1995 and fall 1995 seeding dates showed that *Lolium perenne* did significantly better than *Poa supina*, which was to be expected because of its faster germination rate. The interaction that is occurring where the *Poa supina* did not have greater turfgrass cover than the *Lolium perenne* during the summer and fall 1996 seeding dates.

Among the seven mulches tested, straw, pelletized fiber mulch, and hydrated fiber mulch were the best mulches for providing the greatest turfgrass cover regardless of the seeding date. However, the crumb rubber mulch was very effective when growing conditions were less favorable for the other mulches, and more optimal for the rubber (fall 1995).

Table 4. Turf species by season† interaction 28 days after seeding averaged over all mulch types‡ and the control, East Lansing, MI. 1995-96.

Turfgrass sp.	Percent cover (%) Summer 1995	Fall 1995	Summer 1996	Fall 1996
Poa supina	15.6	30.0	41.0	3.8
Lolium perenne	38.5	50.1	30.5	4.6
LSD§ $_{(0.05)}$		14.6		
LSD¶ $_{(0.05)}$		8.3		

† Includes 1995 (3 July, 29 September) and 1996 (5 July and 1 October) seeding dates.

‡ Mulches include polymer, pellet mulch, hydro mulch, crumb rubber, native soil, straw, and compost.

§ LSD $_{(0.05)}$ for different mulches within the same seeding date.

¶ LSD $_{(0.05)}$ for different seeding dates within the same mulch type.

DISCUSSION

Although the effectiveness of mulching has been ascertained during this experiment, the question of the relative effectiveness of mulch materials naturally arises. Almost any lifeless material can be used for mulching, but the relative effectiveness of the different mulch materials varies according to their physical and chemical properties (Harris and Yao, 1923). The moisture content of the mulches varies depending on their physical and chemical properties, and the total moisture lost from the seedbed surface varies accordingly. That is to say, the more absorptive the mulch the more moisture is lost from the seedbed. Since the purpose of a mulch is to protect the seedbed surface from exposure to the physical agencies of evaporation, the less absorptive the mulch the less water is brought up to the surface to be exposed and therefore the more moisture is held in the seedbed. Harris and Yao (1923) compared mulches for growing vegetable crops and found there was a correlation between the moisture lost from the soil and the moisture contained in the mulches. Harris and Yao (1923) concluded in their experiment that the straw mulch was the best because it had a lower capillary rise than the hay, wood shavings and manure mulches tested, and this is also supported by the results found in this experiment. Similar findings were also concluded in previous research describing the physical and chemical properties of different mulches. For instance, both King (1895) and Wollny (1866) determined the effectiveness of mulching is brought about by diminishing the direct influence of the agencies of evaporation and by retarding the capillary rise of water to the surface of the mulch.

The 0.6 cm depth of the native soil and compost as mulches may have been too deep for the seed to properly germinate, because the light was too limiting. In addition, if moisture was not a problem as a result of capillary rise, the depth of mulching and the water holding capacity of both the native soil and compost could have been a limiting factor. Too much water in the native soil and compost may have resulted in anaerobic conditions, and in turn limited the germination potential of both turf species investigated.

The use of the polymer as a mulch was unsuccessful because it did not protect the germinating seed from the direct elements of the sun and wind. The direct exposure to full sun and wind greatly reduced the establishment potential of both turf species. The use of a polymer augmented these criteria, by absorbing any available water, making it unavailable for the seed.

Aside from maintaining a consistent environment for seed germination, the length of time a favorable environment is provided by mulching is also important. This is especially important for turfgrasses that require many days to germinate such as *Poa supina*.

Turfgrass germination and density was enhanced with the use of a mulching material. The greatest turfgrass density was achieved when straw, pellet mulch, and hydro mulch were applied, respectively. Crumb rubber performed equally as well only during the fall 1995 seeding date when temperatures were cooler. Finally, the faster germinating *Lolium perenne* had greater turfgrass density than *Poa supina*.

Chapter 2

THE EFFECT OF DIFFERENT GROWTH MEDIA FOR TURFGRASS ESTABLISHMENT AND PERFORMANCE

ABSTRACT

Experiment one: Turfgrass establishment

The germination and establishment of *Poa pratensis* and *Poa supina* in four different growth media (sand, pine wood mulch, Ecomat®, and SportGrass™) placed over plastic sheeting was investigated. Percent turfgrass cover (0-100%) as a measure of germination density was evaluated 1, 2, 5, and 10 weeks after seeding. The study began 10 June 1996 and was restarted on 12 August 1996. Results determined that SportGrass™ was the most successful growing medium for turfgrass establishment. The Ecomat® did not have as high turfgrass cover as the SportGrass™, because the watering requirements for the Ecomat® was much greater than the SportGrass™. Establishing turf from seed with different growth mediums, of different water holding capacities under one irrigation block results in too much or too little water being applied to each growth medium. There were no significant differences between turfgrass species ten weeks after seeding.

Experiment two: Turfgrass performance

The athletic field performance of *Poa supina* sod grown on four different growth media over plastic were compared. Washed *Poa supina* sod was included as a control. Crumb rubber topdressing was applied as a split treatment on the five sod types. The plots were subjected to simulated athletic field traffic under reduced light conditions.

Results showed the use of crumb rubber contributed to higher turfgrass density. No significant differences in turfgrass density between sod types occurred, because not enough wear was applied to show potential differences.

INTRODUCTION

Maximizing footing and minimizing player injury are two criteria expected from turf fields by athletic field managers. Having a tough, shear resistant turf is one way to augment these criteria. However, turfgrass is living plant material and when exposed to heavy athletic or recreational use, the quality of the turf will deteriorate. To maintain a tough, shear resistant turf, resodding is often implemented. In sod production and in installation, tear-resistant turf that quickly roots is most desirable (Hall, 1993).

Shear strength of sod is the force required to tear or break a piece of cut sod apart (Hall, 1993). In the case of conventional sod, shear strength is dependent upon the remaining root mass after harvesting, rhizomes and/or stolons, soil type, and moisture content (Rogers and Waddington, 1992). Additionally, sod produced over an impervious layer like plastic increases shear strength as a result of the dense and intact root mass provided.

Sod produced on plastic is a method of turfgrass establishment that possesses many benefits. One of the greatest benefits of sod on plastic is the ability to select the desired growth medium. Choosing a particular growth medium can reduce the likelihood of problems commonly associated with conventional sodding practices. For instance, choosing a non-soil-growing medium can eliminate soil layering. In addition, selecting a growth medium that contributes to increasing turf shear strength also has practical applications. However, comparative research between establishing turfgrass on plastic using various growth media, and how they perform under traffic as an established turf is limited, and warrants further investigation.

Part one: Turfgrass establishment

For this study, four different growth media were investigated for turfgrass establishment using two turfgrass species. The four growth media selected for this study were, pine mulch, sand, refined wood fiber mat (Ecomat®) and SportGrass™ topdressed with sand. The pine mulch, sand, and SportGrass™ are three growth media currently in use for sod production over plastic. SportGrass™ is a woven polyethylene mat with synthetic strands intended to provide additional support for the turfgrass. The Ecomat® is a refined wood fiber mat available in large rolls (40 m x 1.5 m), and provides a very light weight and stable surface for turfgrass establishment. The two turfgrass species selected were *Poa supina* var. 'Supranova' and *Poa pratensis* var. 'Touchdown'. Both species are cool season turves used for athletic fields. *P. pratensis* has a rhizomatous growth habit, and *P. supina* has a stoloniferous growth habit.

Part two: Turfgrass performance

Poa supina performs well under reduced light conditions when exposed to (high traffic) athletic field conditions (Stier, 1997). Optimum fertilizer levels and applications of plant growth regulators (PGRs) for the management of *P. supina* under reduced light conditions have been determined (Stier, 1997), but further research is warranted to improve the wear resistance of the turfgrass.

Previous research has shown that compost grown sod over plastic performed as well or better than conventional sod grown commercially (Cisar and Snyder, 1992), and the basis of tear resistance for compost grown and commercially grown sod, were noticeably different. For this experiment, established *Poa supina* sod was investigated for athletic field use in low light conditions. The *P. supina* was established within four different growth media over plastic (pine wood mulch, Ecomat®, SportGrass™, and compost) and a fifth treatment washed *Poa supina* was included. The pine wood mulch, Ecomat® and SportGrass™ sods were selected from the Part one: Turfgrass establishment study. Pacific Sod Company (Camullo, California) grew the compost sod in California (nine months old), and the washed sod was grown in Nepean, Ontario, Canada, by the Manderley Sod Company (18 months old).

Further attempts to reduce wear through the use of crumb rubber as a topdressing material has been proven to be an effective amendment for reducing surface compaction and turfgrass wear (Rogers *et al.*, 1998). Therefore, the inclusion of crumb rubber topdressing as a second treatment to improve the overall performance of the turfgrass under high traffic and low light conditions was investigated. The purpose of this study was to compare the four growth media with crumb rubber topdressing, exposed to extreme conditions including high traffic and reduced light situations.

MATERIALS AND METHODS

Part one: Turfgrass Establishment

The experimental design was a 2 x 4 factorial randomized complete block design with three replications. The 24 plots were 7.3 m x 2.8 m, and randomized over black 6 mil polyethylene sheeting at the Hancock Turfgrass Research Center (HTRC), Michigan State University. The four growth media included sand, pine wood mulch, SportGrass™ (SportGrass™ Ltd., Richmond, Virginia) and Ecomat® (Canadian Forest Products Ltd., New Westminster, British Columbia) Sand and pine mulches were laid over the polyethylene sheeting at a 20-mm depth. The SportGrass™ was rolled out over the polyethylene sheeting back filled with 25-mm of sand, with the individual strands vertically aligned. Each growth media gave the appearance of a shallow seeding bed. *Poa supina* var. 'Supranova' and *P. pratensis* var. 'Touchdown' were seeded on 3 June 1996 at 4.9 g m^{-2}. All plots were then mulched with PennMulch® at 37 kg 100 m^{-2}. Fertilizer was applied on 3 and 10 June 1996 using 12-25-12 Starter Fertilizer at 4.9 g P m^{-2}. On 17 June 1996 73 mm of rain in 90 minutes washed out the entire study. The experiment was restarted on 12 August 1996 following the above protocol. Fertilizer applications were applied at the beginning of each week for the first four weeks using the 13-25-12 Starter Fertilizer at 4.9 g P m^{-2}. Three fertilizer applications were applied every two weeks using 18-3-18 at 2.5 g N m^{-2} beginning 13 September 1996. Irrigation was applied as needed using an automatic irrigation system, and by hand watering. The hand watering was required because the four growth media each had different watering requirements. Percent turfgrass cover was visually measured at two, three, five, and ten weeks after seeding.

Part two: Turfgrass performance

Poa supina var. 'Supranova' sod was grown on four different growth media (pine wood mulch, sand, Ecomat®, and SportGrass™) during the summer of 1996 at the Hancock Turfgrass Research Center (HTRC) on the campus of Michigan State University. On 11 November 1996 fifteen 1.2 m x 1.2 m x 0.15 m depth boxes were sodded over a sand:peat mix (80:20 v/v) inside the indoor turfgrass research facility at the HTRC, Michigan State University. This facility, constructed of sheerfill II fiberglass fabric (Chemical Fabrics Corporation, Buffalo, NY), was an air-supported structure (600 m^2) designed to simulate the conditions inside the Pontiac Siverdome (Stier, 1993). The sheerfill II fiberglass fabric is a white cover that allows neutral density light to pass through (approximately 9 to 13%) *Poa supina* sod grown in the pine wood mulch, Ecomat®, and SportGrass™ growth media, *P. supina* sod grown in compost from the Pacific Sod Company in California, and washed *P. supina* sod from Manderley Sod Company in Nepean, Ontario were sodded on individual boxes. The compost-grown sod (50 mm depth) and washed sod were delivered to the HTRC in spring 1996 and were maintained outside on plastic until they were moved inside on 11 November 1996. On 27 December, each plot was split and crumb rubber was topdressed at a 19-mm depth.

The experiment was setup as a randomized complete block design (RCBD) growth media as a factor, and crumb rubber as a split plot on the first factor. Factor A consisted of the four different media and the washed sod. Factor B was the crumb rubber topdressing applied to one half of the Factor A plots. Fertilizer was applied twice per month at 2.5 g N m^{-2} using Lebanon Country Club 18-3-18 fertilizer until the end of April 1997. Traffic applications were applied two times a week using molded soccer cleats (thirteen 14-mm studs per shoe), 10 January 1997 through 11 April 1997. A total of 50 jogging passes were applied during each traffic application to simulate typical athletic field wear. PGR (Trinexapac ethyl) was applied on 8 December 1996 at 0.13 ml m^{-2}, and on 7 January 1997, 26 February 1997, and 28 March 1997. Chlorosis and browning of the leaf tips became apparent after the second PGR application. Therefore, the appearance of PGR toxicity accounts for the rate reduction, and lag between the 7 January and 26 February PGR applications. Iprodione (Chipco®) was applied on 10 December 1996, 29 January 1997, and 8 March 1997, after *Microdochium nivale* (pink snow mold) became visible. The Iprodione was applied at 1.3-ml a.i. m^{-2}. Mowing was done every Monday, Wednesday, and Friday at 32 mm using a reel mower. Watering was done on an as needed basis, and fans were used to provide air movement across the turf. Color, density, and quality ratings were visually taken every two weeks. Color and quality ratings were based on a 1-9 scale with 1 being the dead or bare ground, 9 being the ideal turf and 6 being acceptable. Turfgrass cover was visually estimated as a percent cover. Clippings were collected and weighed weekly. Clegg and shear vane data were also collected to measure surface hardness and turf shear strength. The Clegg meter measures surface hardness in gravity deceleration (G_{max}), and shear vane measured lateral turf strength in Newton meters (Nm) (Stier, 1997).

RESULTS

Part one: Turfgrass establishment

Successful turfgrass establishment can be determined after the first 10 weeks of seeding, and differences between the different growth media existed (Table 5). The significance for the two treatment effects for percent turfgrass cover, at two, three, five, and ten weeks after seeding determined the SportGrass™ provided greater turfgrass density than the Ecomat®, pine wood mulch, and sand, respectively (Table 6). *Poa supina* had significantly greater turf cover only at five weeks after seeding (Table 6).

Table 5. Part one: Turfgrass establishment – Significance of treatment effects for turfgrass cover[†], East Lansing, MI. 1996.

	Weeks after seeding			
Source	2	3	5	10
Turf species (T)	ns	ns	*	ns
Growth media (G)	*	**	**	**
T x G	ns	ns	ns	ns

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
ns Not significant at the 0.05 probability level.
† Turfgrass cover was visually estimated on a percent (0-100%) scale.

Table 6. Part one: Turfgrass establishment – Turfgrass cover[†] (0-100%) for turfgrass species and growth media established as sod on plastic, East Lansing, MI. 1996.

	Weeks after seeding			
Turfgrass sp.	2	3	5	10
Poa pratensis	2.1	5.3	30.6	42.8
Poa supina	2.2	6.9	37.9	51.8
$LSD_{(0.05)}$	ns	ns	*	ns
Growth media				
Pine mulch	1.8	5.0	15.2	35.8
Sand	1.3	2.8	12.0	18.8
Ecomat®	2.0	3.3	19.5	36.7
SportGrass™	3.3	13.2	90.3	97.8
LSD	ns	2.4	7.9	14.4

ns Not significant at the 0.05 probability level.
† Turfgrass cover was visually estimated on a percent (0-100%) scale.

Part two: Turfgrass performance

The fiberglass fabric of the indoor research facility transmitted approximately 11% ± 2% sd sunlight. The temperature inside was normally maintained at 16.8 ± 0.9 °C sd; temperature extremes ranged from 3-23 °C. Relative humidity (RH) averaged 44.8% ± 6.2 sd with a range of 24-70% RH. The fiberglass fabric provided relatively neutral shading. As expected, the high pressure sodium lamps provided a high proportion of their radiation in the yellow to red wavelengths (Stier, 1997).

No important significant differences occurred among either factor (growth media and crumb rubber topdressing) for color ratings (Table 7). Significant differences in turf cover between plots with crumb rubber versus plots without crumb rubber existed (Table 8) during the final three rating periods (13, 31, and 28 March 1997). The plots with crumb rubber had greater turfgrass cover (Table 8). The increased turf cover on the crumb rubber plots resulted in significantly higher quality turf ratings (Table 9). However, turfgrass cover and quality did not differ significantly among the five different growth media. Clipping yields determined no significant differences among treatments (Table 10).

Table 7. Part two: Turfgrass performance – Effect of traffic on turf color† of supina bluegrass grown on different growth media with crumb rubber topdressing as a split, East Lansing, MI. 1996-97.

	Color							
Growth media	8/12	27/12	17/01	4/02	17/02	13/03	21/03	28/03
Ecomat	7.5	7.3	6.0	5.1	5.0	6.3	6.7	6.5
SportGrass	8.0	7.7	6.6	6.3	5.6	5.4	6.3	6.4
Compost	5.8	7.0	7.0	7.7	6.8	6.5	7.0	7.0
Pine mulch	6.5	7.7	7.0	7.8	6.7	6.6	7.0	6.8
Washed sod	7.0	7.5	6.6	5.6	5.5	6.9	7.0	6.3
LSD	1.4	ns	0.7	0.7	ns	0.8	ns	ns
Topdressing								
No	7.0	7.4	6.5	6.4	5.9	6.2	6.8	6.6
Yes	7.0	7.4	6.8	6.6	5.9	6.5	6.8	6.6
LSD	ns	ns	**	ns	ns	*	ns	ns

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
ns Not significant at the 0.05 probability level.
† Color was rated visually on a 1-9 scale: 1=100% brown, 9=dark green.

Table 8. Part two: Turfgrass performance – Effect of traffic on turf cover† of supina bluegrass grown on various growth media with crumb rubber topdressing as a split, East Lansing, MI. 1996-97.

	% cover							
Growth media	8/12	27/12	17/01	4/02	17/02	13/03	21/03	28/03
Ecomat	97.7	98.7	98.3	98.7	96.0	93.2	90.5	90.8
SportGrass	100.0	100.0	98.7	97.3	94.8	87.5	75.0	74.2
Compost	98.7	99.0	98.2	98.3	99.0	89.7	88.8	88.3
Pine mulch	97.7	99.7	98.5	98.5	99.0	89.7	85.0	82.2
Washed sod	99.3	100.0	98.8	98.7	99.0	92.7	86.3	86.0
LSD	ns	ns	ns	ns	ns	ns	ns	ns
Topdressing								
No	98.7	99.5	98.2	97.9	97.0	88.7	82.1	80.5
Yes	98.7	99.5	99.0	98.7	98.1	92.4	88.2	88.1
LSD	ns	ns	*	ns	ns	**	*	**

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
ns Not significant at the 0.05 probability level.
† Turf cover was visually estimated on a percent (0-100%) scale.

Table 9. Part two: Turfgrass performance – Effect of traffic on turf quality† of supina bluegrass grown on various growth media with crumb rubber topdressing as a split, East Lansing, MI. 1996-97.

	Quality							
Growth media	8/12	27/12	17/01	4/02	17/02	13/03	21/03	28/03
Ecomat	7.7	7.5	6.9	5.3	4.5	6.6	6.8	6.6
SportGrass	8.2	7.7	7.3	6.8	5.1	5.3	5.5	5.8
Compost	6.5	6.8	7.4	7.8	6.8	6.2	7.4	6.5
Pine mulch	7.5	7.8	7.6	7.9	6.8	6.4	6.8	6.3
Washed sod	7.5	7.7	7.0	6.3	4.9	6.4	6.6	6.3
LSD	ns	ns	ns	0.9	1.6	ns	ns	ns
Topdressing								
No	7.5	7.5	7.2	6.7	5.6	6.0	6.4	6.1
Yes	7.5	7.5	7.3	6.9	5.6	6.4	6.8	6.5
LSD	ns	ns	ns	ns	ns	**	**	*

*, ** Significant at the 0.05 and 0.01 probability levels, respectively.
ns Not significant at the 0.05 probability level.
† Quality was rated visually on a 1-9 scale: 1=100% necrotic turf/bare soil, 9=dense, uniform turf with acceptable color (color ≥ 5).

Table 10. Part two: Turfgrass performance – Effect of traffic on clipping yields of supina bluegrass grown on varying growth media (GM) with crumb rubber (CR) topdressing as a split, East Lansing, MI. 1997.

	Clipping yields (grams)†								
Growth media	17/01	24/01	31/01	7/02	28/02	7/03	14/03	21/03	28/03
Ecomat	0.3	0.4	0.5	0.4	3.2	3.2	1.3	1.9	1.7
SportGrass	0.5	0.7	0.5	0.6	3.6	2.9	1.1	1.6	1.7
Compost	0.7	0.9	0.6	1.0	3.8	4.2	1.0	1.6	1.2
Pine mulch	0.4	0.8	0.7	1.0	3.3	3.7	1.0	1.3	1.8
Washed sod	0.5	0.6	0.5	0.5	3.7	4.3	1.6	2.2	1.9
LSD	ns	ns	ns	0.4	ns	ns	ns	ns	ns
Topdressing									
No	0.5	0.6	0.5	0.7	3.4	3.4	1.3	1.7	1.6
Yes	0.5	0.7	0.6	0.7	3.7	3.9	1.0	1.8	1.8
LSD	ns	ns	ns	ns	*	ns	ns	ns	ns

*,** Significant at 0.05 and 0.01 probability levels, respectively; ns = not significant at p = 0.05.
† Clippings were collected using a reel mower set at 3.2 cm, and weights were measured in grams.

Surface hardness characteristics differed significantly among the two treatments (growth media and crumb rubber topdressing) tested. SportGrass™ plots had a significantly harder surface (64.0 G_{max}) than any other growth media (Table 11). Plots treated with crumb rubber exhibited significantly lower surface hardness characteristics.

The SportGrass™ , Ecomat®, and washed sod had significantly higher shear strength readings than the compost and pine wood mulch (Table 11). Additionally, plots topdressed with crumb rubber had significantly lower shear strength than the plots without crumb rubber (Table 11).

Interactions show that the growth media without crumb rubber topdressing had a significantly greater shear strength than the media with crumb rubber (Table 11) except for the washed sod and pine wood mulch treatments. The rubber likely had not worked into the mat layer during the 3 January rating date (Rogers *et al.*, 1998). Differences in March showed that there were differences with rubber among plots with backings (Ecomat® and SportGrass™).

Table 11. Part two: Turfgrass performance – Effect of surface hardness† and shear strength‡ on *Poa supina* grown on varying growth media with crumb rubber topdressing as a split, East Lansing, MI. 1997.

	Date		
	3 Jan.	3 Jan.	29 March
Growth media (GM)	Clegg (G_{max})	Shear Vane (nm)	Shear Vane (nm)
Ecomat (EM)	51.8	14.6	22.8
SportGrass (SG)	64.0	17.1	24.2
Compost (CP)	40.1	15.1	16.6
Pine mulch (PM)	41.3	13.5	13.1
Washed sod (WS)	51.8	21.1	20.4
$LSD_{(0.05)}$	4.2	2.9	4.1
Crumb rubber (CR)			
No	51.7	20.1	21.9
Yes	48.1	12.4	16.9
LSD	**	**	**
GM x CR			
EM – CR	54.7	17.7	27.5
EM + CR	49.0	11.5	18.0
SG – CR	67.7	23.5	31.7
SG + CR	60.3	10.7	16.7
CP – CR	40.8	18.2	18.2
CP + CR	40.3	12.0	15.0
PM – CR	43.0	16.0	12.7
PM + CR	39.7	11.0	13.5
WS – CR	52.3	25.2	19.3
WS + CR	51.3	17.0	21.5
LSD§ $_{(0.05)}$	ns	3.3	3.2
LSD¶ $_{(0.05)}$	ns	4.3	4.6

*,** Significant at the 0.05 and 0.01 probability levels, respectively.

ns Not significant at $p = 0.05$.

† Surface hardness was measured using the Clegg Impact Soil Tester in gravity deceleration (G_{max}).

‡ Shear strength was measured using the Eijelkamp Shear Vane in Newton meters (nm).

§ Between crumb rubber levels with same growth media.

¶ Between growth media with same or different crumb rubber levels.

DISCUSSION

Part one: Turfgrass establishment

Although significant difference between the four growth media existed, the question of the relative accuracy of these results naturally arises. Because the four growth media differed so much in physical characteristics it was nearly impossible to treat each growth medium with the optimal management practices necessary for turfgrass establishment. The experimental design made the watering requirements necessary for each treatment virtually impossible to provide. Chapter One showed that dense turfgrass could be established on the Ecomat® in only 28 days after seeding when the PennMulch® was used. However, in this experiment the Ecomat® only achieved 37% density ten weeks after seeding (70 days after seeding). This occurred because the Ecomat® did not receive satisfactory moisture during the initial stages of seed germination. The pine wood mulch also had a poor turfgrass density ten weeks after seeding because it too did not receive satisfactory moisture during the initial stages of seed germination. For the sand, repeated shifting and washing of the growth medium during water applications resulted in low turfgrass cover. The SportGrass™ had the greatest turfgrass density because it was the growth medium that received the optimal watering regimes during seed germination. In addition the polyethylene fibers of the SportGrass™ provided ideal stability for the back filled sand.

Part two: Turfgrass performance

Beard (1973) noted that sod possessing a particle size substantially different from the underlying soil had a cleavage plane at the interface. However, Cairol and Chevallier (1981) found that cleavage did not appear when a good incorporation of pine bark into the upper 20 mm of the underlying soil was noticed, and the knitting was very satisfying regardless of the intensive or medium traffic conditions applied. Conversely, the findings in this experiment determined significant differences in cleavage (shear strength) occurred among the different growth media tested for turfgrass density. However, unlike the findings by Cairol and Chevallier, the pine wood mulch and compost had significantly lower shear strength than the SportGrass™, Ecomat®, and washed sod. The lower shear strength for the pine wood mulch may also be attributed to the stress provided by the reduced light levels. Root mass and growth is severely limited when turves are exposed to low light conditions (Stier, 1997). Therefore, rooting in the pine wood mulch was likely limited to the mulch itself and the instability of the wood mulching material lessened the shear strength of the sod. In addition, the blades of the shear vane apparatus on penetrate 2.5 cm into the turf; therefore, the shear strength of the pine wood mulch was only measuring the growth medium and not the sand root zone.

Rogers *et al.*, (1998) determined that topdressing turfgrass with crumb rubber initially lowers turfgrass shear strength, and maintains higher turfgrass density when subjected to heavy traffic. They also found that shear vane numbers increased as the age of the turf increased with topdressing. In this experiment the crumb rubber topdressing had a different particle size than the underlying growth media, and is likely the cause for the lower shear strength as a result of topdressing crumb rubber. This supports the findings by Rogers and Vanini (1998), and Beard (1973). Maintaining higher turfgrass density with crumb rubber topdressing and providing lower surface hardness supports the findings by Rogers and Vanini (1998).

Chapter 3

THE EFFECT OF SEEDING RATE AND FERTILIZER SOURCE AND RATE ON TURFGRASS ESTABLISHMENT ON PLASTIC

ABSTRACT

For experiment one, seeding study, the germination and establishment of four turfgrass species (*Poa pratensis*, *Poa supina*, *Lolium perenne*, and *Festuca arundinacea*) within a refined wood fiber mat (Ecomat®) were evaluated using three different seeding rates over plastic sheeting. The three seeding rates were 1, 2, and 4 times the recommended seeding rates for each turfgrass species, respectively. Results determined that four times the recommended seeding rate significantly increased turfgrass cover from the recommended seeding rate, and that *Lolium perenne* had the greatest turfgrass cover. *Festuca arundinacea*, had significantly greater turfgrass density than both *Poa* species.

For experiment two, fertility study, the germination and establishment of *Poa pratensis* in Ecomat® was evaluated using different fertilizer sources and rates. Two nitrogen sources (Milorganite® and ammonium nitrate) were studied using three application rates (1.25, 2.5, and 5.0 g N m^{-2} every two weeks). The Milorganite® at the middle and high rate had significantly higher turfgrass density than all other treatments. The experimental design for both the seeding and fertility studies severely decimated the results of both experiments. Final results are inconclusive because optimal water requirements were unattainable for proper seed germination.

INTRODUCTION

Manufactured in New Westminster, British Columbia, by Canadian Forest Products Ltd., Ecomat® is used extensively as an erosion control mat for use along roadsides. Ecomat® is a recycled wood fiber mat and can be used as the growth medium on plastic sheeting for turfgrass establishment. Sod production on plastic is a unique practice and demonstrates many advantages versus traditional sod production. Root shearing during sod harvesting is eliminated when grown on plastic which allows the sod to establish faster than conventional sod. The sod is light-weight due to the absence of soil, potentially allowing for cheaper shipping costs and larger sod pieces. The sod pieces are held together by the binding of the roots, thus enabling the production of turfgrasses with bunch type growth habits. Since the Ecomat® is a soil less growing media, the recommended seeding rates and fertilizer rates and type will differ from conventional turfgrass establishment in soil. Currently, sod production on plastic utilizes wood chips, compost, and sand as the growth media for turfgrass establishment. Although sod production on soil less growing media has been practiced for a number of years, little published research exists to recommend specific establishment practices. In 1997, two separate experiments were conducted to satisfy the following objectives: 1) Determine the optimum seeding rate for turfgrass establishment on a soil less media (Ecomat®) over plastic, and 2) Determine the optimum fertilizer type (organic vs. mineral) and application rate for turfgrass establishment on a soil less media (Ecomat®) over plastic.

<u>Experiment one</u>: Seeding study

Too much seed slows turfgrass maturity (Madison, 1966). Because of excessive seedling competition, seedlings cannot develop until some factor, usually disease, decimates the population so surviving individuals have space to grow (Crocker and

Barton, 1957; Wells and Robinson, 1954). Conversely, too little seed results in a sparse stand, and while the grass slowly fills in, the area is open to weed invasion (Madison, 1966). Therefore, knowing the proper seeding rate prior to seeding affirms the possibility of achieving a more mature turfgrass stand.

Recommendations for seeding rates are based on an assumed number of seeds per unit (generally seeds/ pound or gram) (Christians, *et al.,* 1979). Estimates of the number of seeds per gram for *Poa pratensis* in current use range from 4,800 to 4,960 seeds per gram, and this differs from the estimates required for *Festuca arundinacea* (approximately 500 seeds per gram (Beard 1973; Musser and Perkins, 1969). *Poa supina* has a similar seed size to *Poa pratensis*, and *Lolium perenne* has a similar seed size to *Festuca arundinacea*, and their respective seeding rates are approximately the same.

For this experiment, four turfgrass species (*Poa pratensis*, *Poa supina*, *Lolium perenne*, and *Festuca arundinacea*) were seeded into Ecomat® over polyethylene sheeting using three different seeding rates (one, two, and four times the recommended seeding rates). Because the Ecomat® is a soil-less growing medium, the vital seed to soil contact does not exist for turfgrass establishment. Therefore, the optimal seeding rates on Ecomat® for each species need to be investigated.

Experiment two: Fertility study

Various recommendations on rates, ratios, and placement of fertilizer for turfgrass establishment have been made (Davis, *et al.*, 1964; Harper, *et al.*, 1962; Skogley, 1962). In particular, the recommendations vary in the amounts of phosphorous recommended relative to nitrogen and potassium (King and Skogley, 1969). In addition, the amount of nitrogen suggested varies (King and Skogley, 1969). Establishing turfgrass in a relatively inert material such as the Ecomat®, nutrient availability and holding capacity is limited, and increased fertilizer application rates may be warranted.

To combat the detrimental effects of compaction on soil physical properties for heavily trafficked turfgrass areas, sandier growing media are being used (Waddington, *et al.*, 1990). Zimmerman (1969) reported that increasing sand in the rootzone mix decreased cation exchange capacity and available nutrient levels. This same effect also exists when Ecomat® is used as the growing media. Using organic sources of nitrogen is one way to aid in compensating for the low nutrients in the growth media without changing the physical properties in growing media such as sandy soils and Ecomat®. Effects of an organic fertilizer (Milorganite®) rate resulted in increased concentrations of phosphorous, potassium, calcium, sulfur, manganese, iron, copper, and zinc for turfgrass establishment in a sand growing medium (Waddington, *et al.*, 1990).

For this experiment, different sources of nitrogen (Milorganite® and ammonium nitrate) were investigated at different rates (1.25, 2.5, and 5 g N m^{-2}) for *Poa pratensis* establishment in Ecomat® over polyethylene sheeting. In addition, one rate of urea (2.5 g N m^{-2}) and two rates of phosphorous and potassium (2.5 and 5.0 g P or K m^{-2}) were investigated as orthogonal contrasts to the 2.5 g N m^{-2} ammonium nitrate fertilizer treatment.

MATERIALS AND METHODS

Experiment one: Seeding rate

Four cool season turfgrasses were established from seed in Ecomat® over impermeable polyethylene sheeting (6 mil thickness) at the Hancock Turfgrass Research Center, Michigan State University, during summer 1997. The experiment was a 2 factor randomized complete block design (RCBD) with 3 replications. Factor one was the four turf species, which included: *Poa pratensis* L. (Kentucky bluegrass), *P. supina* Schrad. (supina bluegrass), *Lolium perenne* L. (perennial ryegrass), and *Festuca arundinacea* Schreb . (tall fescue). Factor two was the three seeding rates for each turf species (Table 12). The initial seeding rate was the typical recommended seeding rate for conventional turfgrass establishment on soil (Turgeon, 1991). There was a total of 36- 1.22 m by 1.83 m plots which were seeded on 7 June 1997. Seed was applied using a hand shaker, and each plot was individually seeded. Straw was mulched over the seeded plots. Prior to seeding all plots were fertilized with 5 g N m^{-2} using Lebanon Country Club (13-25-12) Starter Fertilizer. Every two weeks an additional 2.5 g N m^{-2} was applied using the 13-25-12 fertilizer for a total of seven fertilizer applications. Water was applied, as needed using an automatic irrigation system. Mowing began four weeks after seeding, and was done twice per week using a reel mower at a 32 mm mowing height. Turf density was visually estimated to determine percent turfgrass cover for establishment.

Table 12. Seeding rates (g m^{-2}) for turfgrass establishment on four turf species, East Lansing, MI. 1997.

	Turfgrass species			
Seeding rate	*P. pratensis*	*P. supina*	*L. perenne*	*F. arundinacea*
1x	7.3	7.3	39.1	39.1
2x	14.7	14.7	78.2	78.2
3x	29.3	29.3	156.4	156.4

Experiment two: Fertility type and rates

On 10 June 1997, 45 0.91 m by 1.22 m Ecomat™ plots were laid on plastic, with 0.5 m *Poa pratensis* sod strips between each plot to act as a buffer. The study consisted of six main treatments consisting of two fertilizer types (two forms of nitrogen (N)), and three fertility rates with five replications (Table 13). The two types of fertilizers used were a organic fertilizer (Milorganite™ 6-2-0), and a mineral fertilizer (ammonium nitrate 34-0-0). The three fertility rates compared were 1.25, 2.5, and 5 g N m^{-2}. An additional three treatments were included for orthogonal contrasts with the 1.25 g N m^{-2} ammonium nitrate treatment (Table 13). The additional treatments included high potassium, high phosphorous, and using urea as the mineral form of nitrogen. The urea (46-0-0), phosphorous (0-46-0), and potassium (0-0-50) were applied at 1.25 g N m^{-2} every two weeks. High nitrogen and phosphorous treatments were applied prior to seeding as a bed source of nutrients. Four post fertilizer treatment applications were made every two weeks after seeding. Table 2 shows the arrangement of the fertilizer treatments. On 11 June 1997 all plots were seeded with *Poa pratensis* var. 'Touchdown' at 7.3 g m^{-2}, and then mulched with straw. Water was applied, as needed using an automatic irrigation system. Mowing began four weeks after seeding, and was done twice per week using a reel mower at a 32 mm mowing height. Turfgrass cover was estimated visually on a percent scale.

Table 13. Fertilizer treatment types and rates for *Poa pratensis* establishment within Ecomat® over plastic, East Lansing, MI. 1997.

Treatment†	Bed N	Post‡ N	Bed P	Post P	Bed K	Post K
1	10 (O)	1.25	10	1.25	0	1.25
2	10 (O)	2.5	10	1.25	0	1.25
3	10 (O)	5.0	10	1.25	0	1.25
4	10 (M)	1.25	10	1.25	0	1.25
5	10 (M)	2.5	10	1.25	0	1.25
6	10 (M)	5.0	10	1.25	0	1.25
7	10 (M)	2.5	10	2.5	0	1.25
8	10 (M)	2.5	10	1.25	0	2.5
9	10 (U)	2.5	10	1.25	0	1.25

† Treatment rates are all in g m^{-2}.

‡ Post treatments began two weeks after seeding and were applied every two weeks.

O=organic form of nitrogen (Milorganite™), M=mineral form of nitrogen (ammonium nitrate), and U=mineral form of nitrogen (urea).

RESULTS

Experiment one: Seeding study

Significant differences in turfgrass cover among the four turf species studied occurred (Table 14). *Lolium perenne* had significantly greater cover than any of the other turf species investigated on all five sampling dates (Table 14). *Festuca arundinacea* had significantly greater turfgrass cover than both *Poa pratensis* and *Poa supina*. The greater turfgrass cover of the *Lolium perenne* and *Festuca arundinacea* were expected on the early data collection dates because, of their superior germination rate than the two *Poa* sp. These results were anticipated, because *Lolium perenne* and *Festuca arundinacea* are faster germinating turves. However, even after two months, the two *Poa* sp. had significantly less cover than the *Lolium perenne* and *Festuca arundinacea*. Overall, only the *Lolium perenne* had what would be considered acceptable turfgrass cover two months after seeding (76.3%).

Significant differences in turfgrass cover among the three seeding rates occurred on all sampling dates except the 2 July rating date (Table 14). Differences between the 1x rate and the 4x rate were significant for all turfgrass cover sampling dates. When seeding at the recommended seeding rate, turfgrass cover was relatively poor even after two months.

Table 14. Seeding study – Effect of three seeding rates on turfgrass cover† for four turfgrass species utilizing Ecomat® on plastic, East Lansing, MI. 1997.

	Date				
	2 July	18 July	30 July	8 Aug.	8 Sept.
Turf species (TS)			% cover		
Poa pratensis‡ (KBG)	0.2	13.7	15.1	16.7	19.2
Poa supina‡ (SBG)	1.3	12.0	17.7	19.6	23.0
Lolium perenne§ (PRG)	29.7	74.1	71.9	73.0	76.3
Festuca arundinacea§ (TF)	12.9	40.0	37.6	37.0	41.1
$LSD_{(0.05)}$	10.7	19.0	18.1	17.6	18.9
Seeding rate (SR)					
1x (times) recommend rate	5.4	23.0	23.6	24.6	27.3
2x (times) recommend rate	12.8	37.3	36.2	36.8	41.3
4x (times) recommend rate	14.9	44.6	46.9	48.3	51.3
$LSD_{(0.05)}$	ns	16.5	15.7	15.2	16.4
TS x SR					
KBG x 1x	0.0	6.0	7.7	9.7	11.0
KBG x 2x	0.7	21.7	21.7	24.3	28.3
KBG x 4x	0.0	13.3	16.0	16.0	18.3
SBG x 1x	0.0	2.7	2.3	2.7	3.0
SBG x 2x	0.0	3.3	17.3	17.7	24.3
SBG x 4x	4.0	30.0	33.3	38.3	41.7
PRG x 1x	20.0	65.0	65.0	66.7	71.7
PRG x 2x	38.3	84.0	79.0	80.0	82.3
PRG x 4x	30.7	73.3	71.7	72.3	75.0
TF x 1x	1.7	18.3	19.3	19.3	23.3
TF x 2x	12.0	40.0	26.7	25.0	30.0
TF x 4x	25.0	61.7	66.7	66.7	70.0
$LSD_{(0.05)}$	ns	ns	ns	ns	ns

ns Indicates no significance at the p = 0.05 probability level.

† Turfgrass cover was visually rated on a percent scale (0-100%).

‡ The recommended seeding rate for *P. pratensis* and *P. supina* is 7.3 g m^{-2}.

§ The recommended seeding rate for *L. perenne* and *F. arundinacea* is 39.1 g m^{-2}.

Experiment two: Fertility study

Significant differences in turfgrass cover occurred within each factor on all four sampling dates (Table 15). Significant interactions between the two factors (nitrogen fertilizer type and rate) also occurred. These results indicate that the use of an organic fertilizer (Milorganite®) significantly increased turfgrass cover during establishment compared to the mineral nitrogen source (ammonium nitrate). This supports conclusion found by Waddington, *et al.*, (1990); where, the use of an organic fertilizer increased turfgrass establishment in sandy soils that had low cation exchange capacity and nutrient availability.

Simply increasing the rate of nitrogen fertility significantly increased turfgrass cover. These results determined that 2.5 g N m^{-2} (every two weeks) using the organic fertilizer was required to increase turfgrass cover (Table 15). King and Skogley (1969) also concluded that increased nitrogen rates increased turfgrass growth or establishment rate.

Table 15. Fertility study – Effect of fertilizer type and rate on turfgrass cover[†] for establishing *Poa pratensis* within Ecomat® over plastic (seeded 11 June 1997), East Lansing, MI. 1997.

	Date			
	10 July	30 July	8 Aug.	8 Sept.
Fertilizer type (FT)	% cover			
Milorganite[‡] (M)	11.4	29.0	31.5	35.5
Ammonium nitrate[§] (AN)	3.9	14.3	12.7	14.9
LSD	*	*	*	*
Fertilizer rate (FR)				
1.25 g m^{-2} (A)	3.5	15.8	13.9	16.6
2.5 g m^{-2} (B)	9.1	21.6	23.6	26.2
5 g m^{-2} (C)	10.5	27.5	28.8	32.8
$LSD_{(0.05)}$	3.2	7.0	8.2	9.6
FT x FR				
M x A	2.6	14.8	13.6	15.6
M x B	15.2	33.0	38.0	42.0
M x C	16.6	39.2	43.0	49.0
AN x A	4.4	16.8	14.2	17.6
AN x B	3.0	10.2	9.2	10.4
AN x C	4.4	15.8	14.6	16.6
$LSD_{(0.05)}$	4.2	9.0	10.6	12.3

* Indicates significance at the 0.01 probability level.

† Turfgrass cover was visually estimated on a percent cover scale (0-100%).

‡ Milorganite® has a 6-2-0 analysis.

§ Ammonium nitrate has a 34-0-0 analysis.

No significant differences occurred in turfgrass cover when the post phosphorous and potassium application rates were doubled (Table 16). Again, this supports findings by King and Skogley (1969) where turfgrass response to different levels of phosphorous was inconsistent.

Finally, establishment results between the two types of mineral nitrogen sources (ammonium nitrate and urea) investigated had no significant differences occur in turfgrass cover (Table 16).

Table 16. Fertility study – Effect of increasing post phosphorous and potassium rates, or using urea nitrogen on turfgrass cover† for establishing *Poa pratensis* within Ecomat® over plastic, East Lansing, MI. 1997.

	Date			
	10 July	30 July	8 Aug.	8 Sept.
Phosphorous‡ rate	% cover			
1.25 g m^{-2}	2.0	10.2	9.8	11.8
2.5 g m^{-2}	7.2	16.2	17.2	20.2
LSD	ns	ns	ns	ns
Potassium§ rate				
1.25 g m^{-2}	1.8	10.2	9.8	10.8
2.5 g m^{-2}	3.6	18.6	13.8	15.6
LSD	ns	*	ns	ns
Nitrogen form 2.5 g m^{-2}				
Ammonium nitrate	2.4	10.2	9.8	14.2
Urea	4.6	17.8	18.8	24.6
LSD	ns	ns	ns	ns

* Indicates significance at the 0.01 probability level, ns = not significance at p = 0.05 probability level.

† Turfgrass cover was visually estimated on a percent cover scale (0-100%).

‡ Additional phosphorous was applied using super phosphate 0-46-0.

§ Additional potassium was applied using sulfate of potash 0-0-50.

DISCUSSION

Environmental:

Results from the two experiments are somewhat inconclusive, because weather and more importantly water played a critical role to decimate the outcome of the two studies. Unfortunately, the configuration of the experiments made watering a near impossible task. Conflicts in watering requirements between the two studies eliminated the practical application of the automatic irrigation system. Therefore, hand watering was necessary and became the primary method for irrigating. In addition, any rainfall that occurred flooded the plots (especially the fertility study). Often the plots were under water from rainfall or the irrigation. Conversely, if the plots were not flooded they were often too dry for proper seed germination and establishment.

Experiment one: Seeding study

It was determined that the seeding at four times the recommended seeding rate significantly increased turfgrass density. However, the repeated flooding and drying out of the plots as a result of the watering problems severely limited the potentials of each species. The poor outcome of the study eliminated the application of a secondary test to determine turfgrass maturity. Because the turves did not establish to an acceptable level (density), the intended root box study was abandoned. Root box pulls were to be done to determine the amount of rooting for each turf species investigated at the three different seeding rates. It was anticipated to find that, although the four times seeding rate provided the greatest turfgrass density that the plants were too immature as a result of over crowding. In turn, reduced rooting would be evident.

Experiment two: Fertility study

It is likely that the organic nitrogen source (Milorganite®) did significantly better than the mineral nitrogen source (ammonium nitrate) as a result of the test site being poorly drained. This in turn, led to too much water accumulating as a result of rainfall or too much irrigation. On many occasions the research plots were submerged under water for long periods of time (as long as 24 hours), and denitrification of the ammonium nitrate likely occurred; therefore, greatly reducing the amount of available nitrogen required for the germinating plants. However, it is likely that the poor results of the ammonium nitrate was because of runoff as a result of the repeated flooding that occurred (Waddington *et al.*, 1994). Denitrification probably did not occur because the decomposing carbon source and the chemoheterotrophic bacteria necessary to break down the nitrate were not present in the Ecomat® (Foth and Ellis, 1988). Conversely, if there were any effects from the ammonium nitrate fertilization, it would likely have caused toxicity (burn) to the immature seedlings. In addition, the high volume of Milorganite® may have been adding to the physical properties of the Ecomat®, and in turn providing a more favorable seedbed for turfgrass establishment.

Similar to the Seeding study, the application of a root box study to determine fertilizer effects on rooting was abandoned as a result of the unacceptable turfgrass density.

CONCLUSIONS

The effectiveness of Ecomat® as a growth medium for turfgrass establishment has been ascertained during these experiments. However, protocol to achieve successful seed germination and establishment has only been initiated. It has been determined that Ecomat®, as an established sod, has the potential to provide an instant turfgrass cover that is durable, lightweight, and quick rooting.

Chapter one: Mulching study

The objective of this experiment was defined, and it was determined that the use of particular mulches can greatly enhance turfgrass density. The straw mulch especially, enhanced more favorable growing conditions for the germinating seed. In addition, the PennMulch™ and hydro mulch provided more favorable growing conditions for the germinating seed. The physical properties of the mulches determined their effectiveness. The mulches with the presumed larger pore spaces had lower capillary rise potential; therefore, water was not moved away from the germinating seed as easily.

The *Lolium perenne* had germinated sooner and had greater density 28 days after seeding. These results were anticipated because of the more rapid germination rate of *L. perenne* than *Poa supina*; therefore, making the mulch a more important component as germination time increases.

Chapter two: Turfgrass establishment and performance

Unfortunately, the configuration of the establishment experiment impeded much of the attainable results. Because of the repeated washing of the study as a result of rainfall, the germination and establishment conditions for the *Poa pratensis* and *P. supina* were not acceptable, particularly on the sand, Ecomat®, and pine wood mulch growth media. In any event, the SportGrass™ was very effective for establishing turfgrass, despite the unfavorable watering regimes, and produced the densest turf. No significant differences occurred between the two *Poa* species.

Turfgrass performance under heavy traffic and low light conditions determined that all growth media were capable of providing acceptable turfgrass density for the duration of the experiment. These acceptable turfgrass densities were augmented with the addition of crumb rubber topdressing.

Chapter three: Turfgrass seeding and fertility studies

The configuration and location of both the seeding and fertility studies severely impeded the potential outcomes of the experiments. Any rainfall or more than three minutes of irrigation was generally enough water added to submerge portions or all of the studies under water. These flooding conditions often persisted for long periods of time (as long as 24 hours) due to the rains.

Increasing the seeding rate in Ecomat® to four times the recommended rate increased turfgrass cover. The *Lolium perenne* had the greatest turfgrass cover.

Organic nitrogen (Milorganite®) established denser *Poa pratensis* turf than the ammonium nitrate. This is likely a result of the organic nitrogen being more of a slow release nitrogen, therefore providing nitrogen to the germinating seed for a longer period of time. The poor performance of the ammonium nitrate could be attributed to run of as a result of the frequent flooding of the plots.

Finally, using a different source of nitrogen fertilizer like urea (46-0-0) and/or increasing the concentration of phosphorous or potassium had no significant effects on turfgrass establishment (percent cover).

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